```
F:\qit\java\mar3\filemonitor\target\qo-ethereum\qo-ethereum-1.doc
0:F:\git\coin\ethereum\go-ethereum\common\hexutil\hexutil.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
/*
Package hexutil implements hex encoding with 0x prefix.
This encoding is used by the Ethereum RPC API to transport binary data in JSON payloads.
Encoding Rules
All hex data must have prefix "0x".
For byte slices, the hex data must be of even length. An empty byte slice
encodes as "0x".
Integers are encoded using the least amount of digits (no leading zero digits). Their
encoding may be of uneven length. The number zero encodes as "0x0".
*/
package hexutil
import (
"encoding/hex"
"fmt"
"math/big"
"strconv"
)
const uintBits = 32 << (uint64(^uint(0)) >> 63)
var (
ErrEmptyString = &decError{"empty hex string"}
ErrSyntax
               = &decError{"invalid hex string"}
ErrMissingPrefix = &decError{"hex string without 0x prefix"}
ErrOddLength = &decError{"hex string of odd length"}
ErrEmptyNumber = &decError{"hex string \"0x\""}
ErrLeadingZero = &decError{"hex number with leading zero digits"}
ErrUint64Range = &decError{"hex number > 64 bits"}
ErrUintRange = &decError{fmt.Sprintf("hex number > %d bits", uintBits)}
```

ErrBig256Range = &decError{"hex number > 256 bits"}

)

```
type decError struct{ msg string }
func (err decError) Error() string {
return string(err.msg)
}
// Decode decodes a hex string with 0x prefix.
func Decode(input string) ([]byte, error) {
if len(input) == 0 {
return nil, ErrEmptyString
if !has0xPrefix(input) {
return nil, ErrMissingPrefix
b, err := hex.DecodeString(input[2:])
if err != nil {
err = mapError(err)
}
return b, err
// MustDecode decodes a hex string with 0x prefix. It panics for invalid input.
func MustDecode(input string) []byte {
dec, err := Decode(input)
if err != nil {
panic(err)
return dec
// Encode encodes b as a hex string with 0x prefix.
func Encode(b []byte) string {
enc := make([]byte, len(b)*2+2)
copy(enc, "0x")
hex.Encode(enc[2:], b)
return string(enc)
}
// DecodeUint64 decodes a hex string with 0x prefix as a quantity.
func DecodeUint64(input string) (uint64, error) {
raw, err := checkNumber(input)
if err != nil {
```

```
return 0, err
}
dec, err := strconv.ParseUint(raw, 16, 64)
if err != nil {
err = mapError(err)
return dec, err
}
// MustDecodeUint64 decodes a hex string with 0x prefix as a quantity.
// It panics for invalid input.
func MustDecodeUint64(input string) uint64 {
dec, err := DecodeUint64(input)
if err != nil {
panic(err)
}
return dec
}
// EncodeUint64 encodes i as a hex string with 0x prefix.
func EncodeUint64(i uint64) string {
enc := make([]byte, 2, 10)
copy(enc, "0x")
return string(strconv.AppendUint(enc, i, 16))
var bigWordNibbles int
func init() {
// This is a weird way to compute the number of nibbles required for big.Word.
// The usual way would be to use constant arithmetic but go vet can't handle that.
b, _ := new(big.Int).SetString("FFFFFFFFF", 16)
switch len(b.Bits()) {
case 1:
bigWordNibbles = 16
case 2:
bigWordNibbles = 8
default:
panic("weird big.Word size")
}
}
```

```
// DecodeBig decodes a hex string with 0x prefix as a quantity.
// Numbers larger than 256 bits are not accepted.
func DecodeBig(input string) (*big.Int, error) {
raw, err := checkNumber(input)
if err != nil {
return nil, err
if len(raw) > 64 {
return nil, ErrBig256Range
}
words := make([]big.Word, len(raw)/bigWordNibbles+1)
end := len(raw)
for i := range words {
start := end - bigWordNibbles
if start < 0 {
start = 0
}
for ri := start; ri < end; ri++ {
nib := decodeNibble(raw[ri])
if nib == badNibble {
return nil, ErrSyntax
}
words[i] *= 16
words[i] += big.Word(nib)
end = start
dec := new(big.Int).SetBits(words)
return dec, nil
}
// MustDecodeBig decodes a hex string with 0x prefix as a quantity.
// It panics for invalid input.
func MustDecodeBig(input string) *big.Int {
dec, err := DecodeBig(input)
if err != nil {
panic(err)
}
return dec
}
```

// EncodeBig encodes bigint as a hex string with 0x prefix.

```
// The sign of the integer is ignored.
func EncodeBig(bigint *big.Int) string {
nbits := bigint.BitLen()
if nbits == 0 {
return "0x0"
return fmt.Sprintf("%#x", bigint)
}
func has0xPrefix(input string) bool {
return len(input) >= 2 && input[0] == '0' && (input[1] == 'x' || input[1] == 'X')
}
func checkNumber(input string) (raw string, err error) {
if len(input) == 0 {
return "", ErrEmptyString
}
if !has0xPrefix(input) {
return "", ErrMissingPrefix
}
input = input[2:]
if len(input) == 0 {
return "", ErrEmptyNumber
if len(input) > 1 && input[0] == '0' {
return "", ErrLeadingZero
}
return input, nil
}
const badNibble = \(^{0}\)
func decodeNibble(in byte) uint64 {
switch {
case in >= '0' && in <= '9':
return uint64(in - '0')
case in >= 'A' && in <= 'F':
return uint64(in - 'A' + 10)
case in >= 'a' && in <= 'f':
return uint64(in - 'a' + 10)
default:
return badNibble
```

```
}
}
func mapError(err error) error {
if err, ok := err.(*strconv.NumError); ok {
switch err.Err {
case strconv.ErrRange:
return ErrUint64Range
case strconv.ErrSyntax:
return ErrSyntax
}
}
if _, ok := err.(hex.InvalidByteError); ok {
return ErrSyntax
}
if err == hex.ErrLength {
return ErrOddLength
}
return err
1:F:\git\coin\ethereum\go-ethereum\common\hexutil\hexutil_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package hexutil
import (
"bytes"
"math/big"
"testing"
)
type marshalTest struct {
input interface{}
want string
}
type unmarshalTest struct {
input
           string
           interface{}
want
wantErr
            error // if set, decoding must fail on any platform
wantErr32bit error // if set, decoding must fail on 32bit platforms (used for Uint tests)
```

```
}
var (
encodeBytesTests = []marshalTest{
{[]byte{}, "0x"},
{[]byte{0}, "0x00"},
{[]byte{0, 0, 1, 2}, "0x00000102"},
}
encodeBigTests = []marshalTest{
{referenceBig("0"), "0x0"},
{referenceBig("1"), "0x1"},
{referenceBig("ff"), "0xff"},
{referenceBig("112233445566778899aabbccddeeff"), "0x112233445566778899aabbccddeeff"},
{referenceBig("80a7f2c1bcc396c00"), "0x80a7f2c1bcc396c00"},
{referenceBig("-80a7f2c1bcc396c00"), "-0x80a7f2c1bcc396c00"},
}
encodeUint64Tests = []marshalTest{
{uint64(0), "0x0"},
{uint64(1), "0x1"},
{uint64(0xff), "0xff"},
{uint64(0x1122334455667788), "0x1122334455667788"},
}
encodeUintTests = []marshalTest{
{uint(0), "0x0"},
{uint(1), "0x1"},
{uint(0xff), "0xff"},
{uint(0x11223344), "0x11223344"},
}
decodeBytesTests = []unmarshalTest{
// invalid
{input: ``, wantErr: ErrEmptyString},
{input: `0`, wantErr: ErrMissingPrefix},
{input: `0x0`, wantErr: ErrOddLength},
{input: `0x023`, wantErr: ErrOddLength},
{input: `0xxx`, wantErr: ErrSyntax},
{input: `0x01zz01`, wantErr: ErrSyntax},
// valid
{input: `0x`, want: []byte{}},
```

```
{input: `0X`, want: []byte{}},
{input: `0x02`, want: []byte{0x02}},
{input: `0X02`, want: []byte{0x02}},
{input: `Oxfffffffff`, want: []byte{Oxff, 0xff, 
{
want: []byte{0xff, 0xff, 0xff,
0xff},
},
}
decodeBigTests = []unmarshalTest{
// invalid
{input: `0`, wantErr: ErrMissingPrefix},
{input: `0x`, wantErr: ErrEmptyNumber},
{input: `0x01`, wantErr: ErrLeadingZero},
{input: `0xx`, wantErr: ErrSyntax},
{input: `0x1zz01`, wantErr: ErrSyntax},
wantErr: ErrBig256Range,
},
// valid
{input: `0x0`, want: big.NewInt(0)},
{input: `0x2`, want: big.NewInt(0x2)},
{input: `0x2F2`, want: big.NewInt(0x2f2)},
{input: `0X2F2`, want: big.NewInt(0x2f2)},
{input: `0x1122aaff`, want: big.NewInt(0x1122aaff)},
{input: `0xbBb`, want: big.NewInt(0xbbb)},
{input: `Oxfffffffff`, want: big.NewInt(0xffffffff)},
{
input: `0x112233445566778899aabbccddeeff`,
want: referenceBig("112233445566778899aabbccddeeff"),
},
{
},
},
```

```
decodeUint64Tests = []unmarshalTest{
// invalid
{input: `0`, wantErr: ErrMissingPrefix},
{input: `0x`, wantErr: ErrEmptyNumber},
{input: `0x01`, wantErr: ErrLeadingZero},
{input: `0xffffffffffffff, wantErr: ErrUint64Range},
{input: `0xx`, wantErr: ErrSyntax},
{input: `0x1zz01`, wantErr: ErrSyntax},
// valid
{input: `0x0`, want: uint64(0)},
\{input: `0x2`, want: uint64(0x2)\},
{input: `0x2F2`, want: uint64(0x2f2)},
{input: `0X2F2`, want: uint64(0x2f2)},
{input: `0x1122aaff`, want: uint64(0x1122aaff)},
{input: `0xbbb`, want: uint64(0xbbb)},
{input: `0xffffffffffff, want: uint64(0xffffffffffff)},
)
func TestEncode(t *testing.T) {
for _, test := range encodeBytesTests {
enc := Encode(test.input.([]byte))
if enc != test.want {
t.Errorf("input %x: wrong encoding %s", test.input, enc)
}
}
}
func TestDecode(t *testing.T) {
for _, test := range decodeBytesTests {
dec, err := Decode(test.input)
if !checkError(t, test.input, err, test.wantErr) {
continue
}
if !bytes.Equal(test.want.([]byte), dec) {
t.Errorf("input %s: value mismatch: got %x, want %x", test.input, dec, test.want)
continue
}
}
}
```

}

```
func TestEncodeBig(t *testing.T) {
for _, test := range encodeBigTests {
enc := EncodeBig(test.input.(*big.Int))
if enc != test.want {
t.Errorf("input %x: wrong encoding %s", test.input, enc)
}
}
}
func TestDecodeBig(t *testing.T) {
for _, test := range decodeBigTests {
dec, err := DecodeBig(test.input)
if !checkError(t, test.input, err, test.wantErr) {
continue
}
if dec.Cmp(test.want.(*big.Int)) != 0 {
t.Errorf("input %s: value mismatch: got %x, want %x", test.input, dec, test.want)
continue
}
}
}
func TestEncodeUint64(t *testing.T) {
for _, test := range encodeUint64Tests {
enc := EncodeUint64(test.input.(uint64))
if enc != test.want {
t.Errorf("input %x: wrong encoding %s", test.input, enc)
}
}
func TestDecodeUint64(t *testing.T) {
for _, test := range decodeUint64Tests {
dec, err := DecodeUint64(test.input)
if !checkError(t, test.input, err, test.wantErr) {
continue
}
if dec != test.want.(uint64) {
t.Errorf("input %s: value mismatch: got %x, want %x", test.input, dec, test.want)
continue
}
```

```
}
}
2:F:\git\coin\ethereum\go-ethereum\common\hexutil\json.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package hexutil
import (
"encoding/hex"
"encoding/json"
"fmt"
"math/big"
"reflect"
"strconv"
var (
textZero = []byte(`0x0`)
bytesT = reflect.TypeOf(Bytes(nil))
bigT
      = reflect.TypeOf((*Big)(nil))
uintT = reflect.TypeOf(Uint(0))
uint64T = reflect.TypeOf(Uint64(0))
)
// Bytes marshals/unmarshals as a JSON string with 0x prefix.
// The empty slice marshals as "0x".
type Bytes []byte
// MarshalText implements encoding.TextMarshaler
func (b Bytes) MarshalText() ([]byte, error) {
result := make([]byte, len(b)*2+2)
copy(result, `0x`)
hex.Encode(result[2:], b)
return result, nil
}
// UnmarshalJSON implements json.Unmarshaler.
func (b *Bytes) UnmarshalJSON(input []byte) error {
if !isString(input) {
return errNonString(bytesT)
}
```

```
return wrapTypeError(b.UnmarshalText(input[1:len(input)-1]), bytesT)
}
// UnmarshalText implements encoding.TextUnmarshaler.
func (b *Bytes) UnmarshalText(input []byte) error {
raw, err := checkText(input, true)
if err != nil {
return err
dec := make([]byte, len(raw)/2)
if _, err = hex.Decode(dec, raw); err != nil {
err = mapError(err)
} else {
*b = dec
return err
}
// String returns the hex encoding of b.
func (b Bytes) String() string {
return Encode(b)
}
// UnmarshalFixedJSON decodes the input as a string with 0x prefix. The length of out
// determines the required input length. This function is commonly used to implement the
// UnmarshalJSON method for fixed-size types.
func UnmarshalFixedJSON(typ reflect.Type, input, out []byte) error {
if !isString(input) {
return errNonString(typ)
return wrapTypeError(UnmarshalFixedText(typ.String(), input[1:len(input)-1], out), typ)
}
// UnmarshalFixedText decodes the input as a string with 0x prefix. The length of out
// determines the required input length. This function is commonly used to implement the
// UnmarshalText method for fixed-size types.
func UnmarshalFixedText(typname string, input, out []byte) error {
raw, err := checkText(input, true)
if err != nil {
return err
}
if len(raw)/2 != len(out) {
```

```
return fmt.Errorf("hex string has length %d, want %d for %s", len(raw), len(out)*2, typname)
}
// Pre-verify syntax before modifying out.
for , b := range raw {
if decodeNibble(b) == badNibble {
return ErrSyntax
}
}
hex.Decode(out, raw)
return nil
// UnmarshalFixedUnprefixedText decodes the input as a string with optional 0x prefix. The
// length of out determines the required input length. This function is commonly used to
// implement the UnmarshalText method for fixed-size types.
func UnmarshalFixedUnprefixedText(typname string, input, out []byte) error {
raw, err := checkText(input, false)
if err != nil {
return err
if len(raw)/2 != len(out) {
return fmt.Errorf("hex string has length %d, want %d for %s", len(raw), len(out)*2, typname)
}
// Pre-verify syntax before modifying out.
for _, b := range raw {
if decodeNibble(b) == badNibble {
return ErrSyntax
}
hex.Decode(out, raw)
return nil
}
// Big marshals/unmarshals as a JSON string with 0x prefix.
// The zero value marshals as "0x0".
//
// Negative integers are not supported at this time. Attempting to marshal them will
// return an error. Values larger than 256bits are rejected by Unmarshal but will be
// marshaled without error.
type Big big.Int
// MarshalText implements encoding.TextMarshaler
```

```
func (b Big) MarshalText() ([]byte, error) {
return []byte(EncodeBig((*big.Int)(&b))), nil
}
// UnmarshalJSON implements json.Unmarshaler.
func (b *Big) UnmarshalJSON(input []byte) error {
if !isString(input) {
return errNonString(bigT)
}
return wrapTypeError(b.UnmarshalText(input[1:len(input)-1]), bigT)
}
// UnmarshalText implements encoding.TextUnmarshaler
func (b *Big) UnmarshalText(input []byte) error {
raw, err := checkNumberText(input)
if err != nil {
return err
}
if len(raw) > 64 {
return ErrBig256Range
}
words := make([]big.Word, len(raw)/bigWordNibbles+1)
end := len(raw)
for i := range words {
start := end - bigWordNibbles
if start < 0 {
start = 0
}
for ri := start; ri < end; ri++ {
nib := decodeNibble(raw[ri])
if nib == badNibble {
return ErrSyntax
}
words[i] *= 16
words[i] += big.Word(nib)
}
end = start
}
var dec big.Int
dec.SetBits(words)
*b = (Big)(dec)
return nil
```

```
}
// Tolnt converts b to a big.Int.
func (b *Big) ToInt() *big.Int {
return (*big.Int)(b)
}
// String returns the hex encoding of b.
func (b *Big) String() string {
return EncodeBig(b.ToInt())
}
// Uint64 marshals/unmarshals as a JSON string with 0x prefix.
// The zero value marshals as "0x0".
type Uint64 uint64
// MarshalText implements encoding.TextMarshaler.
func (b Uint64) MarshalText() ([]byte, error) {
buf := make([]byte, 2, 10)
copy(buf, `0x`)
buf = strconv.AppendUint(buf, uint64(b), 16)
return buf, nil
}
// UnmarshalJSON implements json.Unmarshaler.
func (b *Uint64) UnmarshalJSON(input []byte) error {
if !isString(input) {
return errNonString(uint64T)
return wrapTypeError(b.UnmarshalText(input[1:len(input)-1]), uint64T)
}
// UnmarshalText implements encoding.TextUnmarshaler
func (b *Uint64) UnmarshalText(input []byte) error {
raw, err := checkNumberText(input)
if err != nil {
return err
}
if len(raw) > 16 {
return ErrUint64Range
}
var dec uint64
```

```
for _, byte := range raw {
nib := decodeNibble(byte)
if nib == badNibble {
return ErrSyntax
}
dec *= 16
dec += uint64(nib)
*b = Uint64(dec)
return nil
}
// String returns the hex encoding of b.
func (b Uint64) String() string {
return EncodeUint64(uint64(b))
}
// Uint marshals/unmarshals as a JSON string with 0x prefix.
// The zero value marshals as "0x0".
type Uint uint
// MarshalText implements encoding.TextMarshaler.
func (b Uint) MarshalText() ([]byte, error) {
return Uint64(b).MarshalText()
}
// UnmarshalJSON implements json.Unmarshaler.
func (b *Uint) UnmarshalJSON(input []byte) error {
if !isString(input) {
return errNonString(uintT)
}
return wrapTypeError(b.UnmarshalText(input[1:len(input)-1]), uintT)
}
// UnmarshalText implements encoding.TextUnmarshaler.
func (b *Uint) UnmarshalText(input []byte) error {
var u64 Uint64
err := u64.UnmarshalText(input)
if u64 > Uint64(\(^uint(0))\) || err == ErrUint64Range {
return ErrUintRange
} else if err != nil {
return err
```

```
}
*b = Uint(u64)
return nil
}
// String returns the hex encoding of b.
func (b Uint) String() string {
return EncodeUint64(uint64(b))
}
func isString(input []byte) bool {
return len(input) >= 2 && input[0] == "" && input[len(input)-1] == ""
}
func bytesHave0xPrefix(input []byte) bool {
return len(input) >= 2 && input[0] == '0' && (input[1] == 'x' || input[1] == 'X')
}
func checkText(input []byte, wantPrefix bool) ([]byte, error) {
if len(input) == 0 {
return nil, nil // empty strings are allowed
}
if bytesHave0xPrefix(input) {
input = input[2:]
} else if wantPrefix {
return nil, ErrMissingPrefix
}
if len(input)%2 != 0 {
return nil, ErrOddLength
return input, nil
}
func checkNumberText(input []byte) (raw []byte, err error) {
if len(input) == 0 {
return nil, nil // empty strings are allowed
}
if !bytesHave0xPrefix(input) {
return nil, ErrMissingPrefix
}
input = input[2:]
if len(input) == 0 {
```

```
return nil, ErrEmptyNumber
if len(input) > 1 && input[0] == '0' {
return nil, ErrLeadingZero
}
return input, nil
}
func wrapTypeError(err error, typ reflect.Type) error {
if _, ok := err.(*decError); ok {
return &json.UnmarshalTypeError{Value: err.Error(), Type: typ}
}
return err
}
func errNonString(typ reflect.Type) error {
return &json.UnmarshalTypeError{Value: "non-string", Type: typ}
}
3:F:\git\coin\ethereum\go-ethereum\common\hexutil\json_example_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package hexutil_test
import (
"encoding/json"
"fmt"
"github.com/ethereum/go-ethereum/common/hexutil"
)
type MyType [5]byte
func (v *MyType) UnmarshalText(input []byte) error {
return hexutil.UnmarshalFixedText("MyType", input, v[:])
}
func (v MyType) String() string {
return hexutil.Bytes(v[:]).String()
}
func ExampleUnmarshalFixedText() {
```

```
var v1, v2 MyType
fmt.Println("v1 error:", json.Unmarshal([]byte(`"0x01"`), &v1))
fmt.Println("v2 error:", json.Unmarshal([]byte(`"0x0101010101"`), &v2))
fmt.Println("v2:", v2)
// Output:
// v1 error: hex string has length 2, want 10 for MyType
// v2 error: <nil>
// v2: 0x0101010101
}
4:F:\git\coin\ethereum\go-ethereum\common\hexutil\json_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package hexutil
import (
"bytes"
"encoding/hex"
"encoding/json"
"errors"
"math/big"
"testing"
)
func checkError(t *testing.T, input string, got, want error) bool {
if got == nil {
if want != nil {
t.Errorf("input %s: got no error, want %q", input, want)
return false
}
return true
}
if want == nil {
t.Errorf("input %s: unexpected error %q", input, got)
} else if got.Error() != want.Error() {
t.Errorf("input %s: got error %q, want %q", input, got, want)
}
return false
}
func referenceBig(s string) *big.Int {
b, ok := new(big.Int).SetString(s, 16)
```

```
if !ok {
panic("invalid")
}
return b
}
func referenceBytes(s string) []byte {
b, err := hex.DecodeString(s)
if err != nil {
panic(err)
}
return b
}
var errJSONEOF = errors.New("unexpected end of JSON input")
var unmarshalBytesTests = []unmarshalTest{
// invalid encoding
{input: "", wantErr: errJSONEOF},
{input: "null", wantErr: errNonString(bytesT)},
{input: "10", wantErr: errNonString(bytesT)},
{input: `"0"`, wantErr: wrapTypeError(ErrMissingPrefix, bytesT)},
{input: `"0x0"`, wantErr: wrapTypeError(ErrOddLength, bytesT)},
{input: `"0xxx"`, wantErr: wrapTypeError(ErrSyntax, bytesT)},
{input: `"0x01zz01"`, wantErr: wrapTypeError(ErrSyntax, bytesT)},
// valid encoding
{input: `""`, want: referenceBytes("")},
{input: `"0x"`, want: referenceBytes("")},
{input: `"0x02"`, want: referenceBytes("02")},
{input: `"0X02"`, want: referenceBytes("02")},
{input: `"0xfffffffff"`, want: referenceBytes("fffffffff")},
{
},
}
func TestUnmarshalBytes(t *testing.T) {
for _, test := range unmarshalBytesTests {
var v Bytes
err := json.Unmarshal([]byte(test.input), &v)
```

```
if !checkError(t, test.input, err, test.wantErr) {
continue
}
if !bytes.Equal(test.want.([]byte), []byte(v)) {
t.Errorf("input %s: value mismatch: got %x, want %x", test.input, &v, test.want)
continue
}
}
}
func BenchmarkUnmarshalBytes(b *testing.B) {
input := []byte(`"0x123456789abcdef123456789abcdef"`)
for i := 0; i < b.N; i++ \{
var v Bytes
if err := v.UnmarshalJSON(input); err != nil {
b.Fatal(err)
}
}
}
func TestMarshalBytes(t *testing.T) {
for _, test := range encodeBytesTests {
in := test.input.([]byte)
out, err := json.Marshal(Bytes(in))
if err != nil {
t.Errorf("%x: %v", in, err)
continue
}
if want := "" + test.want + "; string(out) != want {
t.Errorf("%x: MarshalJSON output mismatch: got %q, want %q", in, out, want)
continue
}
if out := Bytes(in).String(); out != test.want {
t.Errorf("%x: String mismatch: got %g, want %g", in, out, test.want)
continue
}
}
}
var unmarshalBigTests = []unmarshalTest{
// invalid encoding
{input: "", wantErr: errJSONEOF},
```

```
{input: "null", wantErr: errNonString(bigT)},
{input: "10", wantErr: errNonString(bigT)},
{input: `"0"`, wantErr: wrapTypeError(ErrMissingPrefix, bigT)},
{input: `"0x"`, wantErr: wrapTypeError(ErrEmptyNumber, bigT)},
{input: `"0x01"`, wantErr: wrapTypeError(ErrLeadingZero, bigT)},
{input: `"0xx"`, wantErr: wrapTypeError(ErrSyntax, bigT)},
{input: `"0x1zz01"`, wantErr: wrapTypeError(ErrSyntax, bigT)},
{
wantErr: wrapTypeError(ErrBig256Range, bigT),
},
// valid encoding
{input: `""`, want: big.NewInt(0)},
{input: `"0x0"`, want: big.NewInt(0)},
{input: `"0x2"`, want: big.NewInt(0x2)},
{input: `"0x2F2"`, want: big.NewInt(0x2f2)},
{input: `"0X2F2"`, want: big.NewInt(0x2f2)},
{input: `"0x1122aaff"`, want: big.NewInt(0x1122aaff)},
{input: `"0xbBb"`, want: big.NewInt(0xbbb)},
{input: `"0xffffffff"`, want: big.NewInt(0xffffffff)},
{
input: `"0x112233445566778899aabbccddeeff"`,
want: referenceBig("112233445566778899aabbccddeeff"),
},
{
},
{
},
}
func TestUnmarshalBig(t *testing.T) {
for _, test := range unmarshalBigTests {
var v Big
err := json.Unmarshal([]byte(test.input), &v)
if !checkError(t, test.input, err, test.wantErr) {
continue
}
```

```
if test.want != nil && test.want.(*big.Int).Cmp((*big.Int)(&v)) != 0 {
t.Errorf("input %s: value mismatch: got %x, want %x", test.input, (*big.Int)(&v), test.want)
continue
}
}
}
func BenchmarkUnmarshalBig(b *testing.B) {
input := []byte(`"0x123456789abcdef123456789abcdef"`)
for i := 0; i < b.N; i++ \{
var v Big
if err := v.UnmarshalJSON(input); err != nil {
b.Fatal(err)
}
}
}
func TestMarshalBig(t *testing.T) {
for _, test := range encodeBigTests {
in := test.input.(*big.Int)
out, err := json.Marshal((*Big)(in))
if err != nil {
t.Errorf("%d: %v", in, err)
continue
}
if want := "" + test.want + "; string(out) != want {
t.Errorf("%d: MarshalJSON output mismatch: got %q, want %q", in, out, want)
continue
if out := (*Big)(in).String(); out != test.want {
t.Errorf("%x: String mismatch: got %q, want %q", in, out, test.want)
continue
}
}
}
var unmarshalUint64Tests = []unmarshalTest{
// invalid encoding
{input: "", wantErr: errJSONEOF},
{input: "null", wantErr: errNonString(uint64T)},
{input: "10", wantErr: errNonString(uint64T)},
{input: `"0"`, wantErr: wrapTypeError(ErrMissingPrefix, uint64T)},
```

```
{input: `"0x"`, wantErr: wrapTypeError(ErrEmptyNumber, uint64T)},
{input: `"0x01"`, wantErr: wrapTypeError(ErrLeadingZero, uint64T)},
{input: `"0xffffffffffff"`, wantErr: wrapTypeError(ErrUint64Range, uint64T)},
{input: `"0xx"`, wantErr: wrapTypeError(ErrSyntax, uint64T)},
{input: `"0x1zz01"`, wantErr: wrapTypeError(ErrSyntax, uint64T)},
// valid encoding
{input: `""`, want: uint64(0)},
{input: `"0x0"`, want: uint64(0)},
{input: `"0x2"`, want: uint64(0x2)},
{input: `"0x2F2"`, want: uint64(0x2f2)},
{input: `"0X2F2"`, want: uint64(0x2f2)},
{input: `"0x1122aaff"`, want: uint64(0x1122aaff)},
{input: `"0xbbb"`, want: uint64(0xbbb)},
{input: `"0xfffffffffff"`, want: uint64(0xffffffffffff)},
}
func TestUnmarshalUint64(t *testing.T) {
for _, test := range unmarshalUint64Tests {
var v Uint64
err := json.Unmarshal([]byte(test.input), &v)
if !checkError(t, test.input, err, test.wantErr) {
continue
if uint64(v) != test.want.(uint64) {
t.Errorf("input %s: value mismatch: got %d, want %d", test.input, v, test.want)
continue
}
}
}
func BenchmarkUnmarshalUint64(b *testing.B) {
input := []byte(`"0x123456789abcdf"`)
for i := 0; i < b.N; i++ \{
var v Uint64
v.UnmarshalJSON(input)
}
}
func TestMarshalUint64(t *testing.T) {
for _, test := range encodeUint64Tests {
in := test.input.(uint64)
```

```
out, err := json.Marshal(Uint64(in))
if err != nil {
t.Errorf("%d: %v", in, err)
continue
}
if want := `"` + test.want + `"`; string(out) != want {
t.Errorf("%d: MarshalJSON output mismatch: got %q, want %q", in, out, want)
continue
}
if out := (Uint64)(in).String(); out != test.want {
t.Errorf("%x: String mismatch: got %q, want %q", in, out, test.want)
continue
}
}
}
func TestMarshalUint(t *testing.T) {
for _, test := range encodeUintTests {
in := test.input.(uint)
out, err := json.Marshal(Uint(in))
if err != nil {
t.Errorf("%d: %v", in, err)
continue
}
if want := `"` + test.want + `"`; string(out) != want {
t.Errorf("%d: MarshalJSON output mismatch: got %q, want %q", in, out, want)
continue
}
if out := (Uint)(in).String(); out != test.want {
t.Errorf("%x: String mismatch: got %q, want %q", in, out, test.want)
continue
}
}
}
var (
// These are variables (not constants) to avoid constant overflow
// checks in the compiler on 32bit platforms.
maxUint33bits = uint64(^uint32(0)) + 1
maxUint64bits = ^uint64(0)
)
```

```
var unmarshalUintTests = []unmarshalTest{
// invalid encoding
{input: "", wantErr: errJSONEOF},
{input: "null", wantErr: errNonString(uintT)},
{input: "10", wantErr: errNonString(uintT)},
{input: `"0"`, wantErr: wrapTypeError(ErrMissingPrefix, uintT)},
{input: `"0x"`, wantErr: wrapTypeError(ErrEmptyNumber, uintT)},
{input: `"0x01"`, wantErr: wrapTypeError(ErrLeadingZero, uintT)},
{input: `"0x100000000"`, want: uint(maxUint33bits), wantErr32bit: wrapTypeError(ErrUintRange,
uintT)},
{input: `"0xfffffffffffff"`, wantErr: wrapTypeError(ErrUintRange, uintT)},
{input: `"0xx"`, wantErr: wrapTypeError(ErrSyntax, uintT)},
{input: `"0x1zz01"`, wantErr: wrapTypeError(ErrSyntax, uintT)},
// valid encoding
{input: `""`, want: uint(0)},
{input: `"0x0"`, want: uint(0)},
{input: `"0x2"`, want: uint(0x2)},
{input: `"0x2F2"`, want: uint(0x2f2)},
{input: `"0X2F2"`, want: uint(0x2f2)},
{input: `"0x1122aaff"`, want: uint(0x1122aaff)},
{input: `"0xbbb"`, want: uint(0xbbb)},
{input: `"0xffffffff"`, want: uint(0xffffffff)},
{input: `"0xffffffffffff"`, want: uint(maxUint64bits), wantErr32bit: wrapTypeError(ErrUintRange,
uintT)},
}
func TestUnmarshalUint(t *testing.T) {
for , test := range unmarshalUintTests {
var v Uint
err := json.Unmarshal([]byte(test.input), &v)
if uintBits == 32 && test.wantErr32bit != nil {
checkError(t, test.input, err, test.wantErr32bit)
continue
}
if !checkError(t, test.input, err, test.wantErr) {
continue
}
if uint(v) != test.want.(uint) {
t.Errorf("input %s: value mismatch: got %d, want %d", test.input, v, test.want)
continue
}
```

```
}
}
func TestUnmarshalFixedUnprefixedText(t *testing.T) {
tests := []struct {
input string
want []byte
wantErr error
}{
{input: "0x2", wantErr: ErrOddLength},
{input: "2", wantErr: ErrOddLength},
{input: "4444", wantErr: errors.New("hex string has length 4, want 8 for x")},
{input: "4444", wantErr: errors.New("hex string has length 4, want 8 for x")},
// check that output is not modified for partially correct input
{input: "444444gg", wantErr: ErrSyntax, want: []byte{0, 0, 0, 0}},
{input: "0x444444gg", wantErr: ErrSyntax, want: []byte{0, 0, 0, 0}},
// valid inputs
{input: "44444444", want: []byte{0x44, 0x44, 0x44, 0x44}},
{input: "0x44444444", want: []byte{0x44, 0x44, 0x44, 0x44}},
}
for _, test := range tests {
out := make([]byte, 4)
err := UnmarshalFixedUnprefixedText("x", []byte(test.input), out)
switch {
case err == nil && test.wantErr != nil:
t.Errorf("%q: got no error, expected %q", test.input, test.wantErr)
case err != nil && test.wantErr == nil:
t.Errorf("%g: unexpected error %g", test.input, err)
case err != nil && err.Error() != test.wantErr.Error():
t.Errorf("%q: error mismatch: got %q, want %q", test.input, err, test.wantErr)
}
if test.want != nil && !bytes.Equal(out, test.want) {
t.Errorf("%q: output mismatch: got %x, want %x", test.input, out, test.want)
}
}
}
5:F:\git\coin\ethereum\go-ethereum\common\main_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package common
```

```
import (
"testing"
checker "gopkg.in/check.v1"
)
func Test(t *testing.T) { checker.TestingT(t) }
6:F:\git\coin\ethereum\go-ethereum\common\math\big.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package math provides integer math utilities.
package math
import (
"fmt"
"math/big"
var (
tt255 = BigPow(2, 255)
tt256 = BigPow(2, 256)
tt256m1 = new(big.Int).Sub(tt256, big.NewInt(1))
MaxBig256 = new(big.Int).Set(tt256m1)
tt63
       = BigPow(2, 63)
MaxBig63 = new(big.Int).Sub(tt63, big.NewInt(1))
)
const (
// number of bits in a big.Word
wordBits = 32 \ll (uint64(^big.Word(0)) >> 63)
// number of bytes in a big.Word
wordBytes = wordBits / 8
)
// HexOrDecimal256 marshals big.Int as hex or decimal.
type HexOrDecimal256 big.Int
// UnmarshalText implements encoding.TextUnmarshaler.
func (i *HexOrDecimal256) UnmarshalText(input []byte) error {
bigint, ok := ParseBig256(string(input))
```

```
if !ok {
return fmt.Errorf("invalid hex or decimal integer %q", input)
*i = HexOrDecimal256(*bigint)
return nil
}
// MarshalText implements encoding.TextMarshaler.
func (i *HexOrDecimal256) MarshalText() ([]byte, error) {
if i == nil \{
return []byte("0x0"), nil
}
return []byte(fmt.Sprintf("%#x", (*big.Int)(i))), nil
}
// ParseBig256 parses s as a 256 bit integer in decimal or hexadecimal syntax.
// Leading zeros are accepted. The empty string parses as zero.
func ParseBig256(s string) (*big.Int, bool) {
if s == "" {
return new(big.Int), true
}
var bigint *big.Int
var ok bool
if len(s) >= 2 \&\& (s[:2] == "0x" || s[:2] == "0X") {
bigint, ok = new(big.Int).SetString(s[2:], 16)
} else {
bigint, ok = new(big.Int).SetString(s, 10)
}
if ok && bigint.BitLen() > 256 {
bigint, ok = nil, false
}
return bigint, ok
}
// MustParseBig parses s as a 256 bit big integer and panics if the string is invalid.
func MustParseBig256(s string) *big.Int {
v, ok := ParseBig256(s)
if !ok {
panic("invalid 256 bit integer: " + s)
return v
}
```

```
// BigPow returns a ** b as a big integer.
func BigPow(a, b int64) *big.Int {
r := big.NewInt(a)
return r.Exp(r, big.NewInt(b), nil)
}
// BigMax returns the larger of x or y.
func BigMax(x, y *big.Int) *big.Int {
if x.Cmp(y) < 0 {
return y
}
return x
}
// BigMin returns the smaller of x or y.
func BigMin(x, y *big.Int) *big.Int {
if x.Cmp(y) > 0 {
return y
}
return x
}
// FirstBitSet returns the index of the first 1 bit in v, counting from LSB.
func FirstBitSet(v *big.Int) int {
for i := 0; i < v.BitLen(); i++ {
if v.Bit(i) > 0 {
return i
}
return v.BitLen()
}
// PaddedBigBytes encodes a big integer as a big-endian byte slice. The length
// of the slice is at least n bytes.
func PaddedBigBytes(bigint *big.Int, n int) []byte {
if bigint.BitLen()/8 >= n {
return bigint.Bytes()
ret := make([]byte, n)
ReadBits(bigint, ret)
return ret
```

```
// bigEndianByteAt returns the byte at position n,
// in Big-Endian encoding
// So n==0 returns the least significant byte
func bigEndianByteAt(bigint *big.Int, n int) byte {
words := bigint.Bits()
// Check word-bucket the byte will reside in
i := n / wordBytes
if i \ge len(words) {
return byte(0)
}
word := words[i]
// Offset of the byte
shift := 8 * uint(n%wordBytes)
return byte(word >> shift)
}
// Byte returns the byte at position n,
// with the supplied padlength in Little-Endian encoding.
// n==0 returns the MSB
// Example: bigint '5', padlength 32, n=31 => 5
func Byte(bigint *big.Int, padlength, n int) byte {
if n >= padlength {
return byte(0)
}
return bigEndianByteAt(bigint, padlength-1-n)
}
// ReadBits encodes the absolute value of bigint as big-endian bytes. Callers must ensure
// that buf has enough space. If buf is too short the result will be incomplete.
func ReadBits(bigint *big.Int, buf []byte) {
i := len(buf)
for _, d := range bigint.Bits() {
for j := 0; j < wordBytes && <math>i > 0; j++ {
i--
buf[i] = byte(d)
d >>= 8
}
}
}
```

}

```
// U256 encodes as a 256 bit two's complement number. This operation is destructive.
func U256(x *big.Int) *big.Int {
return x.And(x, tt256m1)
}
// S256 interprets x as a two's complement number.
// x must not exceed 256 bits (the result is undefined if it does) and is not modified.
//
// S256(0)
              = 0
// S256(1)
                = 1
// S256(2**255) = -2**255
// S256(2**256-1) = -1
func S256(x *big.Int) *big.Int {
if x.Cmp(tt255) < 0 {
return x
} else {
return new(big.Int).Sub(x, tt256)
}
// Exp implements exponentiation by squaring.
// Exp returns a newly-allocated big integer and does not change
// base or exponent. The result is truncated to 256 bits.
//
// Courtesy @karalabe and @chfast
func Exp(base, exponent *big.Int) *big.Int {
result := big.NewInt(1)
for _, word := range exponent.Bits() {
for i := 0; i < wordBits; i++ \{
if word&1 == 1 {
U256(result.Mul(result, base))
U256(base.Mul(base, base))
word >>= 1
}
}
return result
```

```
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package math
import (
"bytes"
"encoding/hex"
"math/big"
"testing"
"github.com/ethereum/go-ethereum/common"
)
func TestHexOrDecimal256(t *testing.T) {
tests := []struct {
input string
num *big.Int
ok bool
}{
{"", big.NewInt(0), true},
{"0", big.NewInt(0), true},
{"0x0", big.NewInt(0), true},
{"12345678", big.NewInt(12345678), true},
{"0x12345678", big.NewInt(0x12345678), true},
{"0X12345678", big.NewInt(0x12345678), true},
// Tests for leading zero behaviour:
{"0123456789", big.NewInt(123456789), true}, // note: not octal
{"00", big.NewInt(0), true},
{"0x00", big.NewInt(0), true},
{"0x012345678abc", big.NewInt(0x12345678abc), true},
// Invalid syntax:
{"abcdef", nil, false},
{"0xgg", nil, false},
// Larger than 256 bits:
{"11579208923731619542357098500868790785326998466564056403945758400791312963993
6", nil, false},
}
for _, test := range tests {
var num HexOrDecimal256
err := num.UnmarshalText([]byte(test.input))
if (err == nil) != test.ok {
t.Errorf("ParseBig(%q) -> (err == nil) == %t, want %t", test.input, err == nil, test.ok)
```

```
continue
}
if test.num != nil && (*big.Int)(&num).Cmp(test.num) != 0 {
t.Errorf("ParseBig(%q) -> %d, want %d", test.input, (*big.Int)(&num), test.num)
}
}
}
func TestMustParseBig256(t *testing.T) {
defer func() {
if recover() == nil {
t.Error("MustParseBig should've panicked")
}
}()
MustParseBig256("ggg")
}
func TestBigMax(t *testing.T) {
a := big.NewInt(10)
b := big.NewInt(5)
max1 := BigMax(a, b)
if max1 != a {
t.Errorf("Expected %d got %d", a, max1)
max2 := BigMax(b, a)
if max2 != a {
t.Errorf("Expected %d got %d", a, max2)
}
}
func TestBigMin(t *testing.T) {
a := big.NewInt(10)
b := big.NewInt(5)
min1 := BigMin(a, b)
if min1 != b {
t.Errorf("Expected %d got %d", b, min1)
}
min2 := BigMin(b, a)
```

```
if min2 != b {
t.Errorf("Expected %d got %d", b, min2)
}
}
func TestFirstBigSet(t *testing.T) {
tests := []struct {
num *big.Int
ix int
}{
{big.NewInt(0), 0},
{big.NewInt(1), 0},
{big.NewInt(2), 1},
{big.NewInt(0x100), 8},
}
for _, test := range tests {
if ix := FirstBitSet(test.num); ix != test.ix {
t.Errorf("FirstBitSet(b%b) = %d, want %d", test.num, ix, test.ix)
}
}
}
func TestPaddedBigBytes(t *testing.T) {
tests := []struct {
num *big.Int
     int
result []byte
}{
{num: big.NewInt(0), n: 4, result: []byte{0, 0, 0, 0}},
{num: big.NewInt(1), n: 4, result: []byte{0, 0, 0, 1}},
{num: big.NewInt(512), n: 4, result: []byte{0, 0, 2, 0}},
{num: BigPow(2, 32), n: 4, result: []byte{1, 0, 0, 0, 0}},
}
for _, test := range tests {
if result := PaddedBigBytes(test.num, test.n); !bytes.Equal(result, test.result) {
t.Errorf("PaddedBigBytes(%d, %d) = %v, want %v", test.num, test.n, result, test.result)
}
}
}
func BenchmarkPaddedBigBytesLargePadding(b *testing.B) {
bigint := MustParseBig256("123456789123456789123456789")
```

```
for i := 0; i < b.N; i++ \{
PaddedBigBytes(bigint, 200)
}
}
func BenchmarkPaddedBigBytesSmallPadding(b *testing.B) {
bigint :=
MustParseBig256("0x18F8F8F100011100011001110022200433005230000000000000000FEFC
F3CC")
for i := 0; i < b.N; i++ \{
PaddedBigBytes(bigint, 5)
}
}
func BenchmarkPaddedBigBytesSmallOnePadding(b *testing.B) {
bigint :=
MustParseBig256("0x18F8F8F100011100011001110022200433005230000000000000000FEFC
F3CC")
for i := 0; i < b.N; i++ \{
PaddedBigBytes(bigint, 32)
}
}
func BenchmarkByteAtBrandNew(b *testing.B) {
bigint :=
MustParseBig256("0x18F8F8F100011100011001110022200433005230000000000000000FEFC
F3CC")
for i := 0; i < b.N; i++ \{
bigEndianByteAt(bigint, 15)
}
}
func BenchmarkByteAt(b *testing.B) {
bigint :=
MustParseBig256("0x18F8F8F100011100011001110022200433005230000000000000000FEFC
F3CC")
for i := 0; i < b.N; i++ \{
bigEndianByteAt(bigint, 15)
}
}
func BenchmarkByteAtOld(b *testing.B) {
```

```
bigint :=
MustParseBig256("0x18F8F8F100011100011001110022200433005230000000000000000FEFC
F3CC")
for i := 0; i < b.N; i++ \{
PaddedBigBytes(bigint, 32)
}
}
func TestReadBits(t *testing.T) {
check := func(input string) {
want, _ := hex.DecodeString(input)
int, _ := new(big.Int).SetString(input, 16)
buf := make([]byte, len(want))
ReadBits(int, buf)
if !bytes.Equal(buf, want) {
t.Errorf("have: %x\nwant: %x", buf, want)
}
}
check("18F8F8F1000111000110011100222004330052300000000000000000FEFCF3F8F0")
}
func TestU256(t *testing.T) {
tests := []struct{ x, y *big.Int }{
{x: big.NewInt(0), y: big.NewInt(0)},
{x: big.NewInt(1), y: big.NewInt(1)},
{x: BigPow(2, 255), y: BigPow(2, 255)},
{x: BigPow(2, 256), y: big.NewInt(0)},
{x: new(big.Int).Add(BigPow(2, 256), big.NewInt(1)), y: big.NewInt(1)},
// negative values
{x: big.NewInt(-1), y: new(big.Int).Sub(BigPow(2, 256), big.NewInt(1))},
{x: big.NewInt(-2), y: new(big.Int).Sub(BigPow(2, 256), big.NewInt(2))},
{x: BigPow(2, -255), y: big.NewInt(1)},
}
for _, test := range tests {
if y := U256(new(big.Int).Set(test.x)); y.Cmp(test.y) != 0 {
t.Errorf("U256(%x) = %x, want %x", test.x, y, test.y)
}
}
}
```

```
func TestBigEndianByteAt(t *testing.T) {
tests := []struct {
x string
y int
exp byte
}{
{"00", 0, 0x00},
{"01", 1, 0x00},
{"00", 1, 0x00},
{"01", 0, 0x01},
}
for _, test := range tests {
v := new(big.Int).SetBytes(common.Hex2Bytes(test.x))
actual := bigEndianByteAt(v, test.y)
if actual != test.exp {
t.Fatalf("Expected [%v] %v:th byte to be %v, was %v.", test.x, test.y, test.exp, actual)
}
}
func TestLittleEndianByteAt(t *testing.T) {
tests := []struct {
x string
y int
exp byte
}{
{"00", 0, 0x00},
{"01", 1, 0x00},
{"00", 1, 0x00},
{"01", 0, 0x00},
```

```
}
for _, test := range tests {
v := new(big.Int).SetBytes(common.Hex2Bytes(test.x))
actual := Byte(v, 32, test.y)
if actual != test.exp {
t.Fatalf("Expected [%v] %v:th byte to be %v, was %v.", test.x, test.y, test.exp, actual)
}
}
}
func TestS256(t *testing.T) {
tests := []struct{ x, y *big.Int }{
{x: big.NewInt(0), y: big.NewInt(0)},
{x: big.NewInt(1), y: big.NewInt(1)},
{x: big.NewInt(2), y: big.NewInt(2)},
x: new(big.Int).Sub(BigPow(2, 255), big.NewInt(1)),
y: new(big.Int).Sub(BigPow(2, 255), big.NewInt(1)),
},
{
x: BigPow(2, 255),
y: new(big.Int).Neg(BigPow(2, 255)),
},
{
x: new(big.Int).Sub(BigPow(2, 256), big.NewInt(1)),
y: big.NewInt(-1),
},
{
x: new(big.Int).Sub(BigPow(2, 256), big.NewInt(2)),
y: big.NewInt(-2),
},
}
for _, test := range tests {
if y := S256(test.x); y.Cmp(test.y) != 0 {
```

```
t.Errorf("S256(%x) = %x, want %x", test.x, y, test.y)
}
}
}
func TestExp(t *testing.T) {
tests := []struct{ base, exponent, result *big.Int }{
{base: big.NewInt(0), exponent: big.NewInt(0), result: big.NewInt(1)},
{base: big.NewInt(1), exponent: big.NewInt(0), result: big.NewInt(1)},
{base: big.NewInt(1), exponent: big.NewInt(1), result: big.NewInt(1)},
{base: big.NewInt(1), exponent: big.NewInt(2), result: big.NewInt(1)},
{base: big.NewInt(3), exponent: big.NewInt(144), result:
MustParseBig256("50752878605641560071975415974169635690874225019166388726362744
2114881")},
{base: big.NewInt(2), exponent: big.NewInt(255), result:
MustParseBig256("57896044618658097711785492504343953926634992332820282019728792
003956564819968")},
}
for _, test := range tests {
if result := Exp(test.base, test.exponent); result.Cmp(test.result) != 0 {
t.Errorf("Exp(%d, %d) = %d, want %d", test.base, test.exponent, result, test.result)
}
}
}
8:F:\git\coin\ethereum\go-ethereum\common\math\integer.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package math
import (
"fmt"
"strconv"
const (
// Integer limit values.
MaxInt8 = 1 < 7 - 1
MinInt8 = -1 << 7
MaxInt16 = 1 << 15 - 1
MinInt16 = -1 << 15
MaxInt32 = 1 << 31 - 1
```

```
MinInt32 = -1 << 31
MaxInt64 = 1 << 63 - 1
MinInt64 = -1 << 63
MaxUint8 = 1 << 8 - 1
MaxUint16 = 1 << 16 - 1
MaxUint32 = 1 << 32 - 1
MaxUint64 = 1 << 64 - 1
)
// HexOrDecimal64 marshals uint64 as hex or decimal.
type HexOrDecimal64 uint64
// UnmarshalText implements encoding.TextUnmarshaler.
func (i *HexOrDecimal64) UnmarshalText(input []byte) error {
int, ok := ParseUint64(string(input))
if !ok {
return fmt.Errorf("invalid hex or decimal integer %q", input)
}
*i = HexOrDecimal64(int)
return nil
}
// MarshalText implements encoding.TextMarshaler.
func (i HexOrDecimal64) MarshalText() ([]byte, error) {
return []byte(fmt.Sprintf("%#x", uint64(i))), nil
}
// ParseUint64 parses s as an integer in decimal or hexadecimal syntax.
// Leading zeros are accepted. The empty string parses as zero.
func ParseUint64(s string) (uint64, bool) {
if s == "" {
return 0, true
}
if len(s) >= 2 \&\& (s[:2] == "0x" || s[:2] == "0X") {
v, err := strconv.ParseUint(s[2:], 16, 64)
return v, err == nil
}
v, err := strconv.ParseUint(s, 10, 64)
return v, err == nil
}
```

// MustParseUint64 parses s as an integer and panics if the string is invalid.

```
func MustParseUint64(s string) uint64 {
v, ok := ParseUint64(s)
if !ok {
panic("invalid unsigned 64 bit integer: " + s)
}
return v
}
// NOTE: The following methods need to be optimised using either bit checking or asm
// SafeSub returns subtraction result and whether overflow occurred.
func SafeSub(x, y uint64) (uint64, bool) {
return x - y, x < y
}
// SafeAdd returns the result and whether overflow occurred.
func SafeAdd(x, y uint64) (uint64, bool) {
return x + y, y > MaxUint64-x
}
// SafeMul returns multiplication result and whether overflow occurred.
func SafeMul(x, y uint64) (uint64, bool) {
if x == 0 || y == 0 {
return 0, false
return x * y, y > MaxUint64/x
}
9:F:\git\coin\ethereum\go-ethereum\common\math\integer_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package math
import (
"testing"
)
type operation byte
const (
sub operation = iota
add
```

```
mul
)
func TestOverflow(t *testing.T) {
for i, test := range []struct {
      uint64
      uint64
У
overflow bool
op
       operation
}{
// add operations
{MaxUint64, 1, true, add},
{MaxUint64 - 1, 1, false, add},
// sub operations
{0, 1, true, sub},
{0, 0, false, sub},
// mul operations
{0, 0, false, mul},
{10, 10, false, mul},
{MaxUint64, 2, true, mul},
{MaxUint64, 1, false, mul},
} {
var overflows bool
switch test.op {
case sub:
_, overflows = SafeSub(test.x, test.y)
case add:
_, overflows = SafeAdd(test.x, test.y)
case mul:
_, overflows = SafeMul(test.x, test.y)
}
if test.overflow != overflows {
t.Errorf("%d failed. Expected test to be %v, got %v", i, test.overflow, overflows)
}
}
}
func TestHexOrDecimal64(t *testing.T) {
tests := []struct {
```

```
input string
num uint64
ok bool
}{
{"", 0, true},
{"0", 0, true},
{"0x0", 0, true},
{"12345678", 12345678, true},
{"0x12345678", 0x12345678, true},
{"0X12345678", 0x12345678, true},
// Tests for leading zero behaviour:
{"0123456789", 123456789, true}, // note: not octal
{"0x00", 0, true},
{"0x012345678abc", 0x12345678abc, true},
// Invalid syntax:
{"abcdef", 0, false},
{"0xgg", 0, false},
// Doesn't fit into 64 bits:
{"18446744073709551617", 0, false},
}
for _, test := range tests {
var num HexOrDecimal64
err := num.UnmarshalText([]byte(test.input))
if (err == nil) != test.ok {
t.Errorf("ParseUint64(%q) -> (err == nil) = %t, want %t", test.input, err == nil, test.ok)
continue
}
if err == nil && uint64(num) != test.num {
t.Errorf("ParseUint64(%q) -> %d, want %d", test.input, num, test.num)
}
}
}
func TestMustParseUint64(t *testing.T) {
if v := MustParseUint64("12345"); v != 12345 {
t.Errorf(`MustParseUint64("12345") = %d, want 12345`, v)
}
}
func TestMustParseUint64Panic(t *testing.T) {
defer func() {
if recover() == nil {
```

```
t.Error("MustParseBig should've panicked")
}
}()
MustParseUint64("ggg")
}
10:F:\git\coin\ethereum\go-ethereum\common\mclock\mclock.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// package mclock is a wrapper for a monotonic clock source
package mclock
import (
"time"
"github.com/aristanetworks/goarista/monotime"
)
type AbsTime time. Duration // absolute monotonic time
func Now() AbsTime {
return AbsTime(monotime.Now())
}
11:F:\git\coin\ethereum\go-ethereum\common\number\int.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package number
import (
"math/big"
"github.com/ethereum/go-ethereum/common"
)
var tt256 = new(big.Int).Lsh(big.NewInt(1), 256)
var tt256m1 = new(big.Int).Sub(new(big.Int).Lsh(big.NewInt(1), 256), big.NewInt(1))
var tt255 = new(big.Int).Lsh(big.NewInt(1), 255)
func limitUnsigned256(x *Number) *Number {
x.num.And(x.num, tt256m1)
return x
```

```
}
func limitSigned256(x *Number) *Number {
if x.num.Cmp(tt255) < 0 {
return x
} else {
x.num.Sub(x.num, tt256)
return x
}
// Number function
type Initialiser func(n int64) *Number
// A Number represents a generic integer with a bounding function limiter. Limit is called after each
operations
// to give "fake" bounded integers. New types of Number can be created through NewInitialiser
returning a lambda
// with the new Initialiser.
type Number struct {
num *big.Int
limit func(n *Number) *Number
}
// Returns a new initialiser for a new *Number without having to expose certain fields
func NewInitialiser(limiter func(*Number) *Number) Initialiser {
return func(n int64) *Number {
return &Number{big.NewInt(n), limiter}
}
// Return a Number with a UNSIGNED limiter up to 256 bits
func Uint256(n int64) *Number {
return &Number{big.NewInt(n), limitUnsigned256}
}
// Return a Number with a SIGNED limiter up to 256 bits
func Int256(n int64) *Number {
return &Number{big.NewInt(n), limitSigned256}
}
// Returns a Number with a SIGNED unlimited size
```

```
func Big(n int64) *Number {
return &Number{big.NewInt(n), func(x *Number) *Number { return x }}
}
// Sets i to sum of x+y
func (i *Number) Add(x, y *Number) *Number {
i.num.Add(x.num, y.num)
return i.limit(i)
}
// Sets i to difference of x-y
func (i *Number) Sub(x, y *Number) *Number {
i.num.Sub(x.num, y.num)
return i.limit(i)
}
// Sets i to product of x*y
func (i *Number) Mul(x, y *Number) *Number {
i.num.Mul(x.num, y.num)
return i.limit(i)
}
// Sets i to the quotient prodject of x/y
func (i *Number) Div(x, y *Number) *Number {
i.num.Div(x.num, y.num)
return i.limit(i)
}
// Sets i to x % y
func (i *Number) Mod(x, y *Number) *Number {
i.num.Mod(x.num, y.num)
return i.limit(i)
}
// Sets i to x << s
func (i *Number) Lsh(x *Number, s uint) *Number {
i.num.Lsh(x.num, s)
return i.limit(i)
}
// Sets i to x^y
func (i *Number) Pow(x, y *Number) *Number {
```

```
i.num.Exp(x.num, y.num, big.NewInt(0))
return i.limit(i)
}
// Setters
// Set x to i
func (i *Number) Set(x *Number) *Number {
i.num.Set(x.num)
return i.limit(i)
}
// Set x bytes to i
func (i *Number) SetBytes(x []byte) *Number {
i.num.SetBytes(x)
return i.limit(i)
}
// Cmp compares x and y and returns:
//
   -1 if x < y
// 0 if x == y
    +1 \text{ if } x > y
func (i *Number) Cmp(x *Number) int {
return i.num.Cmp(x.num)
}
// Getters
// Returns the string representation of i
func (i *Number) String() string {
return i.num.String()
}
// Returns the byte representation of i
func (i *Number) Bytes() []byte {
return i.num.Bytes()
}
// Uint64 returns the Uint64 representation of x. If x cannot be represented in an int64, the result is
undefined.
func (i *Number) Uint64() uint64 {
```

```
return i.num.Uint64()
}
// Int64 returns the int64 representation of x. If x cannot be represented in an int64, the result is
undefined.
func (i *Number) Int64() int64 {
return i.num.Int64()
}
// Returns the signed version of i
func (i *Number) Int256() *Number {
return Int(0).Set(i)
}
// Returns the unsigned version of i
func (i *Number) Uint256() *Number {
return Uint(0).Set(i)
}
// Returns the index of the first bit that's set to 1
func (i *Number) FirstBitSet() int {
for j := 0; j < i.num.BitLen(); j++ {
if i.num.Bit(j) > 0 {
return j
}
}
return i.num.BitLen()
}
// Variables
var (
Zero
        = Uint(0)
        = Uint(1)
One
Two
        = Uint(2)
MinOne = Int(-1)
// "typedefs"
Uint = Uint256
```

```
Int = Int256
)
12:F:\git\coin\ethereum\go-ethereum\common\number\uint_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package number
import (
"math/big"
"testing"
"github.com/ethereum/go-ethereum/common"
)
func TestSet(t *testing.T) {
a := Uint(0)
b := Uint(10)
a.Set(b)
if a.num.Cmp(b.num) != 0 {
t.Error("didn't compare", a, b)
}
c := Uint(0).SetBytes(common.Hex2Bytes("0a"))
if c.num.Cmp(big.NewInt(10)) != 0 {
t.Error("c set bytes failed.")
}
}
func TestInitialiser(t *testing.T) {
check := false
init := NewInitialiser(func(x *Number) *Number {
check = true
return x
})
a := init(0).Add(init(1), init(2))
if a.Cmp(init(3)) != 0 {
t.Error("expected 3. got", a)
if !check {
t.Error("expected limiter to be called")
```

}

```
}
func TestGet(t *testing.T) {
a := Uint(10)
if a.Uint64() != 10 {
t.Error("expected to get 10. got", a.Uint64())
}
a = Uint(10)
if a.Int64() != 10 {
t.Error("expected to get 10. got", a.Int64())
}
}
func TestCmp(t *testing.T) {
a := Uint(10)
b := Uint(10)
c := Uint(11)
if a.Cmp(b) != 0 \{
t.Error("a b == 0 failed", a, b)
}
if a.Cmp(c) >= 0 {
t.Error("a c < 0 failed", a, c)
}
if c.Cmp(b) \le 0 {
t.Error("c b > 0 failed", c, b)
}
}
func TestMaxArith(t *testing.T) {
a := Uint(0).Add(MaxUint256, One)
if a.Cmp(Zero) != 0 {
t.Error("expected max256 + 1 = 0 got", a)
}
a = Uint(0).Sub(Uint(0), One)
if a.Cmp(MaxUint256) != 0 {
t.Error("expected 0 - 1 = max256 got", a)
}
```

```
a = Int(0).Sub(Int(0), One)
if a.Cmp(MinOne) != 0 {
t.Error("expected 0 - 1 = -1 got", a)
}
}
func TestConversion(t *testing.T) {
a := Int(-1)
b := a.Uint256()
if b.Cmp(MaxUint256) != 0  {
t.Error("expected -1 => unsigned to return max. got", b)
}
}
13:F:\git\coin\ethereum\go-ethereum\common\path.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package common
import (
"fmt"
"os"
"path/filepath"
"runtime"
)
// MakeName creates a node name that follows the ethereum convention
// for such names. It adds the operation system name and Go runtime version
// the name.
func MakeName(name, version string) string {
return fmt.Sprintf("%s/v%s/%s/%s", name, version, runtime.GOOS, runtime.Version())
}
func FileExist(filePath string) bool {
_, err := os.Stat(filePath)
if err != nil && os.IsNotExist(err) {
return false
return true
}
```

```
func AbsolutePath(Datadir string, filename string) string {
if filepath.lsAbs(filename) {
return filename
}
return filepath.Join(Datadir, filename)
}
14:F:\git\coin\ethereum\go-ethereum\common\size.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package common
import (
"fmt"
type StorageSize float64
func (self StorageSize) String() string {
if self > 1000000 {
return fmt.Sprintf("%.2f mB", self/1000000)
} else if self > 1000 {
return fmt.Sprintf("%.2f kB", self/1000)
} else {
return fmt.Sprintf("%.2f B", self)
}
}
func (self StorageSize) Int64() int64 {
return int64(self)
}
15:F:\git\coin\ethereum\go-ethereum\common\size_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package common
import (
"testing"
)
```

```
func TestStorageSizeString(t *testing.T) {
tests := []struct {
size StorageSize
str string
}{
{2381273, "2.38 mB"},
{2192, "2.19 kB"},
{12, "12.00 B"},
}
for _, test := range tests {
if test.size.String() != test.str {
t.Errorf("%f: got %q, want %q", float64(test.size), test.size.String(), test.str)
}
}
}
16:F:\git\coin\ethereum\go-ethereum\common\test_utils.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package common
import (
"encoding/json"
"fmt"
"io/ioutil"
)
// LoadJSON reads the given file and unmarshals its content.
func LoadJSON(file string, val interface{}) error {
content, err := ioutil.ReadFile(file)
if err != nil {
return err
if err := json.Unmarshal(content, val); err != nil {
if syntaxerr, ok := err.(*json.SyntaxError); ok {
line := findLine(content, syntaxerr.Offset)
return fmt.Errorf("JSON syntax error at %v:%v: %v", file, line, err)
return fmt.Errorf("JSON unmarshal error in %v: %v", file, err)
}
return nil
```

```
}
// findLine returns the line number for the given offset into data.
func findLine(data []byte, offset int64) (line int) {
line = 1
for i, r := range string(data) {
if int64(i) >= offset {
return
if r == '\n' \{
line++
}
return
17:F:\git\coin\ethereum\go-ethereum\common\types.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package common
import (
"encoding/hex"
"fmt"
"math/big"
"math/rand"
"reflect"
"github.com/ethereum/go-ethereum/common/hexutil"
)
const (
HashLength = 32
AddressLength = 20
)
var (
hashT
         = reflect.TypeOf(Hash{})
addressT = reflect.TypeOf(Address{})
)
// Hash represents the 32 byte Keccak256 hash of arbitrary data.
```

```
type Hash [HashLength]byte
func BytesToHash(b []byte) Hash {
var h Hash
h.SetBytes(b)
return h
func StringToHash(s string) Hash { return BytesToHash([]byte(s)) }
func BigToHash(b *big.Int) Hash { return BytesToHash(b.Bytes()) }
func HexToHash(s string) Hash { return BytesToHash(FromHex(s)) }
// Get the string representation of the underlying hash
func (h Hash) Str() string { return string(h[:]) }
func (h Hash) Bytes() []byte { return h[:] }
func (h Hash) Big() *big.Int { return new(big.Int).SetBytes(h[:]) }
func (h Hash) Hex() string { return hexutil.Encode(h[:]) }
// TerminalString implements log. TerminalStringer, formatting a string for console
// output during logging.
func (h Hash) TerminalString() string {
return fmt.Sprintf("%x...%x", h[:3], h[29:])
}
// String implements the stringer interface and is used also by the logger when
// doing full logging into a file.
func (h Hash) String() string {
return h.Hex()
}
// Format implements fmt. Formatter, forcing the byte slice to be formatted as is,
// without going through the stringer interface used for logging.
func (h Hash) Format(s fmt.State, c rune) {
fmt.Fprintf(s, "%"+string(c), h[:])
}
// UnmarshalText parses a hash in hex syntax.
func (h *Hash) UnmarshalText(input []byte) error {
return hexutil.UnmarshalFixedText("Hash", input, h[:])
}
```

// UnmarshalJSON parses a hash in hex syntax.

func (h *Hash) UnmarshalJSON(input []byte) error {

```
return hexutil.UnmarshalFixedJSON(hashT, input, h[:])
}
// MarshalText returns the hex representation of h.
func (h Hash) MarshalText() ([]byte, error) {
return hexutil.Bytes(h[:]).MarshalText()
}
// Sets the hash to the value of b. If b is larger than len(h) it will panic
func (h *Hash) SetBytes(b []byte) {
if len(b) > len(h) {
b = b[len(b)-HashLength:]
}
copy(h[HashLength-len(b):], b)
}
// Set string `s` to h. If s is larger than len(h) it will panic
func (h *Hash) SetString(s string) { h.SetBytes([]byte(s)) }
// Sets h to other
func (h *Hash) Set(other Hash) {
for i, v := range other {
h[i] = v
}
// Generate implements testing/quick.Generator.
func (h Hash) Generate(rand *rand.Rand, size int) reflect.Value {
m := rand.Intn(len(h))
for i := len(h) - 1; i > m; i - \{
h[i] = byte(rand.Uint32())
}
return reflect.ValueOf(h)
}
func EmptyHash(h Hash) bool {
return h == Hash{}
}
// UnprefixedHash allows marshaling a Hash without 0x prefix.
type UnprefixedHash Hash
```

```
// UnmarshalText decodes the hash from hex. The 0x prefix is optional.
func (h *UnprefixedHash) UnmarshalText(input []byte) error {
return hexutil.UnmarshalFixedUnprefixedText("UnprefixedHash", input, h[:])
}
// MarshalText encodes the hash as hex.
func (h UnprefixedHash) MarshalText() ([]byte, error) {
return []byte(hex.EncodeToString(h[:])), nil
}
//////// Address
// Address represents the 20 byte address of an Ethereum account.
type Address [AddressLength]byte
func BytesToAddress(b []byte) Address {
var a Address
a.SetBytes(b)
return a
func StringToAddress(s string) Address { return BytesToAddress([]byte(s)) }
func BigToAddress(b *big.Int) Address { return BytesToAddress(b.Bytes()) }
func HexToAddress(s string) Address { return BytesToAddress(FromHex(s)) }
// IsHexAddress verifies whether a string can represent a valid hex-encoded
// Ethereum address or not.
func IsHexAddress(s string) bool {
if len(s) == 2+2*AddressLength && IsHex(s) {
return true
}
if len(s) == 2*AddressLength && IsHex("0x"+s) {
return true
return false
}
// Get the string representation of the underlying address
func (a Address) Str() string { return string(a[:]) }
func (a Address) Bytes() []byte { return a[:] }
func (a Address) Big() *big.Int { return new(big.Int).SetBytes(a[:]) }
func (a Address) Hash() Hash { return BytesToHash(a[:]) }
```

```
func (a Address) Hex() string { return hexutil.Encode(a[:]) }
// String implements the stringer interface and is used also by the logger.
func (a Address) String() string {
return a.Hex()
}
// Format implements fmt. Formatter, forcing the byte slice to be formatted as is,
// without going through the stringer interface used for logging.
func (a Address) Format(s fmt.State, c rune) {
fmt.Fprintf(s, "%"+string(c), a[:])
}
// Sets the address to the value of b. If b is larger than len(a) it will panic
func (a *Address) SetBytes(b []byte) {
if len(b) > len(a) {
b = b[len(b)-AddressLength:]
}
copy(a[AddressLength-len(b):], b)
}
// Set string `s` to a. If s is larger than len(a) it will panic
func (a *Address) SetString(s string) { a.SetBytes([]byte(s)) }
// Sets a to other
func (a *Address) Set(other Address) {
for i, v := range other {
a[i] = v
}
}
// MarshalText returns the hex representation of a.
func (a Address) MarshalText() ([]byte, error) {
return hexutil.Bytes(a[:]).MarshalText()
}
// UnmarshalText parses a hash in hex syntax.
func (a *Address) UnmarshalText(input []byte) error {
return hexutil.UnmarshalFixedText("Address", input, a[:])
}
// UnmarshalJSON parses a hash in hex syntax.
```

```
func (a *Address) UnmarshalJSON(input []byte) error {
return hexutil.UnmarshalFixedJSON(addressT, input, a[:])
}
// UnprefixedHash allows marshaling an Address without 0x prefix.
type UnprefixedAddress Address
// UnmarshalText decodes the address from hex. The 0x prefix is optional.
func (a *UnprefixedAddress) UnmarshalText(input []byte) error {
return hexutil.UnmarshalFixedUnprefixedText("UnprefixedAddress", input, a[:])
}
// MarshalText encodes the address as hex.
func (a UnprefixedAddress) MarshalText() ([]byte, error) {
return []byte(hex.EncodeToString(a[:])), nil
}
18:F:\qit\coin\ethereum\go-ethereum\common\types template.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// +build none
//sed -e 's/_N_/Hash/g' -e 's/_S_/32/g' -e '1d' types_template.go | gofmt -w hash.go
package common
import "math/big"
type _N_ [_S_]byte
func BytesTo_N_(b []byte) _N_ {
varh N
h.SetBytes(b)
return h
func StringTo_N_(s string) _N_ { return BytesTo_N_([]byte(s)) }
func BigTo_N_(b *big.Int) _N_ { return BytesTo_N_(b.Bytes()) }
func HexTo_N_(s string) _N_ { return BytesTo_N_(FromHex(s)) }
// Don't use the default 'String' method in case we want to overwrite
// Get the string representation of the underlying hash
func (h _N_) Str() string { return string(h[:]) }
```

```
func (h _N_) Bytes() []byte { return h[:] }
func (h _N_) Big() *big.Int { return new(big.Int).SetBytes(h[:]) }
func (h _N_) Hex() string { return "0x" + Bytes2Hex(h[:]) }
// Sets the hash to the value of b. If b is larger than len(h) it will panic
func (h *_N_) SetBytes(b []byte) {
// Use the right most bytes
if len(b) > len(h) {
b = b[len(b)-_S_:]
}
// Reverse the loop
for i := len(b) - 1; i >= 0; i -- \{
h[\_S\_-len(b)+i] = b[i]
}
}
// Set string `s` to h. If s is larger than len(h) it will panic
func (h *_N_) SetString(s string) { h.SetBytes([]byte(s)) }
// Sets h to other
func (h *_N_) Set(other _N_) {
for i, v := range other {
h[i] = v
}
}
19:F:\git\coin\ethereum\go-ethereum\common\types_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package common
import (
"encoding/json"
"math/big"
"strings"
"testing"
)
func TestBytesConversion(t *testing.T) {
bytes := []byte{5}
hash := BytesToHash(bytes)
```

```
var exp Hash
exp[31] = 5
if hash != exp {
t.Errorf("expected %x got %x", exp, hash)
}
}
func TestHashJsonValidation(t *testing.T) {
var tests = []struct {
Prefix string
Size int
Error string
}{
{"", 62, "json: cannot unmarshal hex string without 0x prefix into Go value of type common.Hash"},
{"0x", 66, "hex string has length 66, want 64 for common.Hash"},
{"0x", 63, "json: cannot unmarshal hex string of odd length into Go value of type common. Hash"},
{"0x", 0, "hex string has length 0, want 64 for common.Hash"},
{"0x", 64, ""},
{"0X", 64, ""},
}
for _, test := range tests {
input := `"` + test.Prefix + strings.Repeat("0", test.Size) + `"`
var v Hash
err := json.Unmarshal([]byte(input), &v)
if err == nil {
if test.Error != "" {
t.Errorf("%s: error mismatch: have nil, want %q", input, test.Error)
} else {
if err.Error() != test.Error {
t.Errorf("%s: error mismatch: have %q, want %q", input, err, test.Error)
}
}
}
func TestAddressUnmarshalJSON(t *testing.T) {
var tests = []struct {
Input
        string
ShouldErr bool
```

```
Output *big.Int
}{
{"", true, nil},
{`""`, true, nil},
{`"0x"`, true, nil},
{`"0x00"`, true, nil},
}
for i, test := range tests {
var v Address
err := json.Unmarshal([]byte(test.Input), &v)
if err != nil && !test.ShouldErr {
t.Errorf("test #%d: unexpected error: %v", i, err)
}
if err == nil {
if test.ShouldErr {
t.Errorf("test #%d: expected error, got none", i)
}
if v.Big().Cmp(test.Output) != 0 {
t.Errorf("test #%d: address mismatch: have %v, want %v", i, v.Big(), test.Output)
}
}
}
}
20:F:\git\coin\ethereum\go-ethereum\compression\rle\read_write.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package rle implements the run-length encoding used for Ethereum data.
package rle
import (
"bytes"
"errors"
"github.com/ethereum/go-ethereum/crypto"
)
const (
token
           byte = 0xfe
```

```
emptyShaToken
                       = 0xfd
emptyListShaToken
                        = 0xfe
tokenToken
                    = 0xff
)
var empty = crypto.Keccak256([]byte(""))
var emptyList = crypto.Keccak256([]byte{0x80})
func Decompress(dat []byte) ([]byte, error) {
buf := new(bytes.Buffer)
for i := 0; i < len(dat); i++ \{
if dat[i] == token {
if i+1 < len(dat) {
switch dat[i+1] {
case emptyShaToken:
buf.Write(empty)
case emptyListShaToken:
buf.Write(emptyList)
case tokenToken:
buf.WriteByte(token)
default:
buf.Write(make([]byte, int(dat[i+1]-2)))
}
j++
} else {
return nil, errors.New("error reading bytes. token encountered without proceeding bytes")
}
} else {
buf.WriteByte(dat[i])
}
}
return buf.Bytes(), nil
}
func compressChunk(dat []byte) (ret []byte, n int) {
switch {
case dat[0] == token:
return []byte{token, tokenToken}, 1
case len(dat) > 1 \&\& dat[0] == 0x0 \&\& dat[1] == 0x0:
j := 0
```

```
for j \le 254 \&\& j < len(dat) {
if dat[j] != 0 {
break
}
j++
return []byte{token, byte(j + 2)}, j
case len(dat) >= 32:
if dat[0] == empty[0] && bytes.Equal(dat[:32], empty) {
return []byte{token, emptyShaToken}, 32
} else if dat[0] == emptyList[0] && bytes.Equal(dat[:32], emptyList) {
return []byte{token, emptyListShaToken}, 32
}
fallthrough
default:
return dat[:1], 1
}
}
func Compress(dat []byte) []byte {
buf := new(bytes.Buffer)
i := 0
for i < len(dat) {
b, n := compressChunk(dat[i:])
buf.Write(b)
i += n
}
return buf.Bytes()
}
21:F:\git\coin\ethereum\go-ethereum\compression\rle\read_write_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package rle
import (
"testing"
checker "gopkg.in/check.v1"
)
```

```
func Test(t *testing.T) { checker.TestingT(t) }
type CompressionRleSuite struct{}
var _ = checker.Suite(&CompressionRleSuite{})
func (s *CompressionRleSuite) TestDecompressSimple(c *checker.C) {
exp := []byte{0xc5, 0xd2, 0x46, 0x1, 0x86, 0xf7, 0x23, 0x3c, 0x92, 0x7e, 0x7d, 0xb2, 0xdc, 0xc7, 0xc8, 0xc
0x3, 0xc0, 0xe5, 0x0, 0xb6, 0x53, 0xca, 0x82, 0x27, 0x3b, 0x7b, 0xfa, 0xd8, 0x4, 0x5d, 0x85,
0xa4, 0x70
res, err := Decompress([]byte{token, 0xfd})
c.Assert(err, checker.IsNil)
c.Assert(res, checker.DeepEquals, exp)
exp = []byte{0x56, 0xe8, 0x1f, 0x17, 0x1b, 0xcc, 0x55, 0xa6, 0xff, 0x83, 0x45, 0xe6, 0x92, 0xc0, 0xe8, 0xff, 0xe8, 0xe8, 0xff, 0xe8, 0xff, 0xe8, 0xff, 0xe8, 0xff, 0xe8, 0xe8, 0xe8, 0xff, 0xe8, 0xe
0xf8, 0x6e, 0x5b, 0x48, 0xe0, 0x1b, 0x99, 0x6c, 0xad, 0xc0, 0x1, 0x62, 0x2f, 0xb5, 0xe3, 0x63,
0xb4, 0x21
res, err = Decompress([]byte{token, 0xfe})
c.Assert(err, checker.IsNil)
c.Assert(res, checker.DeepEquals, exp)
res, err = Decompress([]byte{token, 0xff})
c.Assert(err, checker.IsNil)
c.Assert(res, checker.DeepEquals, []byte{token})
res, err = Decompress([]byte{token, 12})
c.Assert(err, checker.IsNil)
c.Assert(res, checker.DeepEquals, make([]byte, 10))
}
22:F:\git\coin\ethereum\go-ethereum\consensus\clique\api.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package clique
import (
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/rpc"
```

```
)
// API is a user facing RPC API to allow controlling the signer and voting
// mechanisms of the proof-of-authority scheme.
type API struct {
chain consensus.ChainReader
clique *Clique
}
// GetSnapshot retrieves the state snapshot at a given block.
func (api *API) GetSnapshot(number *rpc.BlockNumber) (*Snapshot, error) {
// Retrieve the requested block number (or current if none requested)
var header *types.Header
if number == nil || *number == rpc.LatestBlockNumber {
header = api.chain.CurrentHeader()
} else {
header = api.chain.GetHeaderByNumber(uint64(number.Int64()))
}
// Ensure we have an actually valid block and return its snapshot
if header == nil {
return nil, errUnknownBlock
}
return api.clique.snapshot(api.chain, header.Number.Uint64(), header.Hash(), nil)
}
// GetSnapshotAtHash retrieves the state snapshot at a given block.
func (api *API) GetSnapshotAtHash(hash common.Hash) (*Snapshot, error) {
header := api.chain.GetHeaderByHash(hash)
if header == nil {
return nil, errUnknownBlock
}
return api.clique.snapshot(api.chain, header.Number.Uint64(), header.Hash(), nil)
}
// GetSigners retrieves the list of authorized signers at the specified block.
func (api *API) GetSigners(number *rpc.BlockNumber) ([]common.Address, error) {
// Retrieve the requested block number (or current if none requested)
var header *types.Header
if number == nil || *number == rpc.LatestBlockNumber {
header = api.chain.CurrentHeader()
} else {
header = api.chain.GetHeaderByNumber(uint64(number.Int64()))
```

```
}
// Ensure we have an actually valid block and return the signers from its snapshot
if header == nil {
return nil, errUnknownBlock
}
snap, err := api.clique.snapshot(api.chain, header.Number.Uint64(), header.Hash(), nil)
if err != nil {
return nil, err
return snap.signers(), nil
}
// GetSignersAtHash retrieves the state snapshot at a given block.
func (api *API) GetSignersAtHash(hash common.Hash) ([]common.Address, error) {
header := api.chain.GetHeaderByHash(hash)
if header == nil {
return nil, errUnknownBlock
}
snap, err := api.clique.snapshot(api.chain, header.Number.Uint64(), header.Hash(), nil)
if err != nil {
return nil, err
}
return snap.signers(), nil
}
// Proposals returns the current proposals the node tries to uphold and vote on.
func (api *API) Proposals() map[common.Address]bool {
api.clique.lock.RLock()
defer api.clique.lock.RUnlock()
proposals := make(map[common.Address]bool)
for address, auth := range api.clique.proposals {
proposals[address] = auth
return proposals
}
// Propose injects a new authorization proposal that the signer will attempt to
// push through.
func (api *API) Propose(address common.Address, auth bool) {
api.clique.lock.Lock()
defer api.clique.lock.Unlock()
```

```
api.clique.proposals[address] = auth
}
// Discard drops a currently running proposal, stopping the signer from casting
// further votes (either for or against).
func (api *API) Discard(address common.Address) {
api.clique.lock.Lock()
defer api.clique.lock.Unlock()
delete(api.clique.proposals, address)
}
23:F:\git\coin\ethereum\go-ethereum\consensus\clique\clique.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package clique implements the proof-of-authority consensus engine.
package clique
import (
"bytes"
"errors"
"math/big"
"math/rand"
"svnc"
"time"
"github.com/ethereum/go-ethereum/accounts"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/hexutil"
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/crypto/sha3"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/params"
"github.com/ethereum/go-ethereum/rlp"
"github.com/ethereum/go-ethereum/rpc"
Iru "github.com/hashicorp/golang-Iru"
)
```

```
const (
checkpointInterval = 1024 // Number of blocks after which to save the vote snapshot to the
database
inmemorySnapshots = 128 // Number of recent vote snapshots to keep in memory
inmemorySignatures = 4096 // Number of recent block signatures to keep in memory
wiggleTime = 500 * time.Millisecond // Random delay (per signer) to allow concurrent signers
// Clique proof-of-authority protocol constants.
var (
epochLength = uint64(30000) // Default number of blocks after which to checkpoint and reset the
pending votes
blockPeriod = uint64(15) // Default minimum difference between two consecutive block's
timestamps
extraVanity = 32 // Fixed number of extra-data prefix bytes reserved for signer vanity
extraSeal = 65 // Fixed number of extra-data suffix bytes reserved for signer seal
nonceAuthVote = hexutil.MustDecode("0xffffffffffff") // Magic nonce number to vote on adding a
new signer
nonceDropVote = hexutil.MustDecode("0x000000000000000") // Magic nonce number to vote on
removing a signer.
uncleHash = types.CalcUncleHash(nil) // Always Keccak256(RLP([])) as uncles are meaningless
outside of PoW.
diffInTurn = big.NewInt(2) // Block difficulty for in-turn signatures
diffNoTurn = big.NewInt(1) // Block difficulty for out-of-turn signatures
)
// Various error messages to mark blocks invalid. These should be private to
// prevent engine specific errors from being referenced in the remainder of the
// codebase, inherently breaking if the engine is swapped out. Please put common
// error types into the consensus package.
var (
// errUnknownBlock is returned when the list of signers is requested for a block
// that is not part of the local blockchain.
errUnknownBlock = errors.New("unknown block")
// errInvalidCheckpointBeneficiary is returned if a checkpoint/epoch transition
```

```
// block has a beneficiary set to non-zeroes.
errInvalidCheckpointBeneficiary = errors.New("beneficiary in checkpoint block non-zero")
// errInvalidVote is returned if a nonce value is something else that the two
// allowed constants of 0x00..0 or 0xff..f.
errInvalidVote = errors.New("vote nonce not 0x00..0 or 0xff..f")
// errInvalidCheckpointVote is returned if a checkpoint/epoch transition block
// has a vote nonce set to non-zeroes.
errInvalidCheckpointVote = errors.New("vote nonce in checkpoint block non-zero")
// errMissingVanity is returned if a block's extra-data section is shorter than
// 32 bytes, which is required to store the signer vanity.
errMissingVanity = errors.New("extra-data 32 byte vanity prefix missing")
// errMissingSignature is returned if a block's extra-data section doesn't seem
// to contain a 65 byte secp256k1 signature.
errMissingSignature = errors.New("extra-data 65 byte suffix signature missing")
// errExtraSigners is returned if non-checkpoint block contain signer data in
// their extra-data fields.
errExtraSigners = errors.New("non-checkpoint block contains extra signer list")
// errInvalidCheckpointSigners is returned if a checkpoint block contains an
// invalid list of signers (i.e. non divisible by 20 bytes, or not the correct
// ones).
errInvalidCheckpointSigners = errors.New("invalid signer list on checkpoint block")
// errInvalidMixDigest is returned if a block's mix digest is non-zero.
errInvalidMixDigest = errors.New("non-zero mix digest")
// errInvalidUncleHash is returned if a block contains an non-empty uncle list.
errInvalidUncleHash = errors.New("non empty uncle hash")
// errInvalidDifficulty is returned if the difficulty of a block is not either
// of 1 or 2, or if the value does not match the turn of the signer.
errInvalidDifficulty = errors.New("invalid difficulty")
// ErrInvalidTimestamp is returned if the timestamp of a block is lower than
// the previous block's timestamp + the minimum block period.
ErrInvalidTimestamp = errors.New("invalid timestamp")
```

```
// errInvalidVotingChain is returned if an authorization list is attempted to
// be modified via out-of-range or non-contiguous headers.
errInvalidVotingChain = errors.New("invalid voting chain")
// errUnauthorized is returned if a header is signed by a non-authorized entity.
errUnauthorized = errors.New("unauthorized")
)
// SignerFn is a signer callback function to request a hash to be signed by a
// backing account.
type SignerFn func(accounts.Account, []byte) ([]byte, error)
// sigHash returns the hash which is used as input for the proof-of-authority
// signing. It is the hash of the entire header apart from the 65 byte signature
// contained at the end of the extra data.
//
// Note, the method requires the extra data to be at least 65 bytes, otherwise it
// panics. This is done to avoid accidentally using both forms (signature present
// or not), which could be abused to produce different hashes for the same header.
func sigHash(header *types.Header) (hash common.Hash) {
hasher := sha3.NewKeccak256()
rlp.Encode(hasher, []interface{}{
header.ParentHash,
header.UncleHash,
header.Coinbase.
header.Root,
header.TxHash,
header.ReceiptHash,
header.Bloom,
header.Difficulty,
header.Number.
header.GasLimit,
header.GasUsed.
header.Time,
header.Extra[:len(header.Extra)-65], // Yes, this will panic if extra is too short
header.MixDigest,
header.Nonce.
hasher.Sum(hash[:0])
return hash
}
```

```
// ecrecover extracts the Ethereum account address from a signed header.
func ecrecover(header *types.Header, sigcache *Iru.ARCCache) (common.Address, error) {
// If the signature's already cached, return that
hash := header.Hash()
if address, known := sigcache.Get(hash); known {
return address.(common.Address), nil
}
// Retrieve the signature from the header extra-data
if len(header.Extra) < extraSeal {
return common.Address{}, errMissingSignature
}
signature := header.Extra[len(header.Extra)-extraSeal:]
// Recover the public key and the Ethereum address
pubkey, err := crypto.Ecrecover(sigHash(header).Bytes(), signature)
if err != nil {
return common.Address{}, err
var signer common. Address
copy(signer[:], crypto.Keccak256(pubkey[1:])[12:])
sigcache.Add(hash, signer)
return signer, nil
}
// Clique is the proof-of-authority consensus engine proposed to support the
// Ethereum testnet following the Ropsten attacks.
type Clique struct {
config *params.CliqueConfig // Consensus engine configuration parameters
     ethdb.Database
db
                         // Database to store and retrieve snapshot checkpoints
         *Iru.ARCCache // Snapshots for recent block to speed up reorgs
signatures *Iru.ARCCache // Signatures of recent blocks to speed up mining
proposals map[common.Address]bool // Current list of proposals we are pushing
signer common. Address // Ethereum address of the signing key
                    // Signer function to authorize hashes with
signFn SignerFn
lock sync.RWMutex // Protects the signer fields
}
```

```
// New creates a Clique proof-of-authority consensus engine with the initial
// signers set to the ones provided by the user.
func New(config *params.CliqueConfig, db ethdb.Database) *Clique {
// Set any missing consensus parameters to their defaults
conf := *config
if conf.Epoch == 0 {
conf.Epoch = epochLength
}
if conf.Period == 0 {
conf.Period = blockPeriod
// Allocate the snapshot caches and create the engine
recents, _ := Iru.NewARC(inmemorySnapshots)
signatures, _ := Iru.NewARC(inmemorySignatures)
return &Clique{
config:
         &conf,
db:
        db,
recents: recents,
signatures: signatures,
proposals: make(map[common.Address]bool),
}
}
// Author implements consensus. Engine, returning the Ethereum address recovered
// from the signature in the header's extra-data section.
func (c *Clique) Author(header *types.Header) (common.Address, error) {
return ecrecover(header, c.signatures)
}
// VerifyHeader checks whether a header conforms to the consensus rules.
func (c *Clique) VerifyHeader(chain consensus.ChainReader, header *types.Header, seal bool)
error {
return c.verifyHeader(chain, header, nil)
}
// VerifyHeaders is similar to VerifyHeader, but verifies a batch of headers. The
// method returns a quit channel to abort the operations and a results channel to
// retrieve the async verifications (the order is that of the input slice).
func (c *Clique) VerifyHeaders(chain consensus.ChainReader, headers []*types.Header, seals
[]bool) (chan<- struct{}, <-chan error) {
abort := make(chan struct{})
```

```
results := make(chan error, len(headers))
go func() {
for i, header := range headers {
err := c.verifyHeader(chain, header, headers[:i])
select {
case <-abort:
return
case results <- err:
}
}()
return abort, results
// verifyHeader checks whether a header conforms to the consensus rules. The
// caller may optionally pass in a batch of parents (ascending order) to avoid
// looking those up from the database. This is useful for concurrently verifying
// a batch of new headers.
func (c *Clique) verifyHeader(chain consensus.ChainReader, header *types.Header, parents
[]*types.Header) error {
if header.Number == nil {
return errUnknownBlock
number := header.Number.Uint64()
// Don't waste time checking blocks from the future
if header.Time.Cmp(big.NewInt(time.Now().Unix())) > 0 {
return consensus.ErrFutureBlock
}
// Checkpoint blocks need to enforce zero beneficiary
checkpoint := (number % c.config.Epoch) == 0
if checkpoint && header.Coinbase != (common.Address{}) {
return errInvalidCheckpointBeneficiary
}
// Nonces must be 0x00..0 or 0xff..f, zeroes enforced on checkpoints
if !bytes.Equal(header.Nonce[:], nonceAuthVote) && !bytes.Equal(header.Nonce[:],
nonceDropVote) {
return errInvalidVote
}
if checkpoint && !bytes.Equal(header.Nonce[:], nonceDropVote) {
```

```
return errInvalidCheckpointVote
}
// Check that the extra-data contains both the vanity and signature
if len(header.Extra) < extraVanity {
return errMissingVanity
if len(header.Extra) < extraVanity+extraSeal {</pre>
return errMissingSignature
// Ensure that the extra-data contains a signer list on checkpoint, but none otherwise
signersBytes := len(header.Extra) - extraVanity - extraSeal
if !checkpoint && signersBytes != 0 {
return errExtraSigners
if checkpoint && signersBytes%common.AddressLength != 0 {
return errInvalidCheckpointSigners
}
// Ensure that the mix digest is zero as we don't have fork protection currently
if header.MixDigest != (common.Hash{}) {
return errInvalidMixDigest
}
// Ensure that the block doesn't contain any uncles which are meaningless in PoA
if header.UncleHash != uncleHash {
return errInvalidUncleHash
// Ensure that the block's difficulty is meaningful (may not be correct at this point)
if number > 0 {
if header.Difficulty == nil || (header.Difficulty.Cmp(diffInTurn) != 0 &&
header.Difficulty.Cmp(diffNoTurn) != 0) {
return errInvalidDifficulty
}
// All basic checks passed, verify cascading fields
return c.verifyCascadingFields(chain, header, parents)
}
// verifyCascadingFields verifies all the header fields that are not standalone,
// rather depend on a batch of previous headers. The caller may optionally pass
// in a batch of parents (ascending order) to avoid looking those up from the
// database. This is useful for concurrently verifying a batch of new headers.
func (c *Clique) verifyCascadingFields(chain consensus.ChainReader, header *types.Header,
parents []*types.Header) error {
```

```
// The genesis block is the always valid dead-end
number := header.Number.Uint64()
if number == 0 {
return nil
}
// Ensure that the block's timestamp isn't too close to it's parent
var parent *types.Header
if len(parents) > 0 {
parent = parents[len(parents)-1]
} else {
parent = chain.GetHeader(header.ParentHash, number-1)
if parent == nil || parent.Number.Uint64() != number-1 || parent.Hash() != header.ParentHash {
return consensus.ErrUnknownAncestor
}
if parent.Time.Uint64()+c.config.Period > header.Time.Uint64() {
return ErrInvalidTimestamp
}
// Retrieve the snapshot needed to verify this header and cache it
snap, err := c.snapshot(chain, number-1, header.ParentHash, parents)
if err != nil {
return err
}
// If the block is a checkpoint block, verify the signer list
if number%c.config.Epoch == 0 {
signers := make([]byte, len(snap.Signers)*common.AddressLength)
for i, signer := range snap.signers() {
copy(signers[i*common.AddressLength:], signer[:])
extraSuffix := len(header.Extra) - extraSeal
if !bytes.Equal(header.Extra[extraVanity:extraSuffix], signers) {
return errInvalidCheckpointSigners
}
// All basic checks passed, verify the seal and return
return c.verifySeal(chain, header, parents)
}
// snapshot retrieves the authorization snapshot at a given point in time.
func (c *Clique) snapshot(chain consensus.ChainReader, number uint64, hash common.Hash,
parents []*types.Header) (*Snapshot, error) {
// Search for a snapshot in memory or on disk for checkpoints
```

```
var (
headers []*types.Header
snap
      *Snapshot
)
for snap == nil {
// If an in-memory snapshot was found, use that
if s, ok := c.recents.Get(hash); ok {
snap = s.(*Snapshot)
break
}
// If an on-disk checkpoint snapshot can be found, use that
if number%checkpointInterval == 0 {
if s, err := loadSnapshot(c.config, c.signatures, c.db, hash); err == nil {
log.Trace("Loaded voting snapshot form disk", "number", number, "hash", hash)
snap = s
break
}
// If we're at block zero, make a snapshot
if number == 0 {
genesis := chain.GetHeaderByNumber(0)
if err := c.VerifyHeader(chain, genesis, false); err != nil {
return nil, err
signers := make([]common.Address, (len(genesis.Extra)-extraVanity-
extraSeal)/common.AddressLength)
for i := 0; i < len(signers); i++ {
copy(signers[i][:], genesis.Extra[extraVanity+i*common.AddressLength:])
snap = newSnapshot(c.config, c.signatures, 0, genesis.Hash(), signers)
if err := snap.store(c.db); err != nil {
return nil, err
log.Trace("Stored genesis voting snapshot to disk")
break
}
// No snapshot for this header, gather the header and move backward
var header *types.Header
if len(parents) > 0 {
// If we have explicit parents, pick from there (enforced)
header = parents[len(parents)-1]
if header.Hash() != hash || header.Number.Uint64() != number {
```

```
return nil, consensus.ErrUnknownAncestor
}
parents = parents[:len(parents)-1]
} else {
// No explicit parents (or no more left), reach out to the database
header = chain.GetHeader(hash, number)
if header == nil {
return nil, consensus.ErrUnknownAncestor
}
headers = append(headers, header)
number, hash = number-1, header.ParentHash
}
// Previous snapshot found, apply any pending headers on top of it
for i := 0; i < len(headers)/2; i++ {
headers[i], headers[len(headers)-1-i] = headers[len(headers)-1-i], headers[i]
}
snap, err := snap.apply(headers)
if err != nil {
return nil, err
}
c.recents.Add(snap.Hash, snap)
// If we've generated a new checkpoint snapshot, save to disk
if snap.Number%checkpointInterval == 0 && len(headers) > 0 {
if err = snap.store(c.db); err != nil {
return nil, err
log.Trace("Stored voting snapshot to disk", "number", snap.Number, "hash", snap.Hash)
return snap, err
}
// VerifyUncles implements consensus. Engine, always returning an error for any
// uncles as this consensus mechanism doesn't permit uncles.
func (c *Clique) VerifyUncles(chain consensus.ChainReader, block *types.Block) error {
if len(block.Uncles()) > 0 {
return errors.New("uncles not allowed")
return nil
}
```

```
// VerifySeal implements consensus. Engine, checking whether the signature contained
// in the header satisfies the consensus protocol requirements.
func (c *Clique) VerifySeal(chain consensus.ChainReader, header *types.Header) error {
return c.verifySeal(chain, header, nil)
}
// verifySeal checks whether the signature contained in the header satisfies the
// consensus protocol requirements. The method accepts an optional list of parent
// headers that aren't yet part of the local blockchain to generate the snapshots
// from.
func (c *Clique) verifySeal(chain consensus.ChainReader, header *types.Header, parents
[]*types.Header) error {
// Verifying the genesis block is not supported
number := header.Number.Uint64()
if number == 0 {
return errUnknownBlock
}
// Retrieve the snapshot needed to verify this header and cache it
snap, err := c.snapshot(chain, number-1, header.ParentHash, parents)
if err != nil {
return err
}
// Resolve the authorization key and check against signers
signer, err := ecrecover(header, c.signatures)
if err != nil {
return err
}
if _, ok := snap.Signers[signer]; !ok {
return errUnauthorized
}
for seen, recent := range snap.Recents {
if recent == signer {
// Signer is among recents, only fail if the current block doesn't shift it out
if limit := uint64(len(snap.Signers)/2 + 1); seen > number-limit {
return errUnauthorized
}
}
// Ensure that the difficulty corresponds to the turn-ness of the signer
inturn := snap.inturn(header.Number.Uint64(), signer)
if inturn && header.Difficulty.Cmp(diffInTurn) != 0 {
```

```
return errInvalidDifficulty
}
if !inturn && header.Difficulty.Cmp(diffNoTurn) != 0 {
return errInvalidDifficulty
}
return nil
// Prepare implements consensus. Engine, preparing all the consensus fields of the
// header for running the transactions on top.
func (c *Clique) Prepare(chain consensus.ChainReader, header *types.Header) error {
// If the block isn't a checkpoint, cast a random vote (good enough for now)
header.Coinbase = common.Address{}
header.Nonce = types.BlockNonce{}
number := header.Number.Uint64()
// Assemble the voting snapshot to check which votes make sense
snap, err := c.snapshot(chain, number-1, header.ParentHash, nil)
if err != nil {
return err
if number%c.config.Epoch != 0 {
c.lock.RLock()
// Gather all the proposals that make sense voting on
addresses := make([]common.Address, 0, len(c.proposals))
for address, authorize := range c.proposals {
if snap.validVote(address, authorize) {
addresses = append(addresses, address)
}
}
// If there's pending proposals, cast a vote on them
if len(addresses) > 0 {
header.Coinbase = addresses[rand.Intn(len(addresses))]
if c.proposals[header.Coinbase] {
copy(header.Nonce[:], nonceAuthVote)
} else {
copy(header.Nonce[:], nonceDropVote)
}
}
c.lock.RUnlock()
```

```
}
// Set the correct difficulty
header.Difficulty = diffNoTurn
if snap.inturn(header.Number.Uint64(), c.signer) {
header.Difficulty = diffInTurn
// Ensure the extra data has all it's components
if len(header.Extra) < extraVanity {</pre>
header.Extra = append(header.Extra, bytes.Repeat([]byte{0x00}, extraVanity-len(header.Extra))...)
}
header.Extra = header.Extra[:extraVanity]
if number%c.config.Epoch == 0 {
for _, signer := range snap.signers() {
header.Extra = append(header.Extra, signer[:]...)
}
header.Extra = append(header.Extra, make([]byte, extraSeal)...)
// Mix digest is reserved for now, set to empty
header.MixDigest = common.Hash{}
// Ensure the timestamp has the correct delay
parent := chain.GetHeader(header.ParentHash, number-1)
if parent == nil {
return consensus.ErrUnknownAncestor
}
header.Time = new(big.Int).Add(parent.Time, new(big.Int).SetUint64(c.config.Period))
if header.Time.Int64() < time.Now().Unix() {
header.Time = big.NewInt(time.Now().Unix())
}
return nil
}
// Finalize implements consensus. Engine, ensuring no uncles are set, nor block
// rewards given, and returns the final block.
func (c *Clique) Finalize(chain consensus.ChainReader, header *types.Header, state
*state.StateDB, txs []*types.Transaction, uncles []*types.Header, receipts []*types.Receipt)
(*types.Block, error) {
// No block rewards in PoA, so the state remains as is and uncles are dropped
header.Root = state.IntermediateRoot(chain.Config().IsEIP158(header.Number))
header.UncleHash = types.CalcUncleHash(nil)
```

```
// Assemble and return the final block for sealing
return types.NewBlock(header, txs, nil, receipts), nil
}
// Authorize injects a private key into the consensus engine to mint new blocks
// with.
func (c *Clique) Authorize(signer common.Address, signFn SignerFn) {
c.lock.Lock()
defer c.lock.Unlock()
c.signer = signer
c.signFn = signFn
}
// Seal implements consensus. Engine, attempting to create a sealed block using
// the local signing credentials.
func (c *Clique) Seal(chain consensus.ChainReader, block *types.Block, stop <-chan struct{})
(*types.Block, error) {
header := block.Header()
// Sealing the genesis block is not supported
number := header.Number.Uint64()
if number == 0 {
return nil, errUnknownBlock
}
// Don't hold the signer fields for the entire sealing procedure
c.lock.RLock()
signer, signFn := c.signer, c.signFn
c.lock.RUnlock()
// Bail out if we're unauthorized to sign a block
snap, err := c.snapshot(chain, number-1, header.ParentHash, nil)
if err != nil {
return nil, err
}
if _, authorized := snap.Signers[signer]; !authorized {
return nil, errUnauthorized
// If we're amongst the recent signers, wait for the next block
for seen, recent := range snap.Recents {
if recent == signer {
```

```
// Signer is among recents, only wait if the current block doesn't shift it out
if limit := uint64(len(snap.Signers)/2 + 1); number < limit || seen > number-limit {
log.Info("Signed recently, must wait for others")
<-stop
return nil, nil
}
}
}
// Sweet, the protocol permits us to sign the block, wait for our time
delay := time.Unix(header.Time.Int64(), 0).Sub(time.Now())
if header.Difficulty.Cmp(diffNoTurn) == 0 {
// It's not our turn explicitly to sign, delay it a bit
wiggle := time.Duration(len(snap.Signers)/2+1) * wiggleTime
delay += time.Duration(rand.Int63n(int64(wiggle)))
log.Trace("Out-of-turn signing requested", "wiggle", common.PrettyDuration(wiggle))
}
log.Trace("Waiting for slot to sign and propagate", "delay", common.PrettyDuration(delay))
select {
case <-stop:
return nil, nil
case <-time.After(delay):
// Sign all the things!
sighash, err := signFn(accounts.Account{Address: signer}, sigHash(header).Bytes())
if err != nil {
return nil, err
copy(header.Extra[len(header.Extra)-extraSeal:], sighash)
return block.WithSeal(header), nil
}
// APIs implements consensus. Engine, returning the user facing RPC API to allow
// controlling the signer voting.
func (c *Clique) APIs(chain consensus.ChainReader) []rpc.API {
return []rpc.API{{
Namespace: "clique",
Version: "1.0",
Service: &API{chain: chain, clique: c},
Public: false,
```

```
}}
}
24:F:\git\coin\ethereum\go-ethereum\consensus\clique\snapshot.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package clique
import (
"bytes"
"encoding/json"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/params"
Iru "github.com/hashicorp/golang-Iru"
)
// Vote represents a single vote that an authorized signer made to modify the
// list of authorizations.
type Vote struct {
Signer common.Address `json:"signer"` // Authorized signer that cast this vote
Block
                    'json:"block" // Block number the vote was cast in (expire old votes)
Address common.Address 'json:"address" // Account being voted on to change its
authorization
Authorize bool
                     `json:"authorize"` // Whether to authorize or deauthorize the voted account
}
// Tally is a simple vote tally to keep the current score of votes. Votes that
// go against the proposal aren't counted since it's equivalent to not voting.
type Tally struct {
Authorize bool `json:"authorize"` // Whether the vote is about authorizing or kicking someone
Votes
         int `json:"votes"`
                             // Number of votes until now wanting to pass the proposal
}
// Snapshot is the state of the authorization voting at a given point in time.
type Snapshot struct {
config *params.CliqueConfig // Consensus engine parameters to fine tune behavior
sigcache *Iru.ARCCache
                              // Cache of recent block signatures to speed up ecrecover
Number uint64
                             `json:"number"` // Block number where the snapshot was created
```

```
`json:"hash"` // Block hash where the snapshot was created
Hash common.Hash
Signers map[common.Address]struct{} `json:"signers"` // Set of authorized signers at this moment
Recents map[uint64]common.Address `json:"recents"` // Set of recent signers for spam
protections
Votes []*Vote
                           `json:"votes"` // List of votes cast in chronological order
Tally map[common.Address]Tally `json:"tally"` // Current vote tally to avoid recalculating
}
// newSnapshot creates a new snapshot with the specified startup parameters. This
// method does not initialize the set of recent signers, so only ever use if for
// the genesis block.
func newSnapshot(config *params.CliqueConfig, sigcache *Iru.ARCCache, number uint64, hash
common.Hash, signers []common.Address) *Snapshot {
snap := &Snapshot{
config: config,
sigcache: sigcache,
Number: number,
Hash: hash,
Signers: make(map[common.Address]struct{}),
Recents: make(map[uint64]common.Address),
Tally: make(map[common.Address]Tally),
}
for _, signer := range signers {
snap.Signers[signer] = struct{}{}
}
return snap
}
// loadSnapshot loads an existing snapshot from the database.
func loadSnapshot(config *params.CliqueConfig, sigcache *Iru.ARCCache, db ethdb.Database,
hash common. Hash) (*Snapshot, error) {
blob, err := db.Get(append([]byte("clique-"), hash[:]...))
if err != nil {
return nil, err
}
snap := new(Snapshot)
if err := json.Unmarshal(blob, snap); err != nil {
return nil, err
snap.config = config
snap.sigcache = sigcache
```

```
return snap, nil
}
// store inserts the snapshot into the database.
func (s *Snapshot) store(db ethdb.Database) error {
blob, err := ison.Marshal(s)
if err != nil {
return err
return db.Put(append([]byte("clique-"), s.Hash[:]...), blob)
}
// copy creates a deep copy of the snapshot, though not the individual votes.
func (s *Snapshot) copy() *Snapshot {
cpy := &Snapshot{
config: s.config,
sigcache: s.sigcache,
Number: s.Number,
Hash: s.Hash,
Signers: make(map[common.Address]struct{}),
Recents: make(map[uint64]common.Address),
Votes: make([]*Vote, len(s.Votes)),
Tally:
       make(map[common.Address]Tally),
for signer := range s.Signers {
cpy.Signers[signer] = struct{}{}
}
for block, signer := range s.Recents {
cpy.Recents[block] = signer
}
for address, tally := range s.Tally {
cpy.Tally[address] = tally
}
copy(cpy.Votes, s.Votes)
return cpy
}
// validVote returns whether it makes sense to cast the specified vote in the
// given snapshot context (e.g. don't try to add an already authorized signer).
func (s *Snapshot) validVote(address common.Address, authorize bool) bool {
_, signer := s.Signers[address]
```

```
return (signer && !authorize) || (!signer && authorize)
}
// cast adds a new vote into the tally.
func (s *Snapshot) cast(address common.Address, authorize bool) bool {
// Ensure the vote is meaningful
if !s.validVote(address, authorize) {
return false
// Cast the vote into an existing or new tally
if old, ok := s.Tally[address]; ok {
old.Votes++
s.Tally[address] = old
} else {
s.Tally[address] = Tally{Authorize: authorize, Votes: 1}
}
return true
}
// uncast removes a previously cast vote from the tally.
func (s *Snapshot) uncast(address common.Address, authorize bool) bool {
// If there's no tally, it's a dangling vote, just drop
tally, ok := s.Tally[address]
if !ok {
return false
// Ensure we only revert counted votes
if tally.Authorize != authorize {
return false
// Otherwise revert the vote
if tally. Votes > 1 {
tally. Votes--
s.Tally[address] = tally
} else {
delete(s.Tally, address)
}
return true
// apply creates a new authorization snapshot by applying the given headers to
// the original one.
```

```
func (s *Snapshot) apply(headers []*types.Header) (*Snapshot, error) {
// Allow passing in no headers for cleaner code
if len(headers) == 0 {
return s, nil
}
// Sanity check that the headers can be applied
for i := 0; i < len(headers)-1; i++ {
if headers[i+1].Number.Uint64() != headers[i].Number.Uint64()+1 {
return nil, errInvalidVotingChain
}
if headers[0].Number.Uint64() != s.Number+1 {
return nil, errInvalidVotingChain
// Iterate through the headers and create a new snapshot
snap := s.copy()
for _, header := range headers {
// Remove any votes on checkpoint blocks
number := header.Number.Uint64()
if number%s.config.Epoch == 0 {
snap.Votes = nil
snap.Tally = make(map[common.Address]Tally)
// Delete the oldest signer from the recent list to allow it signing again
if limit := uint64(len(snap.Signers)/2 + 1); number >= limit {
delete(snap.Recents, number-limit)
}
// Resolve the authorization key and check against signers
signer, err := ecrecover(header, s.sigcache)
if err != nil {
return nil, err
}
if _, ok := snap.Signers[signer]; !ok {
return nil, errUnauthorized
}
for _, recent := range snap.Recents {
if recent == signer {
return nil, errUnauthorized
}
}
snap.Recents[number] = signer
```

```
// Header authorized, discard any previous votes from the signer
for i, vote := range snap. Votes {
if vote.Signer == signer && vote.Address == header.Coinbase {
// Uncast the vote from the cached tally
snap.uncast(vote.Address, vote.Authorize)
// Uncast the vote from the chronological list
snap.Votes = append(snap.Votes[:i], snap.Votes[i+1:]...)
break // only one vote allowed
}
}
// Tally up the new vote from the signer
var authorize bool
switch {
case bytes.Compare(header.Nonce[:], nonceAuthVote) == 0:
authorize = true
case bytes.Compare(header.Nonce[:], nonceDropVote) == 0:
authorize = false
default:
return nil, errInvalidVote
}
if snap.cast(header.Coinbase, authorize) {
snap.Votes = append(snap.Votes, &Vote{
Signer: signer,
Block: number,
Address: header.Coinbase,
Authorize: authorize,
})
// If the vote passed, update the list of signers
if tally := snap.Tally[header.Coinbase]; tally.Votes > len(snap.Signers)/2 {
if tally.Authorize {
snap.Signers[header.Coinbase] = struct{}{}
} else {
delete(snap.Signers, header.Coinbase)
// Signer list shrunk, delete any leftover recent caches
if limit := uint64(len(snap.Signers)/2 + 1); number >= limit {
delete(snap.Recents, number-limit)
}
// Discard any previous votes the deauthorized signer cast
```

```
for i := 0; i < len(snap.Votes); i++ {
if snap.Votes[i].Signer == header.Coinbase {
// Uncast the vote from the cached tally
snap.uncast(snap.Votes[i].Address, snap.Votes[i].Authorize)
// Uncast the vote from the chronological list
snap.Votes = append(snap.Votes[:i], snap.Votes[i+1:]...)
i--
}
}
}
// Discard any previous votes around the just changed account
for i := 0; i < len(snap.Votes); i++ {
if snap.Votes[i].Address == header.Coinbase {
snap.Votes = append(snap.Votes[:i], snap.Votes[i+1:]...)
i--
}
}
delete(snap.Tally, header.Coinbase)
}
}
snap.Number += uint64(len(headers))
snap.Hash = headers[len(headers)-1].Hash()
return snap, nil
}
// signers retrieves the list of authorized signers in ascending order.
func (s *Snapshot) signers() []common.Address {
signers := make([]common.Address, 0, len(s.Signers))
for signer := range s.Signers {
signers = append(signers, signer)
for i := 0; i < len(signers); i++ \{
for j := i + 1; j < len(signers); j++ {
if bytes.Compare(signers[i][:], signers[j][:]) > 0 {
signers[i], signers[j] = signers[j], signers[i]
}
}
}
return signers
```

```
}
// inturn returns if a signer at a given block height is in-turn or not.
func (s *Snapshot) inturn(number uint64, signer common.Address) bool {
signers, offset := s.signers(), 0
for offset < len(signers) && signers[offset] != signer {
offset++
}
return (number % uint64(len(signers))) == uint64(offset)
}
25:F:\git\coin\ethereum\go-ethereum\consensus\clique\snapshot_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package clique
import (
"bytes"
"crypto/ecdsa"
"math/big"
"testing"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/params"
)
type testerVote struct {
signer string
voted string
auth bool
}
// testerAccountPool is a pool to maintain currently active tester accounts,
// mapped from textual names used in the tests below to actual Ethereum private
// keys capable of signing transactions.
type testerAccountPool struct {
accounts map[string]*ecdsa.PrivateKey
}
```

```
func newTesterAccountPool() *testerAccountPool {
return &testerAccountPool{
accounts: make(map[string]*ecdsa.PrivateKey),
}
}
func (ap *testerAccountPool) sign(header *types.Header, signer string) {
// Ensure we have a persistent key for the signer
if ap.accounts[signer] == nil {
ap.accounts[signer], _ = crypto.GenerateKey()
}
// Sign the header and embed the signature in extra data
sig, _ := crypto.Sign(sigHash(header).Bytes(), ap.accounts[signer])
copy(header.Extra[len(header.Extra)-65:], sig)
}
func (ap *testerAccountPool) address(account string) common.Address {
// Ensure we have a persistent key for the account
if ap.accounts[account] == nil {
ap.accounts[account], _ = crypto.GenerateKey()
}
// Resolve and return the Ethereum address
return crypto.PubkeyToAddress(ap.accounts[account].PublicKey)
}
// testerChainReader implements consensus.ChainReader to access the genesis
// block. All other methods and requests will panic.
type testerChainReader struct {
db ethdb.Database
}
func (r *testerChainReader) Config() *params.ChainConfig
                                                                   { panic("not supported") }
func (r *testerChainReader) CurrentHeader() *types.Header
                                                                   { panic("not supported") }
func (r *testerChainReader) GetHeader(common.Hash, uint64) *types.Header { panic("not
supported") }
func (r *testerChainReader) GetBlock(common.Hash, uint64) *types.Block { panic("not
supported") }
func (r *testerChainReader) GetHeaderByHash(common.Hash) *types.Header { panic("not
supported") }
func (r *testerChainReader) GetHeaderByNumber(number uint64) *types.Header {
if number == 0 {
```

```
return core.GetHeader(r.db, core.GetCanonicalHash(r.db, 0), 0)
}
panic("not supported")
// Tests that voting is evaluated correctly for various simple and complex scenarios.
func TestVoting(t *testing.T) {
// Define the various voting scenarios to test
tests := []struct {
epoch uint64
signers []string
votes []testerVote
results []string
}{
{
// Single signer, no votes cast
signers: []string{"A"},
votes: []testerVote{{signer: "A"}},
results: []string{"A"},
}, {
// Single signer, voting to add two others (only accept first, second needs 2 votes)
signers: []string{"A"},
votes: []testerVote{
{signer: "A", voted: "B", auth: true},
{signer: "B"},
{signer: "A", voted: "C", auth: true},
},
results: []string{"A", "B"},
}, {
// Two signers, voting to add three others (only accept first two, third needs 3 votes already)
signers: []string{"A", "B"},
votes: []testerVote{
{signer: "A", voted: "C", auth: true},
{signer: "B", voted: "C", auth: true},
{signer: "A", voted: "D", auth: true},
{signer: "B", voted: "D", auth: true},
{signer: "C"},
{signer: "A", voted: "E", auth: true},
{signer: "B", voted: "E", auth: true},
},
results: []string{"A", "B", "C", "D"},
}, {
```

```
// Single signer, dropping itself (weird, but one less cornercase by explicitly allowing this)
signers: []string{"A"},
votes: []testerVote{
{signer: "A", voted: "A", auth: false},
},
results: []string{},
}, {
// Two signers, actually needing mutual consent to drop either of them (not fulfilled)
signers: []string{"A", "B"},
votes: []testerVote{
{signer: "A", voted: "B", auth: false},
},
results: []string{"A", "B"},
}, {
// Two signers, actually needing mutual consent to drop either of them (fulfilled)
signers: []string{"A", "B"},
votes: []testerVote{
{signer: "A", voted: "B", auth: false},
{signer: "B", voted: "B", auth: false},
},
results: []string{"A"},
}, {
// Three signers, two of them deciding to drop the third
signers: []string{"A", "B", "C"},
votes: []testerVote{
{signer: "A", voted: "C", auth: false},
{signer: "B", voted: "C", auth: false},
},
results: []string{"A", "B"},
}, {
// Four signers, consensus of two not being enough to drop anyone
signers: []string{"A", "B", "C", "D"},
votes: []testerVote{
{signer: "A", voted: "C", auth: false},
{signer: "B", voted: "C", auth: false},
},
results: []string{"A", "B", "C", "D"},
}, {
// Four signers, consensus of three already being enough to drop someone
signers: []string{"A", "B", "C", "D"},
votes: []testerVote{
{signer: "A", voted: "D", auth: false},
```

```
{signer: "B", voted: "D", auth: false},
{signer: "C", voted: "D", auth: false},
results: []string{"A", "B", "C"},
}, {
// Authorizations are counted once per signer per target
signers: []string{"A", "B"},
votes: []testerVote{
{signer: "A", voted: "C", auth: true},
{signer: "B"},
{signer: "A", voted: "C", auth: true},
{signer: "B"},
{signer: "A", voted: "C", auth: true},
},
results: []string{"A", "B"},
}, {
// Authorizing multiple accounts concurrently is permitted
signers: []string{"A", "B"},
votes: []testerVote{
{signer: "A", voted: "C", auth: true},
{signer: "B"},
{signer: "A", voted: "D", auth: true},
{signer: "B"},
{signer: "A"},
{signer: "B", voted: "D", auth: true},
{signer: "A"},
{signer: "B", voted: "C", auth: true},
},
results: []string{"A", "B", "C", "D"},
}, {
// Deauthorizations are counted once per signer per target
signers: []string{"A", "B"},
votes: []testerVote{
{signer: "A", voted: "B", auth: false},
{signer: "B"},
{signer: "A", voted: "B", auth: false},
{signer: "B"},
{signer: "A", voted: "B", auth: false},
results: []string{"A", "B"},
}, {
// Deauthorizing multiple accounts concurrently is permitted
```

```
signers: []string{"A", "B", "C", "D"},
votes: []testerVote{
{signer: "A", voted: "C", auth: false},
{signer: "B"},
{signer: "C"},
{signer: "A", voted: "D", auth: false},
{signer: "B"},
{signer: "C"},
{signer: "A"},
{signer: "B", voted: "D", auth: false},
{signer: "C", voted: "D", auth: false},
{signer: "A"},
{signer: "B", voted: "C", auth: false},
},
results: []string{"A", "B"},
}, {
// Votes from deauthorized signers are discarded immediately (deauth votes)
signers: []string{"A", "B", "C"},
votes: []testerVote{
{signer: "C", voted: "B", auth: false},
{signer: "A", voted: "C", auth: false},
{signer: "B", voted: "C", auth: false},
{signer: "A", voted: "B", auth: false},
},
results: []string{"A", "B"},
}, {
// Votes from deauthorized signers are discarded immediately (auth votes)
signers: []string{"A", "B", "C"},
votes: []testerVote{
{signer: "C", voted: "B", auth: false},
{signer: "A", voted: "C", auth: false},
{signer: "B", voted: "C", auth: false},
{signer: "A", voted: "B", auth: false},
results: []string{"A", "B"},
}, {
// Cascading changes are not allowed, only the account being voted on may change
signers: []string{"A", "B", "C", "D"},
votes: []testerVote{
{signer: "A", voted: "C", auth: false},
{signer: "B"},
{signer: "C"},
```

```
{signer: "A", voted: "D", auth: false},
{signer: "B", voted: "C", auth: false},
{signer: "C"},
{signer: "A"},
{signer: "B", voted: "D", auth: false},
{signer: "C", voted: "D", auth: false},
},
results: []string{"A", "B", "C"},
}, {
// Changes reaching consensus out of bounds (via a deauth) execute on touch
signers: []string{"A", "B", "C", "D"},
votes: []testerVote{
{signer: "A", voted: "C", auth: false},
{signer: "B"},
{signer: "C"},
{signer: "A", voted: "D", auth: false},
{signer: "B", voted: "C", auth: false},
{signer: "C"},
{signer: "A"},
{signer: "B", voted: "D", auth: false},
{signer: "C", voted: "D", auth: false},
{signer: "A"},
{signer: "C", voted: "C", auth: true},
results: []string{"A", "B"},
}, {
// Changes reaching consensus out of bounds (via a deauth) may go out of consensus on first
touch
signers: []string{"A", "B", "C", "D"},
votes: []testerVote{
{signer: "A", voted: "C", auth: false},
{signer: "B"},
{signer: "C"},
{signer: "A", voted: "D", auth: false},
{signer: "B", voted: "C", auth: false},
{signer: "C"},
{signer: "A"},
{signer: "B", voted: "D", auth: false},
{signer: "C", voted: "D", auth: false},
{signer: "A"},
{signer: "B", voted: "C", auth: true},
},
```

```
results: []string{"A", "B", "C"},
}, {
// Ensure that pending votes don't survive authorization status changes. This
// corner case can only appear if a signer is quickly added, removed and then
// readded (or the inverse), while one of the original voters dropped. If a
// past vote is left cached in the system somewhere, this will interfere with
// the final signer outcome.
signers: []string{"A", "B", "C", "D", "E"},
votes: []testerVote{
{signer: "A", voted: "F", auth: true}, // Authorize F, 3 votes needed
{signer: "B", voted: "F", auth: true},
{signer: "C", voted: "F", auth: true},
{signer: "D", voted: "F", auth: false}, // Deauthorize F, 4 votes needed (leave A's previous vote
"unchanged")
{signer: "E", voted: "F", auth: false},
{signer: "B", voted: "F", auth: false},
{signer: "C", voted: "F", auth: false},
{signer: "D", voted: "F", auth: true}, // Almost authorize F, 2/3 votes needed
{signer: "E", voted: "F", auth: true},
{signer: "B", voted: "A", auth: false}, // Deauthorize A, 3 votes needed
{signer: "C", voted: "A", auth: false},
{signer: "D", voted: "A", auth: false},
{signer: "B", voted: "F", auth: true}, // Finish authorizing F, 3/3 votes needed
},
results: []string{"B", "C", "D", "E", "F"},
}, {
// Epoch transitions reset all votes to allow chain checkpointing
epoch: 3,
signers: []string{"A", "B"},
votes: []testerVote{
{signer: "A", voted: "C", auth: true},
{signer: "B"},
{signer: "A"}, // Checkpoint block, (don't vote here, it's validated outside of snapshots)
{signer: "B", voted: "C", auth: true},
},
results: []string{"A", "B"},
},
}
// Run through the scenarios and test them
for i, tt := range tests {
// Create the account pool and generate the initial set of signers
accounts := newTesterAccountPool()
```

```
signers := make([]common.Address, len(tt.signers))
for j, signer := range tt.signers {
signers[j] = accounts.address(signer)
}
for j := 0; j < len(signers); j++ {
for k := j + 1; k < len(signers); k++ {
if bytes.Compare(signers[j][:], signers[k][:]) > 0 {
signers[j], signers[k] = signers[k], signers[j]
}
}
}
// Create the genesis block with the initial set of signers
genesis := &core.Genesis{
ExtraData: make([]byte, extraVanity+common.AddressLength*len(signers)+extraSeal),
}
for j, signer := range signers {
copy(genesis.ExtraData[extraVanity+j*common.AddressLength:], signer[:])
// Create a pristine blockchain with the genesis injected
db, _ := ethdb.NewMemDatabase()
genesis.Commit(db)
// Assemble a chain of headers from the cast votes
headers := make([]*types.Header, len(tt.votes))
for j, vote := range tt.votes {
headers[j] = &types.Header{
Number: big.NewInt(int64(j) + 1),
       big.NewInt(int64(j) * int64(blockPeriod)),
Time:
Coinbase: accounts.address(vote.voted),
Extra: make([]byte, extraVanity+extraSeal),
}
if j > 0 {
headers[j].ParentHash = headers[j-1].Hash()
if vote.auth {
copy(headers[j].Nonce[:], nonceAuthVote)
}
accounts.sign(headers[j], vote.signer)
// Pass all the headers through clique and ensure tallying succeeds
head := headers[len(headers)-1]
```

```
snap, err := New(&params.CliqueConfig{Epoch: tt.epoch}, db).snapshot(&testerChainReader{db:
db}, head.Number.Uint64(), head.Hash(), headers)
if err != nil {
t.Errorf("test %d: failed to create voting snapshot: %v", i, err)
continue
}
// Verify the final list of signers against the expected ones
signers = make([]common.Address, len(tt.results))
for j, signer := range tt.results {
signers[j] = accounts.address(signer)
}
for j := 0; j < len(signers); j++ {
for k := j + 1; k < len(signers); k++ {
if bytes.Compare(signers[j][:], signers[k][:]) > 0 {
signers[j], signers[k] = signers[k], signers[j]
}
}
}
result := snap.signers()
if len(result) != len(signers) {
t.Errorf("test %d: signers mismatch: have %x, want %x", i, result, signers)
continue
for j := 0; j < len(result); j++ {
if !bytes.Equal(result[j][:], signers[j][:]) {
t.Errorf("test %d, signer %d: signer mismatch: have %x, want %x", i, j, result[j], signers[j])
}
}
}
}
26:F:\git\coin\ethereum\go-ethereum\consensus\consensus.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package consensus implements different Ethereum consensus engines.
package consensus
import (
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
```

```
"github.com/ethereum/go-ethereum/params"
"github.com/ethereum/go-ethereum/rpc"
)
// ChainReader defines a small collection of methods needed to access the local
// blockchain during header and/or uncle verification.
type ChainReader interface {
// Config retrieves the blockchain's chain configuration.
Config() *params.ChainConfig
// CurrentHeader retrieves the current header from the local chain.
CurrentHeader() *types.Header
// GetHeader retrieves a block header from the database by hash and number.
GetHeader(hash common.Hash, number uint64) *types.Header
// GetHeaderByNumber retrieves a block header from the database by number.
GetHeaderByNumber(number uint64) *types.Header
// GetHeaderByHash retrieves a block header from the database by its hash.
GetHeaderByHash(hash common.Hash) *types.Header
// GetBlock retrieves a block from the database by hash and number.
GetBlock(hash common.Hash, number uint64) *types.Block
}
// Engine is an algorithm agnostic consensus engine.
type Engine interface {
// Author retrieves the Ethereum address of the account that minted the given
// block, which may be different from the header's coinbase if a consensus
// engine is based on signatures.
Author(header *types.Header) (common.Address, error)
// VerifyHeader checks whether a header conforms to the consensus rules of a
// given engine. Verifying the seal may be done optionally here, or explicitly
// via the VerifySeal method.
VerifyHeader(chain ChainReader, header *types.Header, seal bool) error
// VerifyHeaders is similar to VerifyHeader, but verifies a batch of headers
// concurrently. The method returns a guit channel to abort the operations and
// a results channel to retrieve the async verifications (the order is that of
// the input slice).
```

```
VerifyHeaders(chain ChainReader, headers []*types.Header, seals []bool) (chan<- struct{}, <-chan
error)
// VerifyUncles verifies that the given block's uncles conform to the consensus
// rules of a given engine.
VerifyUncles(chain ChainReader, block *types.Block) error
// VerifySeal checks whether the crypto seal on a header is valid according to
// the consensus rules of the given engine.
VerifySeal(chain ChainReader, header *types.Header) error
// Prepare initializes the consensus fields of a block header according to the
// rules of a particular engine. The changes are executed inline.
Prepare(chain ChainReader, header *types.Header) error
// Finalize runs any post-transaction state modifications (e.g. block rewards)
// and assembles the final block.
// Note: The block header and state database might be updated to reflect any
// consensus rules that happen at finalization (e.g. block rewards).
Finalize(chain ChainReader, header *types.Header, state *state.StateDB, txs []*types.Transaction,
uncles []*types.Header, receipts []*types.Receipt) (*types.Block, error)
// Seal generates a new block for the given input block with the local miner's
// seal place on top.
Seal(chain ChainReader, block *types.Block, stop <-chan struct{}) (*types.Block, error)
// APIs returns the RPC APIs this consensus engine provides.
APIs(chain ChainReader) []rpc.API
}
// PoW is a consensus engine based on proof-of-work.
type PoW interface {
Engine
// Hashrate returns the current mining hashrate of a PoW consensus engine.
Hashrate() float64
}
27:F:\git\coin\ethereum\go-ethereum\consensus\errors.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package consensus
```

```
import "errors"
var (
// ErrUnknownAncestor is returned when validating a block requires an ancestor
// that is unknown.
ErrUnknownAncestor = errors.New("unknown ancestor")
// ErrFutureBlock is returned when a block's timestamp is in the future according
// to the current node.
ErrFutureBlock = errors.New("block in the future")
// ErrInvalidNumber is returned if a block's number doesn't equal it's parent's
// plus one.
ErrInvalidNumber = errors.New("invalid block number")
)
28:F:\git\coin\ethereum\go-ethereum\consensus\ethash\algorithm.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ethash
import (
"encoding/binary"
"hash"
"reflect"
"runtime"
"sync"
"sync/atomic"
"time"
"unsafe"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/bitutil"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/crypto/sha3"
"github.com/ethereum/go-ethereum/log"
)
const (
datasetInitBytes = 1 << 30 // Bytes in dataset at genesis
datasetGrowthBytes = 1 << 23 // Dataset growth per epoch
```

```
cacheInitBytes = 1 << 24 // Bytes in cache at genesis
cacheGrowthBytes = 1 << 17 // Cache growth per epoch
epochLength
                 = 30000 // Blocks per epoch
mixBytes
               = 128
                      // Width of mix
hashBytes
              = 64 // Hash length in bytes
hashWords
                = 16 // Number of 32 bit ints in a hash
datasetParents = 256 // Number of parents of each dataset element
cacheRounds = 3 // Number of rounds in cache production
loopAccesses
                 = 64 // Number of accesses in hashimoto loop
)
// hasher is a repetitive hasher allowing the same hash data structures to be
// reused between hash runs instead of requiring new ones to be created.
type hasher func(dest []byte, data []byte)
// makeHasher creates a repetitive hasher, allowing the same hash data structures
// to be reused between hash runs instead of requiring new ones to be created.
// The returned function is not thread safe!
func makeHasher(h hash.Hash) hasher {
return func(dest []byte, data []byte) {
h.Write(data)
h.Sum(dest[:0])
h.Reset()
}
// seedHash is the seed to use for generating a verification cache and the mining
// dataset.
func seedHash(block uint64) []byte {
seed := make([]byte, 32)
if block < epochLength {
return seed
}
keccak256 := makeHasher(sha3.NewKeccak256())
for i := 0; i < int(block/epochLength); i++ {
keccak256(seed, seed)
}
return seed
// generateCache creates a verification cache of a given size for an input seed.
// The cache production process involves first sequentially filling up 32 MB of
```

```
// memory, then performing two passes of Sergio Demian Lerner's RandMemoHash
// algorithm from Strict Memory Hard Hashing Functions (2014). The output is a
// set of 524288 64-byte values.
// This method places the result into dest in machine byte order.
func generateCache(dest []uint32, epoch uint64, seed []byte) {
// Print some debug logs to allow analysis on low end devices
logger := log.New("epoch", epoch)
start := time.Now()
defer func() {
elapsed := time.Since(start)
logFn := logger.Debug
if elapsed > 3*time.Second {
logFn = logger.Info
logFn("Generated ethash verification cache", "elapsed", common.PrettyDuration(elapsed))
}()
// Convert our destination slice to a byte buffer
header := *(*reflect.SliceHeader)(unsafe.Pointer(&dest))
header.Len *= 4
header.Cap *= 4
cache := *(*[]byte)(unsafe.Pointer(&header))
// Calculate the number of thoretical rows (we'll store in one buffer nonetheless)
size := uint64(len(cache))
rows := int(size) / hashBytes
// Start a monitoring goroutine to report progress on low end devices
var progress uint32
done := make(chan struct{})
defer close(done)
go func() {
for {
select {
case <-done:
return
case <-time.After(3 * time.Second):
logger.Info("Generating ethash verification cache", "percentage",
atomic.LoadUint32(&progress)*100/uint32(rows)/4, "elapsed",
```

```
common.PrettyDuration(time.Since(start)))
}
}
}()
// Create a hasher to reuse between invocations
keccak512 := makeHasher(sha3.NewKeccak512())
// Sequentially produce the initial dataset
keccak512(cache, seed)
for offset := uint64(hashBytes); offset < size; offset += hashBytes {
keccak512(cache[offset:], cache[offset-hashBytes:offset])
atomic.AddUint32(&progress, 1)
}
// Use a low-round version of randmemohash
temp := make([]byte, hashBytes)
for i := 0; i < cacheRounds; i++ {
for j := 0; j < rows; j++ \{
var (
srcOff = ((j - 1 + rows) % rows) * hashBytes
dstOff = j * hashBytes
xorOff = (binary.LittleEndian.Uint32(cache[dstOff:]) % uint32(rows)) * hashBytes
)
bitutil.XORBytes(temp, cache[srcOff:srcOff+hashBytes], cache[xorOff:xorOff+hashBytes])
keccak512(cache[dstOff:], temp)
atomic.AddUint32(&progress, 1)
}
// Swap the byte order on big endian systems and return
if !isLittleEndian() {
swap(cache)
}
}
// swap changes the byte order of the buffer assuming a uint32 representation.
func swap(buffer []byte) {
for i := 0; i < len(buffer); i += 4 {
binary.BigEndian.PutUint32(buffer[i:], binary.LittleEndian.Uint32(buffer[i:]))
}
}
```

```
// prepare converts an ethash cache or dataset from a byte stream into the internal
// int representation. All ethash methods work with ints to avoid constant byte to
// int conversions as well as to handle both little and big endian systems.
func prepare(dest []uint32, src []byte) {
for i := 0; i < len(dest); i++ {
dest[i] = binary.LittleEndian.Uint32(src[i*4:])
}
}
// fnv is an algorithm inspired by the FNV hash, which in some cases is used as
// a non-associative substitute for XOR. Note that we multiply the prime with
// the full 32-bit input, in contrast with the FNV-1 spec which multiplies the
// prime with one byte (octet) in turn.
func fnv(a, b uint32) uint32 {
return a*0x01000193 ^ b
}
// fnvHash mixes in data into mix using the ethash fnv method.
func fnvHash(mix []uint32, data []uint32) {
for i := 0; i < len(mix); i++ \{
mix[i] = mix[i]*0x01000193 \land data[i]
}
}
// generateDatasetItem combines data from 256 pseudorandomly selected cache nodes,
// and hashes that to compute a single dataset node.
func generateDatasetItem(cache []uint32, index uint32, keccak512 hasher) []byte {
// Calculate the number of thoretical rows (we use one buffer nonetheless)
rows := uint32(len(cache) / hashWords)
// Initialize the mix
mix := make([]byte, hashBytes)
binary.LittleEndian.PutUint32(mix, cache[(index%rows)*hashWords]^index)
for i := 1; i < hashWords; i++ {
binary.LittleEndian.PutUint32(mix[i*4:], cache[(index%rows)*hashWords+uint32(i)])
}
keccak512(mix, mix)
// Convert the mix to uint32s to avoid constant bit shifting
intMix := make([]uint32, hashWords)
for i := 0; i < len(intMix); i++ \{
```

```
intMix[i] = binary.LittleEndian.Uint32(mix[i*4:])
}
// fnv it with a lot of random cache nodes based on index
for i := uint32(0); i < datasetParents; i++ {
parent := fnv(index^i, intMix[i%16]) % rows
fnvHash(intMix, cache[parent*hashWords:])
}
// Flatten the uint32 mix into a binary one and return
for i, val := range intMix {
binary.LittleEndian.PutUint32(mix[i*4:], val)
}
keccak512(mix, mix)
return mix
}
// generateDataset generates the entire ethash dataset for mining.
// This method places the result into dest in machine byte order.
func generateDataset(dest []uint32, epoch uint64, cache []uint32) {
// Print some debug logs to allow analysis on low end devices
logger := log.New("epoch", epoch)
start := time.Now()
defer func() {
elapsed := time.Since(start)
logFn := logger.Debug
if elapsed > 3*time.Second {
logFn = logger.Info
logFn("Generated ethash verification cache", "elapsed", common.PrettyDuration(elapsed))
}()
// Figure out whether the bytes need to be swapped for the machine
swapped := !isLittleEndian()
// Convert our destination slice to a byte buffer
header := *(*reflect.SliceHeader)(unsafe.Pointer(&dest))
header.Len *= 4
header.Cap *= 4
dataset := *(*[]byte)(unsafe.Pointer(&header))
// Generate the dataset on many goroutines since it takes a while
```

```
threads := runtime.NumCPU()
size := uint64(len(dataset))
var pend sync.WaitGroup
pend.Add(threads)
var progress uint32
for i := 0; i < threads; i++ \{
go func(id int) {
defer pend.Done()
// Create a hasher to reuse between invocations
keccak512 := makeHasher(sha3.NewKeccak512())
// Calculate the data segment this thread should generate
batch := uint32((size + hashBytes*uint64(threads) - 1) / (hashBytes * uint64(threads)))
first := uint32(id) * batch
limit := first + batch
if limit > uint32(size/hashBytes) {
limit = uint32(size / hashBytes)
}
// Calculate the dataset segment
percent := uint32(size / hashBytes / 100)
for index := first; index < limit; index++ {
item := generateDatasetItem(cache, index, keccak512)
if swapped {
swap(item)
}
copy(dataset[index*hashBytes:], item)
if status := atomic.AddUint32(&progress, 1); status%percent == 0 {
logger.Info("Generating DAG in progress", "percentage", uint64(status*100)/(size/hashBytes),
"elapsed", common.PrettyDuration(time.Since(start)))
}
}
}(i)
// Wait for all the generators to finish and return
pend.Wait()
}
```

// hashimoto aggregates data from the full dataset in order to produce our final

```
// value for a particular header hash and nonce.
func hashimoto(hash []byte, nonce uint64, size uint64, lookup func(index uint32) []uint32) ([]byte,
[]byte) {
// Calculate the number of thoretical rows (we use one buffer nonetheless)
rows := uint32(size / mixBytes)
// Combine header+nonce into a 64 byte seed
seed := make([]byte, 40)
copy(seed, hash)
binary.LittleEndian.PutUint64(seed[32:], nonce)
seed = crypto.Keccak512(seed)
seedHead := binary.LittleEndian.Uint32(seed)
// Start the mix with replicated seed
mix := make([]uint32, mixBytes/4)
for i := 0; i < len(mix); i++ \{
mix[i] = binary.LittleEndian.Uint32(seed[i%16*4:])
// Mix in random dataset nodes
temp := make([]uint32, len(mix))
for i := 0; i < loopAccesses; i++ {
parent := fnv(uint32(i)^seedHead, mix[i%len(mix)]) % rows
for j := uint32(0); j < mixBytes/hashBytes; j++ {
copy(temp[j*hashWords:], lookup(2*parent+j))
}
fnvHash(mix, temp)
// Compress mix
for i := 0; i < len(mix); i += 4 {
mix[i/4] = fnv(fnv(mix[i], mix[i+1]), mix[i+2]), mix[i+3])
}
mix = mix[:len(mix)/4]
digest := make([]byte, common.HashLength)
for i, val := range mix {
binary.LittleEndian.PutUint32(digest[i*4:], val)
return digest, crypto.Keccak256(append(seed, digest...))
}
```

```
// hashimotoLight aggregates data from the full dataset (using only a small
// in-memory cache) in order to produce our final value for a particular header
// hash and nonce.
func hashimotoLight(size uint64, cache []uint32, hash []byte, nonce uint64) ([]byte, []byte) {
keccak512 := makeHasher(sha3.NewKeccak512())
lookup := func(index uint32) []uint32 {
rawData := generateDatasetItem(cache, index, keccak512)
data := make([]uint32, len(rawData)/4)
for i := 0; i < len(data); i++ \{
data[i] = binary.LittleEndian.Uint32(rawData[i*4:])
}
return data
return hashimoto(hash, nonce, size, lookup)
}
// hashimotoFull aggregates data from the full dataset (using the full in-memory
// dataset) in order to produce our final value for a particular header hash and
// nonce.
func hashimotoFull(dataset []uint32, hash []byte, nonce uint64) ([]byte, []byte) {
lookup := func(index uint32) []uint32 {
offset := index * hashWords
return dataset[offset : offset+hashWords]
}
return hashimoto(hash, nonce, uint64(len(dataset))*4, lookup)
}
// datasetSizes is a lookup table for the ethash dataset size for the first 2048
// epochs (i.e. 61440000 blocks).
var datasetSizes = []uint64{
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29:F:\git\coin\ethereum\go-ethereum\consensus\ethash\algorithm_go1.7.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// +build !go1.8
package ethash
// cacheSize calculates and returns the size of the ethash verification cache that
// belongs to a certain block number. The cache size grows linearly, however, we
// always take the highest prime below the linearly growing threshold in order to
// reduce the risk of accidental regularities leading to cyclic behavior.
func cacheSize(block uint64) uint64 {
// If we have a pre-generated value, use that
epoch := int(block / epochLength)
if epoch < len(cacheSizes) {
return cacheSizes[epoch]
// We don't have a way to verify primes fast before Go 1.8
panic("fast prime testing unsupported in Go < 1.8")
}
// datasetSize calculates and returns the size of the ethash mining dataset that
// belongs to a certain block number. The dataset size grows linearly, however, we
// always take the highest prime below the linearly growing threshold in order to
```

```
// reduce the risk of accidental regularities leading to cyclic behavior.
func datasetSize(block uint64) uint64 {
// If we have a pre-generated value, use that
epoch := int(block / epochLength)
if epoch < len(datasetSizes) {
return datasetSizes[epoch]
}
// We don't have a way to verify primes fast before Go 1.8
panic("fast prime testing unsupported in Go < 1.8")
}
30:F:\git\coin\ethereum\go-ethereum\consensus\ethash\algorithm go1.8.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// +build go1.8
package ethash
import "math/big"
// cacheSize calculates and returns the size of the ethash verification cache that
// belongs to a certain block number. The cache size grows linearly, however, we
// always take the highest prime below the linearly growing threshold in order to
// reduce the risk of accidental regularities leading to cyclic behavior.
func cacheSize(block uint64) uint64 {
// If we have a pre-generated value, use that
epoch := int(block / epochLength)
if epoch < len(cacheSizes) {
return cacheSizes[epoch]
// No known cache size, calculate manually (sanity branch only)
size := uint64(cacheInitBytes + cacheGrowthBytes*uint64(epoch) - hashBytes)
for !new(big.Int).SetUint64(size / hashBytes).ProbablyPrime(1) { // Always accurate for n < 2^64
size -= 2 * hashBytes
return size
}
// datasetSize calculates and returns the size of the ethash mining dataset that
// belongs to a certain block number. The dataset size grows linearly, however, we
// always take the highest prime below the linearly growing threshold in order to
// reduce the risk of accidental regularities leading to cyclic behavior.
```

```
func datasetSize(block uint64) uint64 {
// If we have a pre-generated value, use that
epoch := int(block / epochLength)
if epoch < len(datasetSizes) {
return datasetSizes[epoch]
// No known dataset size, calculate manually (sanity branch only)
size := uint64(datasetInitBytes + datasetGrowthBytes*uint64(epoch) - mixBytes)
for !new(big.Int).SetUint64(size / mixBytes).ProbablyPrime(1) { // Always accurate for n < 2^64
size -= 2 * mixBytes
return size
}
31:F:\git\coin\ethereum\go-ethereum\consensus\ethash\algorithm go1.8 test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// +build go1.8
package ethash
import "testing"
// Tests whether the dataset size calculator works correctly by cross checking the
// hard coded lookup table with the value generated by it.
func TestSizeCalculations(t *testing.T) {
var tests []uint64
// Verify all the cache sizes from the lookup table
defer func(sizes []uint64) { cacheSizes = sizes }(cacheSizes)
tests, cacheSizes = cacheSizes, []uint64{}
for i, test := range tests {
if size := cacheSize(uint64(i*epochLength) + 1); size != test {
t.Errorf("cache %d: cache size mismatch: have %d, want %d", i, size, test)
}
}
// Verify all the dataset sizes from the lookup table
defer func(sizes []uint64) { datasetSizes = sizes }(datasetSizes)
tests, datasetSizes = datasetSizes, []uint64{}
for i, test := range tests {
```

```
if size := datasetSize(uint64(i*epochLength) + 1); size != test {
t.Errorf("dataset %d: dataset size mismatch: have %d, want %d", i, size, test)
}
}
}
32:F:\git\coin\ethereum\go-ethereum\consensus\ethash\algorithm_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ethash
import (
"bytes"
"io/ioutil"
"math/big"
"os"
"reflect"
"sync"
"testing"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/hexutil"
"github.com/ethereum/go-ethereum/core/types"
)
// Tests that verification caches can be correctly generated.
func TestCacheGeneration(t *testing.T) {
tests := []struct {
size uint64
epoch uint64
cache []byte
}{
{
size: 1024,
epoch: 0,
cache: hexutil.MustDecode("0x" +
"7ce2991c951f7bf4c4c1bb119887ee07871eb5339d7b97b8588e85c742de90e5bafd5bbe6ce93a1
34fb6be9ad3e30db99d9528a2ea7846833f52e9ca119b6b54" +
"8979480c46e19972bd0738779c932c1b43e665a2fd3122fc3ddb2691f353ceb0ed3e38b8f51fd55b
6940290743563c9f8fa8822e611924657501a12aafab8a8d" +
"88fb5fbae3a99d14792406672e783a06940a42799b1c38bc28715db6d37cb11f9f6b24e386dc52dd
8c286bd8c36fa813dffe4448a9f56ebcbeea866b42f68d22" +
```

```
"6c32aae4d695a23cab28fd74af53b0c2efcc180ceaaccc0b2e280103d097a03c1d1b0f0f26ce5f32a
90238f9bc49f645db001ef9cd3d13d44743f841fad11a37" +
"fa290c62c16042f703578921f30b9951465aae2af4a5dad43a7341d7b4a62750954965a47a1c3af6
38dc3495c4d62a9bab843168c9fc0114e79cffd1b2827b01" +
"75d30ba054658f214e946cf24c43b40d3383fbb0493408e5c5392434ca21bbcf43200dfb876c713d
201813934fa485f48767c5915745cf0986b1dc0f33e57748" +
"bf483ee2aff4248dfe461ec0504a13628401020fc22638584a8f2f5206a13b2f233898c78359b21c82
26024d0a7a93df5eb6c282bdbf005a4aab497e096f2847" +
"76c71cee57932a8fb89f6d6b8743b60a4ea374899a94a2e0f218d5c55818cefb1790c8529a76dba3
1ebb0f4592d709b49587d2317970d39c086f18dd244291d9" +
"eedb16705e53e3350591bd4ff4566a3595ac0f0ce24b5e112a3d033bc51b6fea0a92296dea7f5e20
bf6ee6bc347d868fda193c395b9bb147e55e5a9f67cfe741" +
"7eea7d699b155bd13804204df7ea91fa9249e4474dddf35188f77019c67d201e4c10d7079c5ad492
a71afff9a23ca7e900ba7d1bdeaf3270514d8eb35eab8a0a" +
"718bb7273aeb37768fa589ed8ab01fbf4027f4ebdbbae128d21e485f061c20183a9bc2e31edbda07
27442e9d58eb0fe198440fe199e02e77c0f7b99973f1f74c" +
"c9089a51ab96c94a84d66e6aa48b2d0a4543adb5a789039a2aa7b335ca85c91026c7d3c894da53
ae364188c3fd92f78e01d080399884a47385aa792e38150cda" +
a8620b2ebeca41fbc773bb837b5e724d6eb2de570d99858df0d7d97067fb8103b21757873b73509
7b35d3bea8fd1c359a9e8a63c1540c76c9784cf8d975e995c" +
"778401b94a2e66e6993ad67ad3ecdc2acb17779f1ea8606827ec92b11c728f8c3b6d3f04a3e6ed0
5ff81dd76d5dc5695a50377bc135aaf1671cf68b750315493" +
"6c64510164d53312bf3c41740c7a237b05faf4a191bd8a95dafa068dbcf370255c725900ce5c934f3
6feadcfe55b687c440574c1f06f39d207a8553d39156a24" +
"845f64fd8324bb85312979dead74f764c9677aab89801ad4f927f1c00f12e28f22422bb44200d1969
d9ab377dd6b099dc6dbc3222e9321b2c1e84f8e2f07731c").
},
{
size: 1024,
epoch: 1,
cache: hexutil.MustDecode("0x" +
```

"1f56855d59cc5a085720899b4377a0198f1abe948d85fe5820dc0e346b7c0931b9cde8e541d751d e3b2b3275d0aabfae316209d5879297d8bd99f8a033c9d4df" +

"35add1029f4e6404a022d504fb8023e42989aba985a65933b0109c7218854356f9284983c9e7de9 7de591828ae348b63d1fc78d8db58157344d4e06530ffd422" +

"5c7f6080d451ff94961ec2dd9e28e6d81b49102451676dbdcb6ef1094c1e8b29e7e808d47b2ba5ae b52dabf00d5f0ee08c116289cbf56d8132e5ca557c3d6220" +

"5ba3a48539acabfd4ca3c89e3aaa668e24ffeaeb9eb0136a9fc5a8a676b6d5ad76175eeda0a1fa44 b5ff5591079e4b7f581569b6c82416adcb82d7e92980df67" +

"2248c4024013e7be52cf91a82491627d9e6d80eda2770ab82badc5e120cd33a4c84495f718b5739 6a8f397e797087fad81fa50f0e2f5da71e40816a85de35a96" +

"3cd351364905c45b3116ff25851d43a2ca1d2aa5cdb408440dabef8c57778fc18608bf431d0c7ffd3

```
7649a21a7bb9d90def39c821669dbaf165c0262434dfb08" +
"5d057a12de4a7a59fd2dfc931c29c20371abf748b69b618a9bd485b3fb3166cad4d3d27edf0197aa
beceb28b96670bdf020f26d1bb9b564aaf82d866bdffd6d4" +
"1aea89e20b15a5d1264ab01d1556bfc2a266081609d60928216bd9646038f07de9fedcc9f2b86ab1
b07d7bd88ba1df08b3d89b2ac789001b48a723f217debcb7" +
"090303a3ef50c1d5d99a75c640ec2b401ab149e06511753d8c49cafdde2929ae61e09cc0f0319d2
62869d21ead9e0cf5ff2de3dbedfb994f32432d2e4aa44c82" +
"7c42781d1477fe03ea0772998e776d63363c6c3edd2d52c89b4d2c9d89cdd90fa33b2b41c8e3f78
ef06fe90bcf5cc5756d33a032f16b744141aaa8852bb4cb3a" +
"40792b93489c6d6e56c235ec4aa36c263e9b766a4daaff34b2ea709f9f811aef498a65bfbc1deffd36
fcc4d1a123345fac7bf57a1fb50394843cd28976a6c7ff" +
"fe70f7b8d8f384aa06e2c9964c92a8788cef397fffdd35181b42a35d5d98cd7244bbd09e802888d7ef
c0311ae58e0961e3656205df4bdc553f317df4b6ede4ca" +
"846294a32aec830ab1aa5aac4e78b821c35c70fd752fec353e373bf9be656e775a0111bcbeffdfebd
3bd5251d27b9f6971aa561a2bd27a99d61b2ce3965c3726" +
"1e114353e6a31b09340f4078b8a8c6ce6ff4213067a8f21020f78aff4f8b472b701ef730aacb8ce780
6ea31b14abe8f8efdd6357ca299d339abc4e43ba324ad1" +
"efe6eb1a5a6e137daa6ec9f6be30931ca368a944cfcf2a0a29f9a9664188f0466e6f078c347f9fe26a
9a89d2029462b19245f24ace47aecace6ef85a4e96b31b" +
"5f470eb0165c6375eb8f245d50a25d521d1e569e3b2dccce626752bb26eae624a24511e831a81fa
b6898a791579f462574ca4851e6588116493dbccc3072e0c5"),
},
}
for i, tt := range tests {
cache := make([]uint32, tt.size/4)
generateCache(cache, tt.epoch, seedHash(tt.epoch*epochLength+1))
want := make([]uint32, tt.size/4)
prepare(want, tt.cache)
if !reflect.DeepEqual(cache, want) {
t.Errorf("cache %d: content mismatch: have %x, want %x", i, cache, want)
}
}
}
func TestDatasetGeneration(t *testing.T) {
tests := []struct {
epoch
        uint64
cacheSize uint64
```

datasetSize uint64

[]byte

dataset

```
976bd0944e3ccf8479db39343cbbffa467046ca97e2da63" +
"da5f9d9688c7c33ab7b8aace570e422fa48b24659b72fc534669209d66389ca15b099c5604601e7
581488e3bd6925cec0f12d465f8004d4fa84793f8e1e46a1b" +
"31b7298991c6142f4f0b6e6b296728ae5fa63ccb667b61fbb1b078003d18d97b906af157debed5e6
c55d5a61cae90c85f9e97d565314a2f9fd9e0c08430547d0" +
"7cfcee3271f921b95c32a11596219abaa30abc62c2c72c6725078c436c677320594df6bcb92134c1
b114fffec982a1f68f13a9f812f074b9fb9c78f2cd4c1c90" +
"7ebf1e447f7a422b06303921e3d54f430584d849eaa4b7d652e92a5d659bdfc462adcdd7991e8c66
a19da4ddb5390463d073941491859397f135ebbbdbdf5801" +
"cafb873c383893390141ae385515504d74a33608273310c312ba468046d2e20c271a38cc0e3920
b39705050e752f34f244fc23ddd17ff18677756a87671d4145" +
"3aebf97e4890da1d645f41eb20da92a8537c787ce419580073c46aa3bb154952993142ec5b4fb6e
8f108fd15fc618cd5c27b45a37ee6dcd52a4ce656c0f58604" +
"717ec55f5e592355f1f20e8316f8fd77243734a8b0f50ad93c1d95b5b0482afb22cd0667d935bd605
3d7198b54974e10d100df7ca3ec2e0bb5ccce5807b266e0" +
"8429d5fec2ae6ae1cc7c5efc27f19c89d4b4a6c5c0b9397886dac635ba37446ff528b582457a4fe7f8
03f1a47903574f8982d4a679b627396a4e97aaa12fa179" +
"0d31ba52e9010bc3c26ace81f702f86649fe9eeda9ec03b74a8a5cf540d82e22af33ab893564397df
c4edd8b1677350df5b82ab61d24db95f58fd2d78afb49c7" +
"2d2b1fefa8ff6606b8623829cc752ea37d663b945f3f1d48ad07b1416af252f81b55acd8f164da4faa9
d9453721b3b795041ce7df7c77edc13865dbe04fee331" +
"47daebe18c183c4a6594a6df3a4d2dc5e3811d805102c9c49286e3d12b38927fa49a7b0cdcb1d79
9f57118953e31c560aae213a1799d59a78ae68f0590347061" +
"fc2668caf08f860452f6b7d3ebc1efecc2e1227d33296b1f1850360dee7236e85274eaede4d18a58b
4261ce1f6a7d283dcf64e6d021813f82a566354445327e5" +
"6217279b2393fe5aa0f9eb149d4866e1105106bcc221810ceaf053f2ec733d8a22f409c1baf955e50
184005c5d55de907de97f5f713b62ae10937e1a7af6267b" +
"d2a239e8589017197c343b81540bc26bc52bffd5336fb1da1202a511c7175014d2f500b9d9ce78e4
```

"17a8d7f9195ee97201675a918e3cf520fdc19f92b7e6a3db806d4f3799361334082cc58a22ddb4e4f

"a2462e12578d72db6606f9e24ae659ff411ac9b31d696b8354fd08a591622967a14f8468eaaae390

"e7fa52cb0da09508b5a444aed05a54f416841247a4fe36bd5529029e3adf78b105e22468ed775f4d

b9f2b158d0fb27af352b6f78c129cad642fe909612c9d658" +

5760bd1667c177b26be325166c6bbed669a158fc87acd43" +

7b7818154ba2d6e4581589354d178bb6ae1c03651c44bbf0" +

0954504dd55f2c9b9e6b3a086370b2c0b6fec7efd6914e07" +

"4bc09fbd530a041dd2ec296110a29e8f130f179c59d223f51ecce3126e8b0c74326abc2f32ccd9d7f

}{ {

epoch:

0,

datasetSize: 32 * 1024.

dataset: hexutil.MustDecode("0x" +

cacheSize: 1024,

- "26627edb7a04869a874e31f448271077a7de3031cf81bdbc39848efee6075e0d65fa3a32640e9f03 95cf7ec12139992aff0a54e0a7dfe5048b3cc03246b56f7d" +
- "3093538a7b87538d8792a665bc589373621b2f3cf47d2c1f8f580fe34d79c6b2a66323ce89808ce0 e5cf77700f5a4446c4be01a310e8f7c7ebefe756b0044886" +
- "a0477c88ee8ea8c71503748a4cf9eb40ad5c1c8accf7c63c0f43a94ed2b8a5999df3ab9b11b80de7 3310e036ca88668e640015fcf9cd18eed05517d54896f43e" +
- "25e7931b44872c4e4183500e0e8c5103292bca1c0d6b0b00c9acce25d31204bb3e4f255c03a0a09 16664e9c831b28b364078109a74411a11afb1e610c7d1c9d4" +
- "ba5e10d0ee0da409654d9e7308395e17caeb9caebccb0192679866e6f2ecb5f10044333bb70d617 12adb6d74cdec6918ed9a71d9925da576a1e6f4e906a5cd5f" +
- "0e94a25e48a4141e4e2770144b63e2449b0f84c82879f34d78440cc430196ba85a213fdac1bcf279 a46d7592fa29a876bb7a2efb7081365522a3f06fdceaedd3" +
- "cc0335cef9ea570733fe8799bb1b918aa7732b4d175929d80c7844a78e19f2dc6a6febf648f49b403 20b0f7d784e7f84e45408d70b046bd01cbd8fdaf606fcd3" +
- "02f4e5a48ab8d13e93a246adfcc94f3109e02a7a969986e75b6ced6bf2d11a55ab77488e131b65a0 6398fa8e384dc90d875584c9b17cdcf2da5dd72a461cd07c" +
- "4a955c5fe48509b3284476c42247e086de7d63839b7358cf4ebd9edf9ac8b6fd0c096166405de19c 51e8785009d30feb67cdb8ff9ba55459dfdffba8c022e26c" +
- "0ebd399e4b76ccb4d5491a862c2c4d8cdf1461a96c9b98150e170efacec980edc00a2c7f6d7c6bea 3075627e1eb386a7f1ede1059da81a4ac5cf35aa173c88c5" +
- "1818dc0fbc688b68b82ddc225b6c87588e0c680e303e737c82a13e34be58df8b0cb336aeacc698c 79e7682ebb69e6cd6bdc5d11790c96afcfa9290f39515142f" +
- "5f90b938216a1d14bc049ce3f0ac135722208b989d2557d3520c2186479f179e50fe5b125b8d6638 a65047729c6249b9b2c6381c9103c97d1b389cc9cdb31c21" +
- "8a2eecbf4b9ad1dcfa57446cde88f96563a544c49d6f5303a84a1b7cf074fca78e67e72c9ffa0c542fb 646418c6434b16b771088140725cf2dc723c1a975c4ca" +
- "8a80e633721274907353f51e95952c2b403b45750b42ad10961f60473eb54616f61f7b038c5b7eca 475d6a2b844994a9eeddce4f7bb49782e50ef78bc13b85d1" +
- "9e956f47c60823f3d1981413cb78d309f63a844694861b11b5238961c71f61d82daef6795734f0961 e92b9167c57f48e91693e9656fcc6e88f9ce2d373da26bf" +
- "45b3dff50211fec72387005a7e04828e4ae7ddd10fc2332acf5f1b0f67adcd863752573c2d2448885 7bfc58c41af45be7641f5cfff611f184612fc0d695866f4" +
- "2b396b1d9881f442c4a995f4b500f02d4ab4b53ad6e01776ab0e244583f01301203a1515f3dbb739 06014e36c7143bf882b005f0228ca0562623893c8a24b7c6" +
- "4c2c561912010c121b5c3a1e35e75c0b094731e9c0d6acf5a2b1e5b179355525a175640579705f8 98feb98bffa25633bc126613fa27d2ceb214812902ada23f4" +
- "367a78655d0d2276095c9e83dfa79153730103963499c367c5621fecfd0888253df82b3d5716703e f92594cf269310b9e6c892c488edb3bba1d0b216e92f622a" +
- "7f8f7f00d2926d81a4c7ca6cef40d240576a8d5541ccf561c8e0e699925d20347ba7493ed6e182cfe 3b633e70b3ce3a0d90813574f6fe329c495d3cd46fd5d7e" +
- "bdde58d7eafcb134a9a5d3e5d66136e8c9b5d9ecac195dcc44158941c9fe2d87db52a7ddcedc9f82 ec160901cc36a9c877af80ceae0563dfa75cabde5d7a7c94" +

- "9f24bc190f7c2045368356474ff6eee284e7125d1c5f9a036fbde24cecfd3a30481ce077f20cbcb319 24368296abf66ce4834102cf7cb949d1b4c6faa6d006ef" +
- "21379cead5d5a39324d41555c46e0b42a1e871143e47f8e6b3d794e75d7a43c282732766d856e0 4e666ea346657b157404b0fc8534a2dee8243d40a5e37609e6" +
- "18bc1d52b91a7623aaf8214a97e4c8c5d860b31c3792b129354a121a7a7e42b50dfbe3ab6590769 401eb280545547a43c3a1455355d5d5fdedccb472abfe75b8" +
- "f5e7d62b0b31553d8d55de0c3c71e6f5a2abba6fe81e9a42ec1968f235bc4296c1ac5df743091745 3384450ab56dafa7c7af764cefa3b0bc861c52ae27692365" +
- "9d7d9ed7609958884147acca867909a75bb6a2c364debefaf98c7ff70c7f4acb5cdb81100fd79a48c 5139f8bbdc6553b509f1eb0f5d5d31886a602cd669b3f9f" +
- "59195a1fa2bcff1170003ba1b2e5e9ad7f2bfcd0573d0f2be9d8fc1773c3a63a2b9292cdbf9b4515c0b1d51772e5ee95303ff493d85314c989e269df4ec3a916" +
- "40988a11c6a4ad96f7d0541a150edf444c2b1672aa6d37564453b835c2d39864c05c4366492fc91 64bf73795410e7aae8206430403357fec6389142b4976b218" +
- "d70622b4098e322f73020a0d045f07668d1e512c6eeed6e2befbfc3a6ac64054396df96fd41f7aeefa 0ab1f66bb52ee1a1df066f365fc43ff0800b0398b621f9" +
- "a415895268505a81517c44a56dc94e76580fd107dba034bab9f4f4b8a9f881ff34c60c406c47b6d4a 998894401006aa88f328393f9cd55a2b4d24db5abbcb05e" +
- "20d392f3feab3ca12dac475eb3690f2bf9c699d7d90900d9a840068c8cdda2ca7a27bebd685a26eb 01a768259a65ab4d7efc1811c87a5a1f4e5038f6b3dc74a6" +
- "b46d9ac58d31bfc22dac23645aeef819329c9419326f22e1c24c53457baf62ae9b92ab5f999d4ef0c cfb5a21b7598340eb2d399ec81588b6a674c5a1e45aa238" +
- "c55cae8e1af0f5d64ea378b8afeab263a3a2e5c71cdda4cdb824ae55df2b0260aadf386275ef57781 d46f6da3d0b300ea68c14a620c25b5df738c54aef04d63b" +
- "7dee06cd225e9ed00e78abcddca5a133d8b5e0d9b287e6436014c5da729442239bddb7ecd3fe34 e6f6e530134a03ef45de4ae4fe3bf507f16cdfb9bab1fc90e8" +
- "dc565e4a7ead95352c5a894661e5d82c6d0fc47843d5cab12c4013db76c90734cbff34c73d0d873a c9b27b417665f4948469865f33179624860604a9aba2ceb1" +
- "68e74b6af3d1ad0bfcac4180ea844339a034b6b2c3e2f61f0c7afbaa76c1ebe93727df1d3db27d59a 5cf51b2baaf637b6eb8a20302ef9af0b25dbe3a5e74331c" +
- "6b0c8a0cf2a2ad72d2e19797983e09468ea95270dc229f2fa084dd2aa96e722016504f6d82508572 d9c30711c3ef41ae3ae2f36cc6f5dddbcb0b40d9499b24c5" +
- "4cd36d2927a6b9d57e335e4fca7f0f16887711a8c1ffa0b48bda46c506ca444b7c23e2c8dd086c2a8 7283d5fc0d58e9a384106837318dc84ffe65b52d4cb9141" +
- "2672adfe139c3327350fe3cf355a08c0ca43598a253833e114243c5253077d65643323f5d69b3c79 02d91bab7a0928754e7d80afab8d48539fcbe0d9ab83b4db" +
- "43a6594c4071df2ef35acd1f53006a570f09104f1776b26a303e2aec93a00d2fd8c952d1ca0e54504 cd9b469be7c1e71557ec31467ecc773ee817b17c4418712" +
- "163ae86646b20b80c85860e828c48e88f1309c9ff018e6a95f4c1178de6a4f9f5860039511845da7d 8727b5d824ba2502d0a3d76ce74372db77c2050c728dd65" +
- "b3a15da4f1e1e41c3c2acfebc5618e5e923d503c43a3421d2628ac037c5ce13c74c4ee14d47af023 23872f6bf2e8bf09d017ea6e8ec4d3f9fc4fb203ac4e1663" +

- "756b11629224c676713a42b1f43dfd6362876be1c4865928688765589e26c8dd8bc04ca18d76ced 7f786cdb0fa5028ae53991d5b7b45f93bbd50aeb97300f04e" +
- "69c6736f270907f6a7ad76dde0a365183a961bc8385511e0f22ce0cb8f3c42c5d3928621841e3028 5fb625294865409267dbb0cf91730ba2fb1088fb79789a54" +
- "a856311bdca5b0ac0e95fbc79b11c561dc03ea82db182808031e86ec327097143ee761bb62dae8 a9f4101fabcac1fc87b3c2080820582dc8a7a8287364550013" +
- "08053c781b3eb279c89e817fe97103b6930fef2dbf7728def389403a4283f63ec04ae953784b749f0 ea6f08749781cd17fadfd15bb197afd2f4e0a8aade2b1ad" +
- "5100cbdce49ed59658993c00e06bf57c0026b97beadc30cd25f586ff03ab40fcd731535c9a1ccb2c9 9dc7f8815feab767e1237cb069981f28d8fe26bdec24218" +
- "488e6086c0ab0efc5d4211fa0726b3a11387df9bb62b863a7b154ca390a268f5e49f50dec45d24be ce2a06575cc07a24bfff017d7445024739efb050ace5f345" +
- "98dacda843d4ef5bfb2c931dc16ee3dd8b61a6f01d9a7de8bbb6d89ca8695f8ef8bd1cc6e0455848f ac7691e6789218790270aef40fba114557fd88ff74fe8fc" +
- "476d9b9665d7e45582540710ce92c8dcad1ad8c05642a23a0d58c02db37ae1a0e70fbc5f71b1300 fe398c74cbad37fd57379f58dd3e2d3de6860a17acf3c9321" +
- "02eb4f9d596497bd849c5bfaf59a83113ef389b6896aa4d4665504a22486299993a9987b2bbdb47d59b3f6ce5d2c9f9ba33b5f0760388ca7f8d8af07c1cd28f5" +
- "67a417a59ebde4bb9867d4e7b7b79dd8665602c029e9a16a7718efde3d034f13f7f0b9af1702c335 893526cb87afc2100e874b25c37fd666bf34bf6a653c7cf5" +
- "44e1fe0286a6723c7d33461dea380b392dad68f79a78fe1b785d7833ca0d1cd68cff472991a625e3 099f3ad2cdc99bd37eae35353cecf424098389dbaf1885fd" +
- "7db54909a92ee879609eb2e9ef4de1f4338f0df53dbde486ede944ae69869fac701d4f1f48c83757b 470ea28c9de2ae5f1ef5d1c91118d16ca0d80b1baf3d314" +
- "056949df27a09eff70c9ac50b54feff67a165ce5e22ba2222defedc7c39e02356c3553e97524c1506 441527da4f5de121142ccd494f83114b3ca2dc37e15c752" +
- "e2faed7d50254124d68f67e26f4f50c9f0edf6e58b916ca830c4e33801dc11039b18292b87b08f4f2edbaaacddcdab78ff3a0004f86034080f2ca4394b14aed4" +
- "31e38e3605e6b257bd772954d2f4b846a17df7ed6e5dafa33964d9e56a07a19898fb4dfe8b2ddbd1 1fa0013e6ebc0e429a5166a43d1ec45557cd1fc1bddbec4b" +
- "2e9ca26395394c96395ff8f557bd0f7f805c09f0c18534585b7c7fc1d07f145372983ad77fa804fbb77 65934e72beae0929a87cc6bf7f6c242ff5db2d4d5541c" +
- "8c366d22e24e1da5379836fc0eb484683285f99f178b98ca170464bdff60ee04584c12c65408102a c6dc7d10bf58a7d770bf1b3c636a48f934f6f4bbdbcc75d3" +
- "fc551de3ebaf77006707f6120b3804f2bef9b4bd59f5996610c09ba3953994d1b78a9f3bc3bafeb522 66f10755ea842e5b4370c937c09afd34a092ff9b98b4d3" +
- "518bc2480d4b132455b7f03774ad76b83b254742117921c31cebeab5f39c145f7f373a5603d17dd9 5217ba1af37a0aa95b2992efcd02d0bb4ad08ebafb31440f" +
- "1ccfce45882b547ee4bf6ec7ecae11ed79fc63b03636c8a14ec4e0f6877eb658d839be2eac0f10a89 48e74203f46078ce66aad2764ff05590e2ac7a8dd8b3036" +
- "901fcb7ff3369ee989a28e34b9b62e1e607d14da3049ded1a4ee50257195eaaef995bed79ec8511 1abb522aba1fb306869a1ab381e82943f35345bb5502bb90a" +

- "e2a0af77526a84754ee4d600ba7f8ac98705ee687bab949a081849889d7b83a21a3dd34af84dc2b 9458230ef0ff44c6398d3c6e48e5c09c399ac4d4c7b285549" +
- "e0bcab7fd96de42f072f1cb633e3e250745321049d0d7ecdef4636e70e94c8414e76ecaedd6ee079 2e97de11e7dc1e1e1801ad68f9147278e268d7ad76c5bbb7" +
- "98386fdc13ca8c77569d96e0debba8ea3b751352136c8f1c8d611a69f1baa9aa4b9d0a476ebd5dd 21339ef7f97f09aa86b69a7b114cebe17a6b0e58bf52803d6" +
- "fd47d9eac3a988b51e9bca95c546d49367a3126bf8ee44fbd0e77611473a1d3d2de0ce4ea54f9bb7 f9dd0d0c065f613a623fad43a445eba294fd00037492914f" +
- "b74d10d0b97a0cf9bd3151c3cade89521f36b6fe1aca7f352e79a77d063da5337a7c88d90e9e566b cd97732baa4459305967c2f65adf1a4a4c7991cbc99df3b7" +
- "14335a107a97a4ab104bc94fecd1d003fe6d2f22e717853c449881c4ccaa7e7a1e44961a14a47a0 d0aa1b1493dd02760ff4d31fbddf5941f93c8e5925d1886e2" +
- "8761baef8610fa6be016c8f4fe65bb0f335152d5e94893e274f2ab90118e4c07957d252963755b4b 638ffc0a734fbe6e32c2e304b10a46a4eed330d101c4f0ae" +
- "011e7f94b89bc0eb9d358a6548b3f0c47ccc3c2d986d381437c49041629c6cbf61bdf0825efe17e4a bef128003681450ceeff0e28842895d8e338c247abf81cb" +
- "7260fd45042c1f6c630a4b195579721392e577fbfdb9f5b003a8b9a6bc15ae754f6255131a0be600c7b07e2cee1ffe32aad4687f9a429998ed9059a99fd879ea" +
- "c4dcb55f4551bbb70c187cf1b162e2ca4a929edd6ec9260877df652622ae073fc63c0d8522d3882b a888ac50a67a68fb6530193f93165093a1d8132e87d8887e" +
- "ff2fdab0fbae6ab9506dae61fada4023133d166bcf1956aedc3237c77d1c81dcc84ae957d89367b0fc950c78e58f2cb9c4fd93e16b94421fdecd46c3ff55592e" +
- "075dc08b420e0a545200895207c5a746a18ce9ab64a50d3dcf44da857fb65e4efc29b2b4d532dc6 a03b699dcfd77030a4945e6431273e25f06ad8f913c2a9eb7" +
- "59d8d3049868d337e451726d95c4cf8baf381096fc9b62679175dc8f14e52f8b99f212cab6544414c 62f17c8323256cce95356dcd351e34c7a1576b17c1406d7" +
- "5b8bcca8099a1993df1541ded61b876ae83396b191b719c4b1cbe50d73fc13da352d827ba09aa7fdfef3e4e0273c31ef4fd38b93cf64199c3969a7c09dd5e0f3" +
- "ff93a5a7db9c2c1ec25e3060bcb5481c6802e1eca78f31862842ea08e8f92b8e52856c4c9fedd0bf2 0e386cfdf926425f7756ff41fd3567c5bf334e96e3f492f" +
- "74bd0519d8d98efa0b427ba681b8b1be8fab041ff084dc5f8c4d5d48f481115d7e407ad8a6034f481 c2be86f8451980c3aa83a3fff245d90d13801a54527e97b" +
- "e392b25867882d43e3819f4a8aa380db63954ec23d2f0c11a7aa5bc7a3aedc43ecd3b024280ed88 43399e28deb954bfc11a3197fb14a9c9a895859e390e9586e" +
- "2ad21da39bb9ba79a62222d228a0fc96a24e801f00afc3f98d2168a8a253f24deffe461f6313de9b4 33e1d2e307239c0e3fd5d9fe4c8352c2c6797b1737e93fc" +
- "14d411bc69bbc9d78cf91734052b8aa1dab348e4c243b8e6d623865c135f807de8d5fd88f3921327 affa37066dd538351bc4ec52eece88856de0a424a87d062a" +
- "f68cf24db37dbaa8e8e96a812fbf32ccafdf1b9d27f11bea23df02143bd09061a881c010819a315a5b 6ee44b3c60979b3f7b41f488b2429d49377d6542fb0e22" +

- "d09a0ef5b81aa7c8134c0aecdc7a4f9228559d0bb826d30fd77fe0f834212647ce61e22fef0a1c10e b4177de81c31c12054a15f81b605619f3045646110673d0" +
- "b2d79d80577fa43284266fd2ed54f9a3b9df3509f79559c5bc51a58521bfeb2f95d8851527b7ea47b 92a694f6ea2b67dc2d4f506d11d2db32c2929cdf5c8816b" +
- "7f0c310cceb7ede08d5965ed2c7be6c0a317251c7d31cc4a15f6d7976a8a1e6a2f386fe0071d43a5 0bd0ce5e864a8e449fe9600c6e4a84866879c490de9f9d46" +
- "3f22708abf34d3e180dbb6005484a6afad373838cdac335f05c034e3090b2fbaaa53fa2db1f96bbe1 41d570f17363ff98672500e16994b79be74634755b09e66" +
- "f1b37e338c946bf85e06c97e31dbddf257d58fd10468278648d86f38710c2ca0b6ea7cac4ea0e2c4 9b96bf1998bde1b3d38aa853736308e12b4a0d467fdb8a73" +
- "0d810ce45518614bd5845f58a9835a5cfbe745f45ef59ce9a677d10d8c9f6294f1a0565301efb3c66 10afda35167150bd326c77057e530c213da63af3e6a600a" +
- "d87b16ec5cbf76a13764f71b3e7e0c867086ebd9fad02e1d747030064e071a13da4758cd0fa20872 b3dc350f4cbfcde1b68a97aca41e32207b40beddec412c0e" +
- "c75d87c6671ed94bda5170aa2866509161c28d550190675f60139a7b460469f3d4829b3c65f5d18 5936582629160522fcfdcc53fd0dcc8fc46de11d52bfcc5e6" +
- "3407ecbbb682cc1693d6543756fa4e068e92ae1a94924a1ff6891361e5f262b7d3c3a3bc2866f54e 6d03ebd5479afa3f424077d51668cc60e23b35fb0222ae22" +
- "5223ba8a8c416b68c8853022d150c951f06f8f85c2078d3035b8ac3ae984ffcfb024431acaae8bfbeb981870f9ad6bbb88d7d5ff34ba21a44cbffd0aeaa435ba" +
- "7d40d22602e807ac9a69db514ab13248133142cf03fac999a2b185f34d83fdb495ef042d4a5e92f26 24193c88858d91c0812b18fd67046cf50635e6ab1ea9ade" +
- "7b1fe783dc5147f14f9194cfa92c03a0456f4171f9e5c156fee1c607a1e9e06535f2dac49b92ddf5fdacbf88a062bd7ca5439bae645100121e598deee6043baa" +
- "85cc0d727f08d37a766a55a9ca21ffb6594fb73f9aad15be4a64bafddb6c85d00f7bb5705d9e56b41 0dd80df8b087b6d67c7ca84eff2ad699f901415fab21343" +
- "6351a9bdf83b440e29f3950c7e4c49963ab109686d78fce629e9207db2e17eb5f02f01db6441002d 72c06c6c6bbcdc0a7443589ba29909a5a78864ad51e1dfda" +
- "14782d869e4989ac3c5ef0aa1eabe540e9e7cd4e8eabe25b07f300a134a92718186f085d5c10a71 1ed0e574bf7550f6bccfc3c094d6e59619bde9fd892af8ef2" +
- "50e1cc3afdcd9c84ccb97344542843028b00064b0c3d18ac0f0703fe6f9683d40813abbb883e164c 5797bc1555338566cf8cdd358e9fcb0e93f08f7ae06a5121" +
- "c67a231106ad8fd42f0798d7185c2de78b8b76c10e82272a405212ce3b904f90236eeea02054953 b967cb614e8f8ac49b977152a52df981c86fa4a92f7f70eb6" +
- "cd4eb65986564039b0d77f8bafedb4fcbf9c34b8fe9c5fa87b0785c118a8624498fb0184a0dbbfb167 77579e1964330c12e494449f6aa5cf69ec4a32054be553" +
- "6027e0d27c7044abd4c0b8e43db703209037efcfd08944647a90a1ab0c71011753354990cac5a47 2fae44dc370aac8131ebdf31456a8484e7fdefd268cbf5cb5" +
- "85ac615039d3655b1348fc0b3b078ac41cbcaf6aaedcc1153bb8d55c307f45405ad6a959abb37bf8 891c8dec79a9d7ccd9b791cb60361d4a28f33ec0dfd13fa8" +
- "e0b9b29e14bf36f5047e51a39c2efcefcc156bd08e46c5c1000a3cdc2bb20713e19d6f492c40e51eb 93628cf85d07041ae5353e7decc824cbb1db8ab3a7a7fca" +

- "ff04c2af423bcfb1864ddc864624b827ddcff2a2f8fdb7a3d86d76e72b4f850ec1262d8fc89e7b12e4c c618afe6a2bdf205075c2008f93b7281d80180199409c" +
- "de850d1f14ca0ff960f69772385cf0f0a0f47cafd5489ea4fd8b68ec7aa539b942379139756c95bb90 818842cd43511edbb7577ae469f46728b13a61e6eede06" +
- "3a4cdfab5ed590feb807d55d76e518d1d74bfa6704f7c8ccc672824b4d5ef5fa5b3ab8fdf2b6c17534 04ba35b76aaa931a4e0e5ca7e440524166b23e9a8be9e8" +
- "635381f6c9086802d428fece81395dada6b3b866e905ec00ccc4fb9b8415dd15e443f84b7220e3b2 8700ce3d88f9c6df2afea39e0ead537a50ee11f0c247ee86" +
- "d4b3074e8761de4de611c409c6d4c369c2c11742a7763f6550edfaae49afeec33353a14d2ae6068 7dbeefd2fe29689da6ae79d7b06042dfd25a68bde9182fba4" +
- "1ac53706a8b96535057fc2f99ac84a9cfc6549920c3e2cab44e48a08e77207b6a95b2f6179d6dfd6c 2d9e3c91106a7a687e40bb2a1c5ccf566c0e31a0fdbd0a4" +
- "f270f9812208f939efd9698a8b28ce9c5633f18ace7ab0a7550d9e7e26cf62eef49200331e19a64be d648b5d18ceb389bafbcb3f280ba78e4cf03b053f2a5f08" +
- "3c852452837138004073cf6726143179386279f1a8f15d44876c19bf6c2e2992ce6056191bb1a386 f0e1f6f249495cff126991c6560e3f613e56525c0c49b5cc" +
- "2ea4e736d83480f2b45d7dc840b849887f54a2aa072e72e3fd0db34e5cddb02221fdf2a40fb6ec271ba3a09de8dc73c24328c5d9a33ae0adc9874902f25d5bef" +
- "4d85914557e2983c93fba16cdd4bd929e878b5d51b142b6e9aa0ce84871b7b03ee6cc13251e175 47c2d20a7d4e948760e207e29de58a7ccb71b87f99d79837db" +
- "d0f293ad3d33ffe91435598e8a4584b7b7ef5b1a895a2827b4976f81d335e4aa6feda35396908996 19a4cb34fdcbbecf1b8b38cec2ec7c07ce84ec3044f49656" +
- "28fdba8971585afb509526640d36425777b6ddf5b2a49d795fdcf71e57fd35f29fff37890541b6e152f 14fb6ea4c70a1b9f159d02ed895a68dcc276f5d5ae83e" +
- "47c021392ee22a398c8c73b3446d61562b3ec596036959aa645a65e5d24f733e142ec0e184b72a 2adcbe3913932b2c9503c856a7e989d24f306e01e99268188d" +
- "f858694e297803effeb8e28bf8fb63ed6787acc2c61f509e19099607512d40928a08e649474a43728 b63523175fad12ad088aade0c1e20815c7c12773bc959e8" +
- "640ee23eef2b1653ae8918615b45158a01be5a5f39a75a7c6cd8f1f6b463516539771ad251d5c2d4 0c5049877765512c44e58bd3b9ac3a0ac281771097880fe2" +
- "c9516dcd6f1373e1e8a52fc485d104004dcc839fe3d120f1432b213388dd37980ce8238c87a70d5abe95d78d696d2436eb23a8f620ce74335d5e47f6524b11c3" +
- "e22288644b539e3ab664dd5fd6bafb02897aab35adaef204f82d9318b22f45b787f5bacd74b01d23 537973060868a47f2e3a45c1d8805a1d657f2332af8170e2" +
- "9435d7540e70e92a8c8794bf22d3e11d54ff2d48cbc7a1ac3cecfc48f80fe521f6852f97aafa0605f3e 7084b15e61a74869512c9c2d84180686ea07b562cf35b" +
- "5a0ca529481ddbdba9c60729f821dc7a5a8b5c7eaef1ea7927d455a702aab538e7441933c4fff2d2 7de5659d6fa41f0ee72bb13a829839267f3a7b51a81a85b0" +
- "d737194d94e1bf8173248cb057cee19eb5e2cdda38c529298f3c4d3b95400198063c5b27e9262f9 c66425c65568a09035bed9cd55c1f2ec4becb6b9c59445398" +
- "ad5b7c85142e713b6dd32493dcb817c8bcdbd728e325c25c5a14d764b63f960d1e48a0bc7f4d2bf 51060f83b1d1f2591c6a9b79182e686b887a2c1461442e2f9" +

- "16e8582e298f87ca95a8052df33af20ebded7bb1c528920233d1aca3b3789494d97084890fa3db0e a7eb561b0087c4a90000db41ea072613f91ebba82790f33c" +
- "fd52cdd92d2ef1246911ef1dd82ad083881b72a08a40ee55884380dd136a7c0724cded69c6abf1f1 56b14ecd7284abcbf66522264145ee78ab0ef0d2a74eb390" +
- "10946d5efefb7175164e96621d3f158de8b57956b8b1155c35b32007e47d915cb61dabd556a3705 37737574741fcf9a8a23f7155bf1f0e3d3c0d2088d1191d9c" +
- "9c974139303f3dda55a70ab4810fddca3561114969d370f4e6bad60a53815eab1c4613854d04ba8 b049dd7ab1a935c728299d1502ff9aa3fbb356f87f2a52b6e" +
- "947dc79b5fd211ed31dee722d3fd857f43aad973fbfacb7cbfe1b2553bdc76142ccae5b4021a4647b 8d8087925dd3191a57198792b6f918de87a92705ce57905" +
- "f2dcfb67a20f8c77e700933432d60a4536d0959415f15f3eb8a788f1b19c497d3b68194e27ee73623 1835469d8bf0ce1717ecf533ab77dd97b35881d8eda959f" +
- "54a7935b1bc11d7f2e472757734afaf0463da3fad9804eb948e8d6444e8394b33f1c187618c7c023 71ee6d378ebb7a20b6049a5504daa71999d15944ee82650a" +
- "2388f374f3ec3afd4ca58ef3f2588997d194a2741252cf6562e00cd6b5c5fe4066454d2b315031769 4052b4dafb40c2f04c850e4062cd8f0af2da75280046850" +
- "77990788b27fa457ae9d0b622d18fc070f1d2661ecab529b5cb82f30a29610dc6a9e93ca9a2617ab 0109957a45c1204e5eedb8860c6f4d57122060f39a4194fc" +
- "a285f1e9e7a75cc3511b8cb4865719c2260a630845051876e7795bba59573b6ce5faf7e5708eda7be25dd49c8cace4c04c541074d703e6601e043f6c63a0a371" +
- "1a381f0ff83d136f4aa29de266169ce5b3105cbfeffba370fa306a93830e3c0519a495b8b9f4b72078 e2c45421b4b0667f903676a1339c70ddd1a90dbd21853b" +
- "2826ac3fa5add5073c634d4c5e87db0efe18638ee93c460257e52aacb8600ff36739818056110b2e 974a1959e3784903aa97b0fcd9264f7d8f6bb5d8b7d9f03c" +
- "4b643955bf7966250936d4e7d651712db5e695a6a36b5e6f56c651ff737042b5bb73638e21ca6ce9 a3e63fbb1906675d97001d7ee240d277d62df18acb169677" +
- "963d231c5276bdf5767ec35fbedb062e61c23d759aefd287b2dd62a0d6f0518d90b3c1756fde50afd 33cab395ddf3cd538b9ad8862a199141331c63110c9ddaf" +
- "fa3d6c63a1fb1b45529eace826cc29a1df5df327bb782e573c41864c18e6d31401d19719326e5c35bb50de7fdc67177a6a6015b4264fecba2360ab72ae8b060a" +
- "6c66c5a05782a15fe3c1833b47e3495d29f2cfa579fcb08f02fd064e9ef2ef5564ac6a43cfbcae7d79e 9f87ebc2176611823c6624db11892f8c47f8c96a49539" +
- "1c18f821ecdefb343eae3fd98dae1ef96fa3527788543c0d06d9793579cc62d91dc4d25312901c63 68ba81c8536c6287230e8f97d25f6c77366609580cf26a27" +
- "88502a9aada84a794d3674ae11cd1742cf245e9d9502dbb5b340c2a6c79e3607f6b47666e1ea991 ccfbdf6cc41ede46d043bc4d3e5e6882414dc65d62f9f47b9" +
- "fb7b828a89afd6361ae458c2cdc82f459c54977072702ee5a4c22955b8019d8b8d91f558897c4b66 1f8e5412ccdc10c40521303c0ffd353a0c04cebca5622a71" +
- "192b144d0f9c5c0706a130df887526b7b6e0f358ad9f7d0fd4d87c5fdb29a7453388c0d009da0d4c4 7a5d6cf8363892ac42b6ce3388771f698802b4dbfd66aa3" +
- "5fa6a6f8b42dd8446324501c807b6e72cdd35cfe08956a52f86bb4709fe2980f62152dba3571f18fcc 4c1cf7a25384c4b5174e93e5afc9b9f12db2bd505ddade" +

- "d670d0d71b9548f9a07ef98521961cd96e8f363cf3222336bc4baa284b5305aab47dace615c1b3f3fb1ee23ad9ca3f58b086d9169ee5b2d3c2831e1db4f905da" +
- "11e1fe79e3d48c01bd9879ed68391e4d24d6db8d6774cb8747e7ea368aba3bbf355386408af4a59b23fce74a5e673a1044db66ed8529a65462269480736cdaa5" +
- "0784fbd77e1c41197335b4c517af8a67eef5b7165c5fd6022cceed0396089c3985c36595497db0a0 fcae478e4e4d68c57b93f466aae86dd4244633beaa8116a0" +
- "de25d2a54353b7ee85fee58ad4780a2957d69816585a64f65e75f332614aa6786d1a1432f6acde3 85d3d6e870bc968c60c81401726a958f0caae336c83a9523a" +
- "c174faed43ec67473dcd151506e334a6aaf1731dd3aaa831f934be83beaefafa11810e7eb140f4fe8 0cfba574e6106c1bfe9f0b20173a4ec2663ce0580df6daa" +
- "7966a3a8906677ab680025782c61b95cec6a73b5deb16599e6521f9c6c4cae0d9286566388d518 1d6ba11c51a25c62b510d9b1793f3ce9f73ff0c9226c8aae69" +
- "5d014287df074a244014720ee38e3968557db00aa63dab71854b8573c42c65116e3d88bf040d53 ef3165a5827c717179e2939e310be5eaf6fb75447ba98ce925" +
- "98e83a32a90eea848500a30eaaaceb307d37b1201b83a744468a1a52632ce5525c1fce5f702421e 42e7cc4c61caed539dc09001cd31a8a2b48a783c36c56a3a2" +
- "d50de42c63981c86642cc92bcceeec8a66b4afad3c1be1df4bcb8beedd442c281080c94692bf4531 96ed1a66a074d56a8e7f60238ce18358373efc173e70c691" +
- "f832e1139bc04e6258d77cf7529af7ce5eca28ca5cda818625c0bb5beca96d99fc9b6689a7771434 aa96e23c55a41cff7b7b718df58260b3bc91762034debf49" +
- "7d8ca8d5764c52bc9665bf86db5407ee1b786d90f8d7772597eceb98f0121e3996e771d951568a1 62f6b71042998db8208ece5b8b0c68107b8e2079765b0d8c3" +
- "2747597072756208b0d84415a5334a88d916bda390e26ccf3046b860e7ccbe22c48cd3d3f51bb65 a98ace74d52613f782db726babd02780b8d620655bf9d551c" +
- "ae9ef3056e3d24f5e7c3105c4857492fedd244ac2b8c30a874c1446630b042d819bc6b6d2d96829 de903db22af706e93c5ae876d72c633600222443d1765bc62" +
- "a8a20c458ae55bce8cbbef753cccc5e7d929408d6a3709467373651f0163128aba4142ecc56ef11ff 1fabf5eaf6e955b4252d1350e9002300a1236ab2fa0ed34" +
- "c9cc7dc1d4f09bd31296cec1493e725b57cc496fdac4e8d26197376bda7f74c0965c4352bc9d5c73 1df04f9908899cce6ec3afe15210d115992b2d95308dd032" +
- "13c557ac527424c7db02475a2fc78b88d022d212c3d02d5ee490e2436e6e572e8a1330465b9052f8a3de01aab76662d18fa3d076fb77103fe432d549bc861fcf" +
- "f63f3401cda31673ee48826b68b387802fea4471deb1fc928586f1b1614c16311c9820b563ab0112 c28af5c1af5121818540c4b7d7f549b33906c1b86c6674ad" +
- "799acee7342e4a79d9295493b2430fd08f373338795764621bca444868f3f42b0e40abd4b8e148ca d2861fb4980b83bb58d40eeecd8d8cb1ef1ece17b0ab72e5" +
- "06c6e650a3a43081f545acbac51ed7e121df51edb75120cce30ef7dbf41fad331120e537fb35be45d 93de4fac0cadc7e5f644e2b767a285facd5f12845559785" +
- "57f4afc276e21d77f6162062430dc8918435f035f435ea419ae9f1ddb6afd46b243f8bd6a3a33e797 0e7e76fab9ba6afa72a4806189462f9d0f231a23e3ee1cc" +
- "51cd10cb9043a27deecaca866751f971254fbe3084c243ef5f516bb652988b770896ae5abfa12db2 eb2abe404cf694e9f60d47e734e260ae668b750e11b26001" +

- "0d2bee5ca555a44523742fb069e484f7a69c12d4bad026c03ed7af10ebc9cf2f54d143fbe4de83448 df80668217a11f5a1187f35ff306e6c685cfc2417c14aa7" +
- "aeba1fb7dab05c913fbcbb8e677dd0f89324048862220ab6f5340c38b70804f625f5a526d6675a49fdc22ea6ceed477097fc723a7b6eaffd65c48dbee13df566" +
- "f8f3449d91abb367cf37a8460fc8072c4ac75f88be8b9c840ef438cbf12a2e7d55799f641316e3381f72265425f3e90fbeaa9919533d8f9262da27f1f933d4f9" +
- "a83e07aeb968016fed89e7b16babf0b6af3800a27c9c3d330b6bf8be447d31bedcc526b1bb53ecb1 0c3ea098bfa7d014d93274bec70b6e82bd5c443e860835f0" +
- "ae82b7be7c78cd996e0990e3cac8c1c431481c8159ae1dbc40c03f4ac543e5758f347e12715822d 86c881030de83a76ba1c49e4d4836bab7b5287122ccf523d2" +
- "33935d802d2bca303cf57b36a5ff17e7c611f1cf99699881ae464da2911d77580587a7228db8325f2 04adb14413a13fe318e995d60e35c88bb47b99ba9ee8daa" +
- "3e40ce5818876a3911107a159125dcf768ba04074e5771334e0de430c439070422508577e474e9 532f7dfbc489d0c87d37103920415b6c116a422ac15e0736a8" +
- "1e1e317adc87005f868815950882fc7497794c5eaf76f9def434d198304ff495bd2f9f4026aea33045 0741fb969700b953ab265aabf1fe146d861ba2aedc53d4" +
- "f929abec2dee710aed8fa605fbb9bba914eaff01fdc113836d34d855383e4a311b4ec6ef6e80dfe32bc8035d84ddc4e2c305c112b93560112c1f3dff800d6043" +
- "7eab01991f924075b4dea4db01c377ee1ca374d383ff1fbb463bf7078f6cc7509a0ecf536871abe7c 95bf89f29c71f72f1a2002854113cb0d6d2192c00123010" +
- "8dc9477808a218f84afb81f0274718c024393d5be66edaac7406e520b0c8e2c02ab98ee7b290db2 61f2122ea68bd79f2cc6dc64936af5064cce2b4d1b7078703" +
- "951b6b81b9b60b99da4c2d12bbb50351a5b7713541db0958740910ff69e748c71bc7470a3c05489 febefd384e06d267371935f652736bbcaacb20c34bd50144c" +
- "71923b5a521ac4b1ba694d024ba51b4bef3ffcff74d5dc63810b2c0f529073e13ec3232d8647ad124b21ff73402d371c0db39d46cf4d2d4cf7ad43fd8dd365f6" +
- "9b6b7bcdf664df0e62ba58f3ca0c62ad6fdcc9b091fb4926cb47b5ff8de7d3b12bd8709a46e5c3d5f0d22934c7a0574ee70b87af97d0fa46f7d9673915fed1d5" +
- "a6c57197524ec9978d1bdf65633721ea2ccc25626dcb5e7f5e090b00e413c10a6d20b45fb8e98c22 928de6dda184e856c86792c7cd09d38e4333a76882d363f1" +
- "7f4d773ba104b2d04fd81027da087258fb175bfa8005c035a4719bac5b9630ae57889fb3b52a0fd4 7ec4060137b0f95fa5d5684172d07ca91e91eaf20dbfdea8" +
- "a3e23937f33d8774f30c7e8e5d4b2d5371e5ea5e8d290970904c4c1ff33baf675ed79599653808f65 2ec4fd0088877f7dd7973023ccc8377d1ada2b80c07d077" +
- "d7208686354f511925a3514c9e93c13525353b3d9528ab678e3e783c290ead88c2c3d6230bd4cb 3bf79fce6dc3e95bfebda41e5d994e61ab083d73408ff6b627" +
- "6996a263d2920170fff6869c2311441837a2fc190bee104328591b402defa38b421b972b01d020bd 20b1b6a6ae884b23eb829fdf032a81d4f199a87ef125d4cc" +
- "8662e24deb93700980e6ebc6882bcbaaa0283492e81f81e76bbe2ce18df4fb665436310658918ee 217b5da262f1a1adbd59eb3c555cfebb12280058c75b5b33f" +
- "8aa8c2d7cebf12ce46c5f49ecec5a865a9f0b65476793884f0021f8731b1bd288f55dfa1665776b2a ee1007bcaa6d92a76a2ba9925bcfa68db7cc727b2a07ebc" +

- "e24c0314c96ee4d6164c699e585461388dd73476a1e0519d92f51b64eb2842a7b17bb55d512d52da802df63206ee926f6a6a8c32de7b30e7cd3f23e37e0fd82a" +
- "556323736ecd9de77494a2f8702463f40fb837c2a99270b9050b0cbbc2c305a32380ff5fa94bf9c10 1c667f36293c12ff9aaf6e0a810b75230caf915135cbe6e" +
- "63ffb2a0e8632d32f72a65aa965fc556e10ddf6d5e40be919066eebda09d581a32156e1675300f52 c8b355e88696fc2a67dd8e350a6e902e082af28a9809ba11" +
- "ae0a5fd9c6627fb808d757147e5d59cffd9c45874478ab226e72909ccba6592a54391d072c7eb022 1f1ff7be9924b9d037e4f8c31e94fdc814a8c4cc7ad4c9f6" +
- "eacd5af66dd76bb6222b2fd3ea50a828fc3a91ef8b084214bfdcca56348517be18ca472166dd7f18c 8e444e3641486e7dada626ced8710fc73a2b09b6e9395b0" +
- "31ee2c48c9183851357d230204c911b345457de602824273193b795fc21e90a0c1cdaaba367874 24b23ce73e2116947f143f9641d39a4c07c2e40e02f3bd7c68" +
- "6899fd57e3eb23c6f5615c9dbc279fca0d4218bc79d928e70018533a85b4646bdc78015149b4d41 d77ec7b46900e7fd5250116ce978f825569bd887bf3fd0365" +
- "e1259a7514116fdcdd6da3ffdf432bbe8e59b9bca9222c5dca1eaa61caf29b8461ddced6f312838fe 490f742db696fadddd19bab8de6bedaade878be07aca4ac" +
- "76d69b81a6890e66dccd702720c3bd5601c6abdab95fbe4ccde6e35385b75e1977d5085ace928adfa382ea2890889017b9c4c81d9ba4629771f84cced6280db7" +
- "a6cd83ff9375ffb0a75a6bebba9a209f048788ba39127c1036e4bd0aad9be40754fd75295611e455 909a818a3541af32eae98df7222353a4405da0e7be9f1cf1" +
- "bcb823fdea7976a810e8a3c7bf93fd947f961a344a93aa1ba99bf2df48ec82769d8c08e7b14191050d5706a9467c9122f34e27f060dd4d6e936c414c4e551b9e" +
- "5d6b5b58347ed0012a8a323f41b43bf5e960b2806de59da85b998affdb490fbc965d569114223db3 ca65df69a617f6808bea23017327ddaf32990070aaf5f444" +
- "a9db44a57b5c92bc27bc71c5f8a2b6929edfed8e182bf5942564ef045c75448450eb1a4e4e09a187 5e8a4a74f229879ccb7a2f2cd0359abd91a782c2ec1f68bb" +
- "40ce0a63bcc014b198adc222fc957eec0483f5b93f0db91b7ab3b3e3c59841dae057eec97abb55fc 42b2de124946e66ed2a7fe8cd047cb79051b55f82594ab45" +
- "711c92364f932a5fd274fe184c85583ac7cfaf258c57e296f9c18fd181308565315e27272cbad3b21cb4490ca0e5f675365caac42f299e22d8a74ca51a9d0883" +
- "bb376804e234502db66067e7a434d38c3dc075346e888e4558b1745d00458df99db02f0e4c37702 fb0989387f74d002a924790a6b7351ee0f41684bef079be26" +
- "ee9d70b560c006cff4b08b9578afb5019c21ab9418ae4ecaa7a1cfed2d880a06a03c2c7711b601a2 cb3d9193e1577b4f1d0e614c0be1f69205fa6524fee80bf1" +
- "e1f1906b50e75fea2d19b8a83071a460145e1730581e5e9538888d2e797ee3cbd3b31399ecb4d6 244ee44362493802b142ea397c2e7a3c1bc86f0ea0546a38ce" +
- "574e1df0c27ad8a28dca70f659ae6a1369d8b3aee7d0dd24ea370cc2bc1b1a4dc9f63911b63e60fe 4ed8552bbca10e01c82d11b0ddf748d234b4aa3b31683c09" +
- "86358fad680dd2178902beadc4646b3eceff572631ff9e6b64d8a622ad9f0308cc46b7d422ce792fe 5573e9b9480e1ae9fedf31edaaac3b08c5a2c6c27d6b033" +
- "6b92a3da7b838bb0a2916ebb6ee72bf33a7fa70630491f49c67031ce4b9dec2315088d0a5cbf7473 fd121e0ef5f4e92d43114014c9f8c6e671086a446eb1f66f" +

- "70f0cb0c668998ed96ee0ad2687946681fe40dc46cbd170e0cabb6f6216be61221f171fb2f4273f58 c10d5c4eccafd1df62fdc8ac2c5c8f6d5eb637b71fa89e3" +
- "f8347343f89667a4450c5c6e3791034d2dc3a593185b55bb95d8f8f2984ef981e4b692c1383ace4c b2c4adb80d5d582857b5d0e3ccb12845a59587b47232ad20" +
- "926efa78e05a57b136e284401c516296b6b194d541ec165d11ef94f166cb52f45145d745ff3deaf64 3b5c45573ed0e69a22f0e0c9c5367f6d1398105516729b6" +
- "3f2edf1b01ad9633edf80efbba6555d4253fd99b45a36f16ba98ea0bb0d80533aed806544a084a39 8a692f698c78b9bcfc9b4d3328dd869dbf7085893b8dafe1" +
- "59e0517c2f6a3ddfd4a8c670072b30c96b90f81fcc08523e4fd75919752bfa52a1db7c374debbd83c a8e311b98b0d8275bedad215847fa8984cb50e108f69550" +
- "f6517d719dbb5dade1d3c283357e14b6d9e85d61e33813546517e1262a7cbac814d79cf6b7e21b0 fbbee9b6314f02b2d4e6995d2231670884c78cfd86a2acbcf" +
- "0a178ba64de2f13f022e22b9b968ceefaff374aff02b703811f3dc541a69a21d6e1c5d1aca48889b12 5ff1274e65413f61e42bb0194b60b65a3454c696033cc8" +
- "e3cc3613a52850296a0154bde0e2a81b7a6489bfce505dbe1bc44e0e1052f678297bb19cbdf7970bfa5268af8a54eee004063f9894118ddce7fae8bbba53a428" +
- "678cec8a2bf6cca2b1a5f4a2e95562437e4eae41167f39d2a150f7c46c1eb6da35587f7234d870b1 6ed91c7db548ddc99967381b4bb4f3a2b0a5ebcbc7ab1b06" +
- "7d5418768eaf7d526ca116e239ceb3ab393c45f3b32b713c11fa8e5ae8d7611e6008fa08d1305d56 55315a72c85a04dc853da3e8ea9d46674194e15226f126c1" +
- "a233c26dd7d3cc04ae572320d0c351911b6fcdbc0b8450523e96022f4b964d4e479b6cb1c40a6d2 7699b57ed2952ef7fb3172c69ba7beb8c8633a01070ac4344" +
- "d4c401acf8ca7fcafeaa59e1d4c2ff251bb67dbe10a862103df1b416fd2097fe412b3da9d4095b48ea 094fc3bbf2ca41e4452af3a179580e3bc11a7d97ba050c" +
- "ae1d6b8075da267b3ae2231a1fcfce0c976402f34963c007d4f85d9ca95646990d1bb09691ceea3b 34211dc58409e052d0acf8c2296a7e8fb52d7c673506d89b" +
- "847c369daec7909da8657e8976f59f2ef4c8a049b46fdf30d6d223ea4175e4d60e469bcea0eb3bdc aa4d6024f2b43cf6de9bb40efa9172381291079dd82ac5b2" +
- "39f2051a7f1aabcb8d50333e8c160de19ce1c76ced8056a0724ac630dd45ec4e315437391158a63 3c179a3d1f364b475454fd29c1e539077b9d5f7227786a5d9" +
- "d8ec78e5615c25e517e9fcaf07611b85dff2c131a1b11a901a431a601854e5cb627cf7b8b0c5e66a d6cf60b7ffd6c6441f9ecd58f414013279e9de533d8d797b" +
- "936cfdbfcc78342b7ab586457541df5f3b7d1873612df200896e2929f44c6fe10d24f7e6dbe52b6c42 c0a40c947c1cbda2a41437079eebcdc29716d80957c159" +
- "627e7366cc16df92cdedfa9f52edc848335f1c7152652fe24661a469fd503393229063c7ab20d8d89 5139a2f580dceac9f6dd4c4ac652b1d60c2b8a1b0b2923a" +
- "86c31742807549e6d523b3c88d31e8534b9e05a6c63f6c8fb8a1eb4dad733d92e7071e410f0087c a3074f4a2df511ae89cefe9ed09a8df603d61f23754e43cc2" +
- "e42bcdcbe58b0587aba9a62f32c7507116fdc8a9db3d65d6c0097c8f473eb7f3bcd11ab81d5b636b 0812b7982201a63d0b8d40f2c38f65ffd953668eaa5751b3" +
- "dab7f038aa7adbcd1f1102267c9d55d43649f9b4f65f1851546c5a9ef2c7ef56e84b16f12641e9d5dd aa78ec778b5f113b2e06bad5821e1a5203b006a774e36f" +

- "56c9336d92c8cd8bddcf014b6d58c394e2a93554af6361fc1bbd13c359fed98bb5adfa4dd1266e27 44e126e1bc029ab28fd68b648a2ab26ac23252171b298641" +
- "2621f2a8697a00ab3fdc1b3b04921390ee16d213601ab249a51830661051d34eb777f690fc2d8dfb 8e0898567e388830bac8b0bc896f43003feadf34256a927e" +
- "b4d9293e32ca135351a19d1246cda30551c87de1e148ff5ea576b67e19e1a0389b88a5548b3b1a8 cbee19eecc7de5c2333264c711d50d688a1c57eebc28dd6f3" +
- "3dc0e4cb857973c3d0f28683a6f3c09db9f54b8fabeca9e4f9b86d794ca55d6611858f0d48736adc1 0dd6763ed7199bad81369ab1f3de30f521d43382bcccb7b" +
- "be0178f716d5c3cb87488cebd7d9e2bbe671dfcf2512f1b815075777ea92a867f35e09ff0110e61db 24423d0598eb6fd078dde0dc2b5d7f5e0bb6fee207da109" +
- "2e656b5c982866d5fe01e6db79809646559a6f2b9088e977789aac74435dc625b54296b25788bfb bda9bbb25247d428f5141b03172fa11f12339b91ca96c92e7" +
- "ea5a128c8046087dc7a7eba63e3bdb200565d8a103e7b3c292b088eb06aa27b43688c8516bbffcf 123499574f00908ff43d66b79106cebaf16725f1dee600a29" +
- "7b3a3da878940867f9549e65c73ea798ca923b012fb8a7ef3e2ded1d2c4e85635219f627dc4feb90f884ae6436e7b44f9159f9889d8e194828e079cd2ee60a7a" +
- "6fbb6b8fc1f7355d7322709fabddd76e4283ddda3018b7882ad79b32bac133da415453eecd5bb1f0 deb4f3b987a71a2f2e60194cde63a42b91b39bfe51b4aa8c" +
- "20952b601df11d170c65a7fe935915890849a367936e97bd242edf305eaf2f4f4fb9e5ee1464c51a8 99ba5cc69cf56731502c1b75d0d565b1dce15440b0de0f5" +
- "58bd4f810bf058af99c158a2be0dd02a01bb5317f55675f4d42c6766fc61271954b6988c33a84518b cedbac8de305946d060d19c4691c026953ebd680a4c9012" +
- "0e8bd54675d6c33cc86e65f5cd3c34cb1e6fd47784a64f39e95a1945b5c21df2b3288f963863b333 66908b05c2bd499dd25c1b8e97329d7e435899afeaed174d" +
- "2a2471b6e8d6ad7a0b1b6a8b19fbd976362283e5abffcbd2cd310245092749b23e0d114e7276229 53487f373c833281a74a1b97742ca99e49cac14d9102e3680" +
- "404509889ace009c47d075ba9891e7f67b89aca3e213150f3c715cbab1869135601612d7dffda3cc 104b6508f56eb8b7e7f379b21e1ce290ce5fb96f53e3a7eb" +
- "c7f7bddcbdfc266f23b775602d8d12527d30446cb4144df7fe3c2756e232a8ffca625d7b6ea2c8c0a9 2e6425ba67ab75160623c39f01fd96856b582e257a6930" +
- "224c6da90a6eac4249214c3b85aef52835d904a8a5e224d59eae0c80a33b3141ffb31a7d8e62833f a4c850fa6be135558fff5434777df45feed00316c475759f" +
- "ac6e014e9d3cf23e7322281ed75623ed69a81d6f05ee7de193f6b44ede4a94ced27aef5ab9056144 593a836da80f5297875e7bd84d8ca6df95de8650b00b3528" +
- "123132f26aabf755d00450648e44f3beafa4dc746775958c6dd88bee825c29112a3af582bb2ebe62 8d70364fe9ad01b8a9961d5b71018690440151486114af1a" +
- "d85679bcd3eca510c6d6887e70e0d04b04fc2db5ab1eb21fff925b66f08f4fcbf31be3d743154056ba 137727b63576e72f1756029c86bbcf9452fc6cfd89f3b5" +
- "9f243d84c410253ba7c9284191a0ed87b2513901a93606f1aeb736c90dfe40c0a343d45e9a992ea 894b22ee5d49e0f7d55d9bddaa6c74bde8ca5839db67b77a9" +
- "ef740f9a47241f05e5dc1b9c95c459cc9db560b1db090daa3f4c6de46f695a158baaf357a1fc63ebc0d9db8144137ec4bd69c5af89cdf9cfa66e06bff6339d62" +

- "2c372fbe5a855d14fa7ff3726512f966e4da0556b29ca6d7517803f897d0e1911f9b46a291002a832 0091aa7016cb7ac993e35c8b0f5aed3c94ff0b5dadd8b77" +
- "d3bd1a0ac6b671c48c01d4a0fec7a01ad11040f213461759f9e029c835ca1d22f9a661b69d72bc46 e34b1be7ed85a21830fb87baa74d7ab145ac1647f5f2df68" +
- "671100d4d9e41082d3c81f3b5a6e603bb33fd56c1dbcbdce5e213c651da45d9d1dd7532d9a95520 2338387af6315137dc458fed62920a0e721aa7ff1660981c0" +
- "e4c3de0a4863f6f660a7c1b9745ea26036a25cfa37e1337ded405ebb0401d7041a7938800a97a03 2fcababcc06391a77a580b1a61de014db9d7e280ffa6b2381" +
- "ab6969ae5cfcca00a47ac2fa05be02aae7beb806d2afcc11dc0642d2a12ecde2d2926efd9fe790e1bee19f9114d22ca42f438ef656a1311e4931ab7fac93ed17" +
- "3f68ea0abed18cc2c8905bb2d599780690eabe4996e38872a3190fee361df9fecd5906f664106de4 835f8fbb657366327871a2d38cbb671df04e0d14fe97e260" +
- "c42eb07bd1d70514913c7a64a51e405cc92e06845e5a78981fef9822fc79e9937ce0513138f6bbf2 47f5c457da708cf84e30d083b4ba48d2d43d70e7c31e9482" +
- "4472617910a3de4369217b4daf892c2c3250d1de0457e88b3bcb5c4568f9b26aa675c551a9a730fe9ea8145ce7f8e23ec825be9be3b9edd588c391295fe31ac5" +
- "bfc97d2e438ca9bf6551728b3be6d6c6ac064baca763e0eaa24f754f4bbc84a4377de45fb6a8f3715 0865df18749df1af4ea911b62f616dd4dd4b25b27c7b6fd" +
- "99d8c00ce8a53fde3ced091891e8daf43cade10086be046ee5607003de24101db49b1a4fb0ac270 d05bab12583e263e903e94dab8bba7c785e40499ab01ff92b" +
- "b82c2e5342dce84881adedf77cab593f541e4c963f4f9ffc80a16bd4eb7f20ef4bf3f57abc7cbd86332d8be80f0794fc82767d13c71d8ee20468ee35c13308b0" +
- "dc29ebe8c6a81e02ee9a21807ff57e4d932edcaf59ae9e76f7cdad46b32f94a74982f0887d7083c90 ff54058e873b10cec67fba1b717deba5356e170dec1a40d" +
- "36c57674ad8d43c5c98022b553fe060251b994271585f702de3e71fb1c8e36293dd44a4b99a1baf3 3f6205e9fbc9acdfe8cfdf007224f93a7104e7803454fdc0" +
- "9fc5a20be59f600ee734847257a5ad62c599a7fa836d1174a6291e61c1be4b310bd4d7b7cb9be976dbdfdd2b99340a9863c8c0e5009165d7097317e6c3a29cfc" +
- "dc84b19bc68f38694998f626567b80ce6699124b12bae4bb9e661c2484f5109517318341287e142 a849d61d0d7b11d4996547e7325f28842dcaed26367f7a888" +
- "e58c24c857da2f48a9fb91c78cf351a23e82ae443223580a9fe15a6a778f6c13be66888219e3e159 71170712b6c356520cc15e4e75167993b66e6f125799cd40" +
- "86c72588a85f68361f1c2f09e87f9a4de95ef9a3b92c3313664a706cb72916b96a9cb50771f6917dd cf696ce8d7f2525745fb6edc30bf3fdaad66ca5b013300a" +
- "7ec7cd274327b1b9cd931c068d8fa9fd6336d59f6ac79b84a24b34c47e408b3bcb8ead49428c1239 22e54bfcaec7e39c4d6ef79e5645a35f715d151e679ef5c6" +
- "6f86cd013fdaab978ee4e52eea5e2753e693271344a1f215e1c690de06f29c856c469ccb484d445b acb16694f4def1537cdb32260705e8a50fd65e98a24967a2" +
- "456af6cf90643638999389a35de6e192068fd2e2ec29aced58611560c792ea5c7fa37583ebd5452a 8d94cbf1898937dd8aa6656047e6e03f84dfd0bded514a6c" +

- "b47ca71c2cf1e76f606c04374663712fd96925eecf0ac1c38392390c8cb095f39e1814252ded78b55ebeb9915dc5e2ec14fe99e3a075bd389ac601681f154286" +
- "885289e568a8646d94abc806b4637492e3a407cde582d42764eef0d56ab14b00e9aa1f64d8fdd53 3d4314145c8255c44d0c746af6da844d285eb044d57e8cafb" +
- "ab6c3b962e0177f11a839f4a5c0d2c2e8d5f76375ac115e0a89f460ea1be238f974a68e0693d1579 0117106c1a65ab5f7aa08e738aa888d5b56be39d2078837d" +
- "fb2357d86f5be85a9af41aed611b231495564493e46acc90c6a3e67d5b055320290aef508aa6a189 6f19cb5633edc0fec023216726e50960a44d81e0614ce748" +
- "6ccfdaf620eaac0517e8cdeb1095d55f3a60d61dd27d967eb26128b84c9ea8418779e074cee8961 c5dac811ce5ee8134d3910a47de7a1344293f5c64ae8f1b38" +
- "9d6c457dc74e7005c339394f5f24630f5e40cf270640d1e4c27cb6a74fb440f3203026acfcd31f39cd 4844ede7e785290878fac8770f930e96c3edf61748dc6f" +
- "b7476832cf77ddfbe8eb8e12fd002038630301439ef8a7659bb10593a92cb84018e1ec78856f403e 1eb9d6343aa0bbd77a63d776f1d12838f27f3cf6296ab0b3" +
- "b4436f0ec545a5a1e92a5351fb273b3ed56a40e5a5d25e0057f4077bfeba2e2d8cb17a553b15760 9b20bfb5cd2699af9936f50d823bb59a950a24b8fd15ed705" +
- "b1628663f0eb5b5c2b18f000ab039bc425ebafb2010e1a2264c38fa2bbd0f77e38eac8acd6705654 90fd60cac7fd28d988c8dc0658505dd98425f22c94647d44" +
- "5d0236b97ea58b3c71feee90be0055ce1fabda5ebfced9d9bf5efaeac8408c4b6bcdb39851cfe038d 88ada5211de2f0f69e9e3c62453106c366cf0c40971c0e8" +
- "e8f2a790aa66999a0cb4cdb57a8c2d812e9e4a66df2f001a57e291864339257ec26c9bc2dc6cb2eb 5c3301c167e1ed0387f9ce9f76c6759ebe5c68e8be378c42" +
- "e0350b344acbc8b40c95cee9e82bb43cef5e91a32a6be8a727d5fbe089321ede3abee4da6b9f417 75d7e9abc36f6a5d26ab88ba32978b5ea0ad63f0ce8a772be" +
- "5aa51143bcd00d78bdcbd69beb652139ad658dc7ad242b2057eacee092aab4940d6ff993a8c7d8fbe93c08c93c45d5f3a01058f3c75c94be9da1a19a97754734" +
- "b713e1ad6b7cd472619ec1abd4cf42f50b0648661c2b8dbe8976037c094c7176090ba94618e1918 db44f5d2c367a0c7f911132d9a8b2398b9417542c7ad99b53" +
- "a7ca48253bab8382a1a24d35b9b9818bda513f4b52fc576a71fa63e72aa8042ee1fc806c6fd3fc16e 07ed2caf9f82bd3bb6b393b2708c051c24c2e05aaf72531" +
- "d865888db06f719314d6094b2c4f0718c151c88958d2d6c8a6f49464f81cc46709dde026f4e05325 ea4ca2dddf9a79bf98bff3aa5eb412434f0b7457b4ed47ab" +
- "85a212e0c7720c78c961d56141bff0f964622d4d3984c1017de6f5846c72fae0c771a819ba6c111bd739fcf16f4b85f8101e7c3f0daefe753ec130a6f34c7697" +
- "4dc531f83715ecae28bf2e55111778ae42aef17fa95340584cfae3d4599af9dbd10211baf3aafa8ac8a07edf8243daffd6a6486b1e3be4b60711194261e2b646" +
- "e2667554cc0bb2fc07054b653231cede43154c9002890ca20b0ac81c4788847c6ecf7c174e528f36f8cfc53f3366fa9ce07b1843939cf6d318ed11f7ba6eb791" +
- "ce25e75cbe37d2ee3d45bea487d969de041011959c0fed4e6c86802a7485fad70059ece14a29b03 d4df41677acf71419ee63f1101060ca5e4ca0ab2edd71fe77" +
- "46c6bd9f36bdbbf0a9956eaaf974f7bef982cd34881abd686fe77b536c85d042d77dadd00c5cb0130 737e5318a025e6ae6af96ca28cbd41094d86a85765ff891" +

- "af825793910c406470cc61be5d9282911d2faf82abfb309598fce0101ca64abe3920701a958c20ac 35927733466a23de809afa2bdf331f68c3ab0cfa08b0c549" +
- "a20e9b50dbe85d22d215d0e5fef854ba271a4c0f95e6abca19018bdd4a042721887418136b4a60cf 291bf06ec47a5a4d2f9b29f988733c6bf6f65da5a95f8939" +
- "fe0f2bab0bdce98569a81f861014e532f6a995542db02b6bdf3169191d300fb0429c1cae1d2dd4d29 e0b61751576e04b558d38d3afcce8326c2871e969c1492a" +
- "8391c0becec29edcf7f038a8093471763db9f13b97114acf7a979f5ba3bf6f990317890ee0705850fb 97bfacf306a0ad621b2c3b633af01fc5aa059c0e22ed17" +
- "23584dde6cf140bd1d0087ca9090ca9f07d3b93c60938af8df976555455bafbd8cc986ba32fc3f15b 5962dbb2d37b6ae55a7de0c0c6f2366be0278e26bf9a725" +
- "f61f2bcb545d66f79261783f7f03395f2a5d27e56af62a01ffcf778c3c686e244bd9b7e5029d1d40dd2 250705c6825bf78e83730212640cb5ba54191b61fce33" +
- "9ed36200c4b8b75131e6d1efa913106bb0759aa8255bd6a9dc2b00407358f4523486575b111676 730094f46d0a7b95427df74f053c6611b4c465efa5310f760c" +
- "5ff081e841e5f90c2de35855d45a7f35ce73d7c7f9f61fbfa953398e042c3946aaa4b7a2094d95410b8a5ef76c8b57d49f77311192b3f4578f37bda1a426de7c" +
- "7cc54b5400bd16bb30cd8d1b7b42ff31c5e3759e3c9a7668174c02bc5a08f1bcc7e3ba145fa5f5c41 e48877b41b0ef8fffd0f75c6547047c2e7b7c7e1aef2cda" +
- "c4a778adbf71257618b4eb3c6dbd8211f829c1d6373415b969cc48f33d586d2678e7c1b441364a9f e2bb426a33b2a132741fac547766d196df3505fdb17977de" +
- "7853cdcd8d9932eb9452620aa4921b4416f65055d77573b132a40795bf142815b655e670bf2c446 4adb5d826a1744c8049d7a6cfbc8a4634e66eb32f0cb6fa17" +
- "ffa8925131c3a253101733406a2a3a0dc61ec3ca1448623b6295791d4e2d65d303f78038e15d0ef7 5d823759bcb4b277b51410c37d5efbbb2e3a9e0cd78a8475" +
- "05d44bb1fed7f72b1bf1a96ad0148e816d34c66b1b5faf172b8141ba007bf2e5dbbfee4b09ef66656 ea3cde54f086040d14116aa7f3584ab6773f6091a2fbcee" +
- "f59d6ea115f88ef9fcb358c87c35caf7c1a6022e141a3c688beef17da5a619e733d854218b30d5edc 39b933b19dedd6750acabc52234934b08f930b608a18008" +
- "838cb0fb73d4c78af0c468d9fa4fc5852135ae91ae00a99a6c603371d09b031ee37f87586cdc8389 7d8fd8ee2e07b9d0478a812d3f7eddca08860386e3ad9521" +
- "98d5fc04fd0aba4b3da6ab8bdd9eca8e0399a2012d6158ed75ced5f432a223449b4e3db3fd4b19c4 94a69e9f2670833f8a88f7b2873319e9495f03fc69b6d098" +
- "6006e3ffd8cdb9c1b98f72345848deea1b98ff6ef766f4398e642e5f2b217c1a87a608c1dc701bbb79 d75a4433ca1d600061836888a220ee262124d145d371f6" +
- "576f04cf71701133787a97aaa615ca98138c2be1046604d885e2f274b0de8743af50ad5dfc4c3a09 164448e102be577eecf77ffaec1724f91f00f908ff6af41e" +
- "57056dfa8f5dbcade85a66c10e524bae55922b4084407fb36ca8d6b7322f76a8139be9455a34440c 719d0db8a36385efa48841170c8d35046407b586f5bbd169" +
- "7cbaf6819b663fb17d0f0ae89691a099a8ccf47fa61fb6dbb22b3298e5cf2465e4b93c49da70fa7692 4fdf29389194cc5c61cb4b3084d0851bc3018270d1a24c" +

- "b4b04e8af927d9fec9ea1c9ce18d4dbe61f7aac0ffd4e7c2e9729b49ed9874b883ec644864c6d9ad 0422c4d89f87df1dfb2c96314b6a3e19afd21783f365445f" +
- "bef10562a26b48df42dc344ddd63fcc03220dbde98f1109cade221027c40f0f996f4beb29513c3979ba374c4c6a2c2dc6276ca6be66eecf1dcb245d6efe78aea" +
- "e49ece37f87894bef3c0cb1b993d974685564e2476c12c8d8f63a1aaf142fe34a6840be340b64f96d 441f4537dff434ddce630101ed9f78e807881f6b7590697" +
- "bc97e60accd7a135d8915781f4fc22e437145154dad0a39e5e306c117b11deb10462ba74d58e81d e7674ef0bcb20b38511991447f63ad906b11abd4ba88df3c9" +
- "e6931f87fece49f48543fed0439c88ad78f82aabb32dea03d030bdd76efef6b737daac2de2db1cce1 0e2ec74565b0a609606cbb6aa259ba88715229b8176c874" +
- "db3fc4f6db9f167e7b2d55b33a261f9eecb69a0d36ecf9ec4f8f9cee5b74bcdc5d77b02ada89f56259 edeec0d9ea866ccf454b9abd29d5d21041179912a5c302" +
- "1862d850c3ff483e09479957df5bde03a29504b4a43e1fd40af2b8a2653a37cae89c8d917aecdec3 959fecd32b7fd313a61e134abc15ad008aa993aba9629a5f" +
- "0af0ec713f742bee096e171729e70530b60f910ef83746a61580f0cc6d67723792c0e0e94775d5b1 edf37864a50678d197bb34a97e84d7f764c0bfe05f4b2d0c" +
- "dc431d1f4410500dbe2758eb05bb6b19b154707c255a97cedc6aec1841f1817f6bcba0b9a9c1d3a ebf747bec4423c71309fb8b4ada90dd9f7adbcffebbc905de" +
- "74ce531403df33457c4d0b970fea5df4f85732e3c33c5b8242b041141a8c51a62f0bb14dbe07b14d 3f5ce646d76e87b258e9b62128f9c0c0a8014f2c5b3d3dbd" +
- "a3a77be6222419cd3fbbd3b842c46c099f142bcd36442961e8205ec5d7fd159befdbff12693953307 026f1e06fd57b6447dd3cb52df466f0352cc46f27d1fc56" +
- "56e06f68ca2847d291421bc9e0af6bbcfb7b3ce07600827809506ba3f96f40ca22766f8cba32d4461 488f6596082a52c11e9ac908922075a7b443c41e55b719d" +
- "9cac9fb587cf02432e1accf3cb7a16de0d5bc3a1c0aeff5a1795680b4551316e3d7b5a9bc63a09c6f75b0f00eb69fb6ef5130c1ec40c7a7d5d6ccce364b74f63" +
- "a836a4a711027e592d6a70e10e573cc6d730a0def4a7a2d4dfcf3b0aba37fa2060ae6935710191c0 23a0b8e123a67ee811ed43b5127a1c4cf82d52ad6c40fd66" +
- "1160f77dc320bbed349c8b6d08b2a7a6234a8dc88e4744b51d2d7c56e02f1c3bea9e6c2c3d5522c a02ec7e0b8160555eaf28797ed30b5c931a73562791f5f0a1" +
- "b7ce83824bae17de449cff41312bd441f34df62904f4a0265d6fb9b8a352895ac6f0025d6b2074570 970b4e679c559d03ef40794708eae36567008d9c33f7fc3" +
- "5f8df7e901c27f408cc7fcc52631f1178695ea660d07df541e5a32721d145a32e8d32f06301b50731 49e8798371fdb1a2daa5e1d02c24da07682a2cbacf5af55" +
- "64810e479e5966dc6bfe14b4472c42cb154e19f7b8659d42de5ac926224cc6b0d8f3fa797058fd6e 21ea85146838c4612760d84e24341825b6931a6417327394" +
- "0154125254d4e11ac80e475a178605e851e1be39695cdc0781da241f232cedb32a04b1cc735288 2fb635162ec3f5fc5004cfa7d03780753c14173ae7b12a71cd" +
- "b40d4835023a00a4803bdfb6916956ade9f687af567e6f29981120d306084ad061ca1585f0e9497fdb27f9d54cbac8fecff176145114ebfc17e3f346b246ab91" +
- "094dac0e684a708b45dcea16378fc29683dd033310068339b13d995dce77a50f9ee9cb4cf564566 b05ce352a21159ad21e720e05ce6069a5ef4e9fe8ffd28516" +

- "8356a0b80c4d1da547776f486a117f6f7ff6557edae7d68834cd71973517cfe4af045ad0fecdead68edc8017000958b69410247a51bd9bd3152dd57389f25223" +
- "d5e88c0d343ab3aeb89b763eeb7ee48b3966fee147a4614e436c9a1a398487c80a001700666251 b3dd6a2e5dc96814d21e6498e75811ba4c51160cbecb7d5510" +
- "62697171a25a6abbc41fd806c3dfc83daaa10d7ce47f5a29ef0d85dda5a61429c637520e6a404862 4cbb25f53977254cf803848ad81f25eda07690fe7a0466e4" +
- "d18a2fd145dda1c94a994bc4ba5ce1aa1b50c38151febee757afceeaa91c7b35e57b90ff7b62efa92 9dcb962d32dde5a0bc3159524728621a3d7487eb7c3edd8" +
- "6df3f8a18e590039bfc84a22b23b11468c90dcdc8506187233d8a6b3dc9785ddf6f341709fefccde9 1a7a0925a8446b1896aabd6a6826ef88b756a9711cb3b78" +
- "1ab1f4df4d0515070e41fd5b0c5483270307e60eaaaf0b3a48f6bb96eef6141075445285675bb12f2 ce38b42c91c1e063400d7bba9b322a0783e7d2f5d3f8874" +
- "52ceb65bdedaa032336d969d2e0e3007d2ac07bcf054b9d0330f2e26c486c054bfa709fdabe283ed 9a4ae67cee24f40f2a5c4e70160e6ceead208ca400959922" +
- "70bc35be104c9ad94cdbe288b1c599db1758331340c9e927bc9d688e4186d5badd463bd3ba116bdc22a39c604778cd95503ce4ce642041e89bcdeb86fb19ab25" +
- "e1f94ed2a2f857b228ed4a582ad411d7273a0d5189bf7a2b87a135753e03383033b989ea532041ab9ed397ecb3ce61e01923b3729068f6828ffd12e2ab1d28db" +
- "6ed7423d458decb00476657a0580b4af3aa5615bf07df55beaa2bec71447aeb39791477dd09349b f573e29e9c4fd454b4bbf1e19591bf38dc47c83bf39babdc8" +
- "737d69ce4b586cd10ed406426b88e686c11072f04c680e8b6275166e2dbe91f701642b1b4ed92d2 3d6fe14f39ff7f5a09401f3a398eb4bb742f6cf10aa35e767" +
- "7e6e92aec791e94f8122e8c9cc9d0bc979e3eac6562ab614ff20330b00d9cdbd08e9deaeaf5cd67b 49164f550c5f5c2d7523fe5ad71a2bd03fe2a97329980cb3" +
- "049ecf6d677d815e56f7cc27407cf73528549ea98265ef90277c14763d5acb3572f5a482432cd828 8972af580fdd3418889bfa6a373c4813c4c45e933ea4ec72" +
- "cdd068089c2a30897dd57031445834de9f23faf506ad930d843b1cabad2c0aa8965d1b5e57032c9 69f9f55fe2a3049f4e63d5b5c6f5f760da5ba44e3bb9307e9" +
- "ea39973d05a74a49e15bb71eaecf62373153ca316fdd40b1c64ce2896c95a7b5df970c2bec85edb d5ed84fa7949c08d5ec4d987052fffe357d444e2408a22295" +
- "6ac1fb272f5023740b381e00dae9f09751a33bc6ad673c4221ce3f932164deb99f1da3eb3581caf47 5e385bcc56d47a7a1615a9543403750f0121d5482c4ea5c" +
- "94fa3428178f6a4deea08d754ba2abb3d1aa48c3e06f06ffcdf4571579d398cd991e60599e9633fae 6a0c07e10e538aebb7d33aa127c830f14b083728f6ad7eb" +
- "c9a60a0ba222f47780eaa82a21393a49defee97aa8c3aa2fa53a2af86059a7587074128c2fee7060f 398ae70b156d53aba0bf1af4bff10a966ce7e6382cec4b6" +
- "054a8f6b9ef0e8729ee182f86c862f9b7d5ea36ef7e15bed10ed41b25738c380e58cf42795e320274 9074fe5cb6e8fcb49a116f54d84734a834609a3443b8b42" +
- "97c05ced428f5756ba59bfc1535bc7e16d370d81b72b1f3f78ba75c820b22e485dc042e4f38e93cc2 918a491750c92998f03aee571cbe9abce4d00fdf9801f9e" +
- "8e0fa276822e1e5349945f1d337e656b431c48c1a2e9d4142ea14e9427881bf201ad8cd8effaa6fe6 a7e07c8112299db1b327a0cc34c9fbd35596f4ee25caeee" +

- "221afad93ce7df64aa6ac766cf4fe1660446dcbafdfb86b4e0fea78c29c3e84ce42da4a503178bd25 0a6dbc4fc65e397062229001da05d5be118dea7ca5ce67f" +
- "b4ee07a8b01e408aebef2c913434921df686a242b7d015a559f9efdc54ad62d7f31ceb7246304184 3d7fb60f948fed03ff143fe24ab81bd4ef6bdabb856ef1b7" +
- "174cc987436322271bf48423114e05758a08cdbf300931fc7e950830b7ee920f7033541f1db9b0d2b91cad80d06c049b05fd0a76d6dc211bef2a08d53b1d16d4" +
- "deb6fc87cabe00addf1bf76b83927de26bc2bb3f0cd5945d863b0c31cfe8fd4b60462000a911755cb ecdb6a98139041d52df498aa99aa3876836ce5b5bb426e7" +
- "c22b5977902e0b3425fdbdb8f44e8758b207b469c3e5363f552c89fbf778e95e8b7ff6566ab591fb68 a8bde38d8169c708a321b669c08d9ecf1a06c5321bb1cc" +
- "9c8a585b6381645edfbd1ea4a2ad7e7eb8be6c431958add393c0a257aeb283644c6fe97580aef61 3f1b9d83e5b009f7a4d059025c11e0a0a67801be511dc097e" +
- "4e7c065684effcafab83e0e716e2d0862e83b295f82089ed3ba4f6897c8d8eb2b358231f95eef840e 1fe22e9065de2b3dfb3633e2968135756cd9c109e8acbb3" +
- "172bbb6680c2e4fd69e179916a7849315c9f4dc86991d75cc6358617454694b3fcf2471ec7fca6ea2 d99f704b9aa37a25a3b3183c5e32e3711346ba2336d6001" +
- "489afb9cbd8822dbe4f0323ebf7cfa9367b6548213d473c0f07b1bb6d16e1c66fd2bfa1ca623e0314 9fc81eb6f71c12e7b4b76ca588548bb4872469687f334f9" +
- "7e114a16a0a58ec70ed74ef69dd96666a85aa52d1ca812235796d90b9af4296247f4c1ab632effea aef6acbb637f1aa9379195b3b668ca541bc6eb595bbc430b" +
- "28adc5d1a26fd4cc2239516ac9ca9c0c028110926a2f88881a5886554c31539f4c8260e16364f4ac 27710d2becdadf573f4a2b7b55d76ef059432c91c6f5beb1" +
- "56686a620bdb4aea50df564cc0c5ccd8a93c454e06b8969a0f59d63ae5a29105149c08a5de65e87b0dc445dc5d86db8788ba77b83e22125c69621140d7f17906" +
- "4ec0157a877cc51ce3c0d565bdf6c884f69b0ca631d6863770f6db30eff847e33c8b30d5714668a38 a09f454ee44ff2b7f97207f10efcba74325378f6f272ef9" +
- "9f09c501c12bd0a4155f559a604204b36751ce8d4c0af35a8b445a9290c305d5d3ea21f944e31df9a711ee90bd16a37850e2a87c3bd3fdecdc6e2f261a5d6d0d" +
- "580990fcab9228cbb39f8c79608d821ce27c10b0ee0b5a96474759f67970cbe03cec9fe594765bc9 35abccf867b9717a4087465c8604eae89497c8ffae7e46f7" +
- "ade2848916b54aa796809cb98a4364b7b44c17944dbc408909a92d4cbb24a514b72fe8de7d1cbb a0a101973fa9b29d97dcf1f4ed8a05d5e0cb38849dc6e2d041" +
- "16892ce649e0a553a727bfbb1d5794a059d6a411e43876e561d83bd22c054680cc8fa928f5f4be2d 849f02ddf9c6d11ba35810b81553e1938ab013663f6ef35b" +
- "08f06260932d7acf99f57967eec57a61f03d880c3225e53102a672f5842da21aaaee02444d372ab8 ed7096235a4926e3288912d9c736c2c4dc49918abdfdd6d6" +
- "d0df5be0133abd61b02a6f008909c5350f9077598ab2e612603431bddd3826e314feb280585b37e b89e597f7f0bdb738a9a93d9af224659d50c8f7479b240487" +
- "76c2a960eb18923fa2d3b31b3d20ef538759cf22f5b415d19bdae689f2bab651d79ff99f77a721bc1b 2233da12c12be0c9881ad82fc97a6343b3af8207dda8b6" +

- "5c600644d741b8a16750964e341e060260c4de26f991f3a1f6a606d1153565f1c9cfee58eef327edc 0e9cfaa206ce930b191f521be2344949bc75d583a413a96" +
- "ee4edac424cbf9bdad2883c96a1306b96ee059d8044e3b7af4e7138697f142774ed6409a86a3c6c 456600d4e405e6117ec759f4b22d7e5a185b0f9c67ad987bc" +
- "58d2e8c929d4a487e5b77201d7c1416878e8d63258b2f58727cb631494cf1d68b99c28493b99b04 09ccc1f9c218a2b95c45ff36563f0045ae5c3098f641ea6a9" +
- "b48a3e1489831b2d176a1e0cb2afe6bd8cc5e797de01391e47e798c1aa945d33d5e7dd607aa73c9efe93f0646adcd7e211303ac7deea4d02c80370e8e867e2ad" +
- "9942bfd5a66143560a1f59e5be1f3aeecd7eab689a4a481aec78045ae0604f69d9eea550152f6e2b c692529357b509d60e5a497bd94e63dc698cdfa2a3a55976" +
- "0b2d072a2fe9c1fd41f31518aae0edaab532591476a9c5a61cd76937575cef71ff5dd66e158e7820b 4b6bff4067cc26ee9aa66f41b80f078645b920512b5efd8" +
- "88b3644601a72e3f665b9c8f0ee246593667379b8fa043718f2d75c21d2a11640c328971c32d5743 c11ada6c95cfabf1c6b66e0b09342afc899e1f272ec48a7f" +
- "ba5a51943763bf969cbac879363e14dad1952517d8f4b463511adccf25e655bced7cd9666d01dd4f 2a0a21729ac4f44970c9c478a995d1c3b358a244110f1db9" +
- "fe6335685701e0c2660ae69d33a93a75e44f5374b979a5af140200db43ff612be2728548192ebfd0 a3860a9e135b910fe3fb249926d334167622bf4123bdf0d5" +
- "38e9ff2a3bb67a44f8407328e3c94b47d92e0401aa1db85459967699804df245a7808f972683afde d9cad8fbce15c1be38fd10c62c7abc302eb0537d5cc573ec" +
- "9d7813cc036d6bcc316e869eeddf7b30e4b837e9285eb20397b4d7e0d12080c502c750268bcd6ffc 323cb094afbe8304ae840d37be833878697f2cf931faf06d" +
- "28dc6c7e1b5df69327127b47eddd0237f1bb5942ee5903d8cbfe1b11484199e90fe7c8e7f2f725deb 2293630bd8c8a377d539736e2ccc2b90c08b97abd8c5ce4" +
- "ea91a6219ab06c61c31eb48a35587b3c1719f387bd8c2063c5a79d041ca8a9ffac2e3c728f74efdb74ee0730f84cb3a8aefff7c8a1b570127cfc93eb6d3327f5" +
- "ba7f886dee8be0548f710d6bfb18cbe5910bf61aed2c95028006f419241d968933aa00bb0760a41d 2693465827a00837a84cadaf8a8e804d175adc5915c6cb6e" +
- "fefb2cf70db063f2f3812da17586436c176aa0a815dfc7983eb88bfb1b6d1db7ab119cd3058c0db4d 1910034f70f6eedfee8b742ea45af9780f415be2f851061" +
- "313a218ad48e992b75afaa07c33ca47ee0155fe72e13d7e5736e512c5e5a45d351f7c7902d8b0fa3 1b34569a9aea31b018d63d572a9898c389d07caa427f114d" +
- "251263d56cf5d6663159c2b32683b266fb909ba9d4caadaeda6700c03b25307cdea597a3287fd76 082dbf33f073482872fdb494b892112c594d7f265d2799b5e" +
- "5ec46a30fbf1557fa344a664a7af457a4e8ce2c014a270215d3f95d47a42d8f86a61d6d6b363d04a9 9a0d8f06c5b15cd803d951aea0ca185a807ca4c677db789" +
- "fca64f0c5ba95b8c64f930eda658f9f773a9e1c8669589a7d98ade8dbc2c2c4cbbaf6ea2bbc6e762d 4098f4db0d3f055958ae9da15ae57ee0b60fb9513dacf5a" +
- "d65e34613570186acecf9e165bfa470aabcd35f22620497fbcabf220c53cff84eec12cf9965297b364f 0e9122895c175d213fc2a9c9cbf27ebe1cf96fdacaf1c" +

- "1c79ede66cfaa5057d33e09b31b43869812e5a0ce730663c18c4333141ae9565e437d99ade6b2cbe005214e8b3392c55bf4d7b38ef16e7f84b4ba3c85e1dfd1a" +
- "ca8da1a5c75fd190e7752926533327880aed1461c7e9de2443ba0a2d094f4a14d5fffd3b102ea78a cd34d162e82ab78fbb82bfbc8a9708ab532aa861643c39cd" +
- "2bc89f2be53c583f9930fb2da14f1c5d5f218384b1740a76bd8b7ddd2c9888c8d7e7e78cc7a3304fa 41995c7c1c3316894296caeeb9711f0e6bf16abc380bd41" +
- "10448be3cb03cc3246ee7b9559c858307001033c84ecf89690526544c05c146f206d4a21e710597bb57759d232154a1f9d88eb3f3440374bad1e901da7a154b8" +
- "39a6d1b1b6b2ab0be872ff036a9f9f769a169fbf91bada732d8f28c453b9be49011b211155fa5c588 b43018775f99e3b92b322a4c41282326b79fd26541ccafc" +
- "c0e2f09797e3217fb0e5785b72e654dbcde8ba14b2d56faa2218748c6789c158bb635d43c9a6469 0b004ab70f457e9fd959b2d90875966968c7ac44b103283e7" +
- "50b60deeb1f89444aee25fbdb7fa3a96d70c3dce38246f111e466cdfa3b807c54ed584f5b1a64456e 923dcf37f45b36cea3d602ba3a55a4fd883ebb6dc198650" +
- "b522461614656897b9b7d408d48b12e594af06c91f715b32a4ed65a379f0ab461acb9b8b20d1f1b 12e9f7fea422c0c7d545eff4152e06002cbd120fd74b483d3" +
- "a0ee30cfd851c98e9aa8fb19b60528de4a75b412bed656933ae8ab600aeaef5befdcca4d35fa472e d38ffb91a9017c19c5d500426f262ba379034c45cf5d1627" +
- "48da223207721b4bc4504b79309f3d622c53dfe3c83ff8866dd7614a2e90a85c077b2e18bf1cb600 8f0d785d6a0ffd5f15a83a343036f3fdd25314bfe47b5a12" +
- "58a7c89475f39a58a671d0a17f6fd100a8928181b94d8d53149316d5addf14bd398b538e2593273f 02cf296fd73ff92d02230de939dae94e03d44ce93dd4dfa1" +
- "b9219fd369c854ec409d7bf94b316e5e9c16e1ba525a783e24bd3fc0ecc949be245c402efae8ea77 aaca74c78703506cfd5a5a614793e04c76652b4f344f79fd" +
- "f2da1e34f650fc1094116ead723813d204ffe375d20707fd94d90f21c009194201c88d22afaee83a8a 6be7518dc915331b863664e033d397c64e1516c0fd9324" +
- "11614a1bdf2feb86e0d0ae21e784a55086c596c7eedd44d3afd7295455450f507f1c1a33c9ba94d5 0931ec054d8740510ea23990c266f30678a74fdd485b482b" +
- "cbfb4070e3f10b66c65a4210794a3137adabe887ffb9bcf2a30c625138f840b2666610e76e5a0abc1 83088a94930c025836653eddbc440621bbf94761c74e108" +
- "3672c6a914a753fd452e8e7a02c54b21d7bab4b705b4509b9b5b27e2e5144289eece950c3634b4 10b5e3cf8c5a5f74d98b55d17d45d7014390cf696a7e693777" +
- "4c028517062a69276910cf5f139078e8ef6e77aa8b35aa55fd4f53e48ae6b4875d1732b286ffe8bf8 52b73af7b964fdf1aa4c4f16d9f14485a2b1a704c2615ac" +
- "8ac74eaaacec7e8e4e506e1b418d377e4d5a271dfab47b3d3c11a809beda596fdf37935dfe06c147dfe7d5be696ffb2a0cff907d1eb2a88477c261d5a7aba06c" +
- "d70dc52d00b9a9d851e849f86e1cba91b4c40d1ae3d4f21a2763369dde34d084adfc09d2a6cb5f09 114cd8d6fa26d15f1ec428adc245064e5b8e80f21b0b3ff2" +
- "6690398d3080f5355fc082bc4bf3a38576c7da00efbc80839dc9a06fab2b998a152553c36fab42e03 e3e4b54456ed954e53bd63902d89e2617a263e70146d1eb" +
- "71557baf43aeb0a681f600a784778c895afce26fe17e3ac33990c54cd96fcb2432de79d4f95ab2fb9 6effdd37f4e4247ae5b4c1fa461ca3269d45a90af090333" +

- "fc3ab5152bd5aed4445eab93466701382ba76fc8745abd911bdb45a494e1c62647670380c04377bcdb5e631318dfa79850469a988094acd48a4110bbc7289617" +
- "ce436294ff242302d154ad75437ae2f551df5b84f884c87497de0bb2ef7bd41a8c758e4b158084c78 ef047389d88974faafa00ce7396e849509d39c403fdcca6" +
- "8f47e1d0fc294e5510a07af24c165e1a4b4ba9498e7b333c4e8624c552801079775fc684b6e98b72 ff133164a2052c2aadcef168d9cdeab8a935c98f08e23b95" +
- "859277381a2ce23ea61fbe9ec1439a489523161ed370b0069aa6a5c7981e4a80c04e304ff2fd85f8 0b51e3de3484b53084f376cc72a390aaefc49baddf4d2545" +
- "93dcb5a49326c9c15c3d1c0e0709c9879d68bee07b956d018a995bf1e7f8fa03ef2079d01e0bec60 1519704cced98854c94f1f0ae837653f14c0221e12f2cbdb" +
- "1564066062bc1d4dcf7ed8b2c980b90e8101842d5844375cb370f402d858dffd9eb52572f8420d4d 246462230ca0dbd567250e4f065730a6aecbd804b1acf949" +
- "30e2890a39fdd4c1eb693f7e345504dbad5ac207f1a649968c3a7b416bd972b6a6bfde04375337a9 3b0ac08f6fae62c0fa7df8ae9deeee421f7ac62d8cf5ecf3" +
- "b5ff39877ee4abaeb9db03d8a8f13f7925e54267a2651c55ecf580d5cbb24bf504fb01291e3e97ad1 696ed995608fceda79f2441ca67bfe3c31f4f4bf0fffcd6" +
- "55408744524412cd4d3cbdbdd216694aa7477e88b25f7efeb34abf491a50695ff686829a8fea9e99 9877bcb37291b8dbeeddfd44465a2c28a215aa532590c487" +
- "d4747b6ece4e1aeaef725cb305d11b965a9647bef36a5c2fb45cc334d35ff4e308cd8813b6de3953 b35a4ef6a3ae07794f8b54ef6365a573135320612bd1acfe" +
- "6cac5524c0e98b6f2a33a790b94f5134f0cba075a6fa93c191f4176ca62ea2e365557d6b3363a17b 9ee52f3c347c82cd19f8432d16a934ae9c5d4d4505e7d20e" +
- "1ae31bb64ccb084f7a59744b27d58c2388d449ff4b63604878ae858240348ecfcb51761678265bd6 0d5dd7d51e25e91668fdf80f6b726b29ef6c3f0f229d8af4" +
- "b2cdadc3ca7fbadab49b28819b9c9b92b49cbe9a281e5891f4eae7616013777605a0623dd7a650baf9a9dad66ca9aae3c76ef1e27db32bd9514a2776eb0c8d05" +
- "65eec06fc4c8a69c417efa336842e248e5a51e3b5f3ba3227e3f78f1bd12d81595e03a01f4259c772 fd481ab5f3d7a945e1c95fe0dc3c4742eeb7e15c9426ec3" +
- "ed4c90ee07d56acc78fecfd7c5ce1e04e7db1a970091f15c90f0aae2865d135395d27787aaf68c6a1 79064d82691e0b6c795f61875f317dc6d2e8feea55a28f2" +
- "461d74e14e350351720b6f536adfe3addd4111f08e3a84da2656fd4bc83989b329b383da9f01cf23 92aa0b19577884d1281f2e6c106df451c078a472b36057d3" +
- "065dfc4bbb47ce4e5dce4acf6da095bdd10322f3ae12bcdd1f805e73b303f1fc7a7e16cf3ffd822bd8b25fbc93be065019e394113182713f1ad299ae6537f6bf" +
- "57116e8dc9ec775519b797ab4107c2ac5129ba85188852c3bc5f116044bbd8985b6dc8b8da4659 589bf9d2351c4c3adaed87fe2ea20ef6bf62224c7af86fe8b4" +
- "973e558f39465dff43bf23cf1f78957514e4e82a3009d40d97bf8d8442a11deabde806e2fa84c1ba7 5273da75ce8dad3b2a34786b2958ac4bfd248ebe604a173" +
- "83c727b11dd922b1f72476af700b663fbd7033d0ac74b463d40a92d26c938b69f96fb4a9cb7a9ca2bd9496251270c0c5fcae6b3c2eda5377b897891648a97125" +
- "8ac71fed8dce8e02c30961a299cb7f3145845dbe8f4dfaaaf4baf0ca3fb730abdd258e98215f072a94 3d5aee8d8bc4c86023524f7b69186d99ad88ccdfc0b4bd" +

- "7db422bbad7eaa0824ce24b5c186e172c8c584f1cc5c126c901a69ebee8dbd230a653a3643b7875 672d22fd86079daf8d834ba33664f5ad0b6eec767b4f58b45" +
- "e67b776b90e0a5e130aa5365003eb7fd78b757b1cf9133f6a1d51064b293cb42c8c41b15b7e95e2 a39fa5dae19c6e20031d2bfa4632c37779163fdecc6b45624" +
- "4d6bfd01a8877f6fe7739591917a86e7dd795ad85cc3f256cff5961e8b62e92a0754a51f2c6d59819 446eec8bdd08b87cf9f4fb5373e809d52240d2dd691cd50" +
- "37fc79d35b61d63851917cfdba164868a3f79e2061bd4610c1f5216ed77df00baa75f949ad37142db 4fd282a5c7d2e2636ca590f92fc4781d4f51efa69f53947" +
- "d4fca1dc7dd2429837b6d7e5c9528effdecf6f731f676587785e5c4096bdb6f1f44e72f5f77d9025813 e848881506f65bfb0f2b2d3ae6f9e00731929b5ac083d" +
- "b1c9c324703e63fef6319e1d8150aa0ff7d9a2049961df9158f3e1f2e540a91feb742625d2a859a45 2186d2ccaa3ec2ba086ee0868a4dc24ae6818fc02f9c1df" +
- "dc326cc31c46feefda97265238592f638968627ec24903b97513ab05ed58ce5b516decda0e2fbf01a70e6cb2e53c3e7b8855f80cd7e007b78da727ef0893e099" +
- "592ba684d62ae2d1f06ad148fa7f34cfc724d804149cda21aee7eac064ad20d29132b260c2c2867f a6a2e747739fc30df2f002c2a99da6c7e64ee51e806af7d9" +
- "768aec456b93a05002666cb61b2229c99f2cdef9afc9cea1c4ee3a85dd189823399781ee33cde2ab edff09c47960c035e075a29156005d75845a11fa06abcc50" +
- "5f7f849a0caaf683f334e9e7bbbef90fe6cf94cbf87767219440d31713daef6ad1e4a1cc720ce59fee4 cf7731e46bbba9ec1648908ea345030aa8f10ade10ffa" +
- "3d2acfd480b0b11eadc4fb2b740596b204e911456cb2f35ad9993ab7dd6a48b35ba0c207625384b b3c2ff24437810bd13c7ee96cd6f97f19ffd537ad182a3657" +
- "b0e83d42fd6e2ebac6cbf5ea1bde97465b7cec6954ff5b5be049e59a49ea25ed6667dbace765401bde12031e5cfabf2df7afb728d2a0b2a38b24d79bf23a313c" +
- "40fe5adef97487641c6088dd8712c0c352708e474b02c08fd2d71b6d44f16d82f291ccd61c43a339 408379a8de54cfdbbae5e421e084112fbc17fb5561e084d1" +
- "4149bf4bb06fd161878d8574f856867cff974d5898e161923d55bdac8699c9df6a220bcb6c800d3ae 7f107b8c4acab206d780aafaf6c2e2379de8c900700d9c9" +
- "c87d464772514c5aa3e5f5bfc00fb54f2b74702838b4731c5ac8a070b50783e81dd97fa8d55c739d 026b607a2a78aba1bb79b1a7a3c22c78368672ac020061e6" +
- "d9683d57d6989c6c6f08b8d5d74720f5cb25505fbe81d2bf53a68e972a54784705b20f83fd1ab5afff 30764ef89dba4465b56f48b325ab3810bf8dcbf4faa61f" +
- "676e2043ac8540df9e3af4c0f51d816e89c09bf67253be45fc5f75f64be97f6c7dc0c6392af6fa8e75a ab58eda976b36773cd37d315771400a2cb846fdef3d8a" +
- "a15bce5dfda0379e526f87cf67767a2ab93d41c85b4ed016ed0a89d2f94737433a3ebade813def29 eaa18a1fb925fca7d08d1020f64caebc562cb4ad2fb241e2" +
- "94923b2f2df5e6c4953c4b73be0f5568defe57ce49d16e2a205323e46cbb5a3e77fff1557671503bd 7b5de5320f1fb951fbe26400cfa854af2d12fab0215310c" +
- "f070add34dc4565d1757d7e10a03e3bb73a607ed7e10861b1274ddee76183cf7e56c1de7162c805 c2dba0e0331d36f3a4e2019a2e0705ee2747ed1e52bc3a6fb" +
- "3b061f784348204cdf8d643ff6c271fa72b56900edcc2f77201f3bd4fc296ad6534a7029ea66761bb9 a3589a1f6ef566504c70297b98fbb603214fed2e4b7ca1" +

- "06e3f0e993118897fa641fb9722d4667fa98d07a6837e5ab2144e5ec1548a7dbca28c559f2a9a99d 54b8e55f56d0e59bcef1ac45e2046835b60579da0d2261e7" +
- "30dab9009d138421c6458d146e870358b0b3fa20257e50b58f167c6b47edf7053513d58f33547d0 6ce52458baaa4dcf15f77b103565c66a81f183c827801b455" +
- "b61b6287a46a37a96884075a7eada9ba7f0ddcc14654bf87a26d2e27a978b415257773796923a2 20e06b25af16fb5aaded9b2d081a4c64106df460ddce9c3b2a" +
- "c8553e1521e501ad29a4b7f7681c9b60576a127087a5237c4c2bacf9b163dd590e63f2bc80e7f1e6 13773f87d034313064710404739d63363d204be7b14800c4" +
- "d8c1b6a2a21da70223be51d281fee302ef806454f9d7d28244ba537c1d9f8f1bcc5d47038d986a8f9 5ca48437ffe94fd44a90bb03014a259112a97508adb3db4" +
- "34f72a5268c1af6bc6d5801e579aab2228ca33600ebbf1a1959081c3a4ca99e444f97409f5e0ca47 79241c9aacad1f4ee7fb4369bd6ae076378e4f63000b9a5c" +
- "849ba6e72e47e2454a44659149338ac0767cd25d8693c0d143e354bd600f1c1d3a44eeb024923e a659060665d5cd9a4ca1ca86162819556535fd59b9fde90caa" +
- "29920efe99479fe7e4b4e5371e13ccb43a1419cf023433239d840900d31bab37fabc3fd20e31bb7dbcb3ae8df66f67e2844944bcf544b658364f9e3d0b6d84b4" +
- "63ad4eb621644fd7d774b501407a1178814b15149345d551b474347188067db2ab4d7f4d1abd30 27133039e855e129f3f5649550da8c04fe2db57cb89bf1bf4f" +
- "72eb35ccfe31afb92f6136d4c2a1c115b07b721b2da43151f11c356256230408979c5d9524371442 9e2c9500e7b043b20dac8a9763e5b487d1cbdb34ac379b9c" +
- "6409454c79385b6e562459c4fdaad1b7f9297c1473e9b90fffe6d1c5390e241a187a4cefa2eb0cb0c 11f4ca6c5b961c18ceb57892295290dbc991692556bffa3" +
- "b8c405cf285e6bcb8a90246ad0ac15122f4cf73adc129d23aa2240733404beb6d74bf698e5589288 a522573c774ce9f514b5d5c086382ea1dd4e89ff5facbf23" +
- "d36bc3d203941e17747ede4b82820351f4df278ddb787ce8f6f1cc468ef953399efb072ce706e253f1bab76444bb70be6443cd0db633e958dc57bd223e00418e" +
- "915a7c2e4d94c0623f9788276480cdfe798387d35e2ea2d304d066aec7627794cdd4200a44208d6 c87f242c76e2d4a3f966b6fb96eaa63d892c1a177bef249b4" +
- "fdd1a4c06c791f677dd9919f739ccf318bd77835330b0219786249c9c9736161dac771a838724f2d d70afba46a6782fd27601cf8a7126ae95a66e526131a68d7" +
- "7a809e513533ed8021eecdbc5851dfcf95e10f1bbe47b5c7f079275a1837836245266b66d89fab25 ac4bd6c1225560bea3259b67bf50a58ee056754d574da79e" +
- "f9a1a0df3a5defed0f74fe74ce0bf65a04086f17e94a8451828c723c97932f26f9349f1a2c7866c617a 528602721de4f3cc8916bcfc66cdc106bafa26ea87a13" +
- "94dfa37e396365fb7f92df007b46a50ff04c7f85bfa679230ebedf18c2fb876fc7098dd1c4328adf85de 71c31d94687a308053bfcdc158cfa7772170fbed63f5" +
- "37dda41f65196dfacdd1186b5de0f3369d841ce6502192292d05a19ce7464f5bcab3015c721cac13 ddca561b92dc1ee25d3068dc1945a1b4e2bd1e6604c42e4c" +
- "3c04b490f6365828957990007394557854a903e19feb06906e41cbc8766bf37bd7dece90f4cdc987 709b1129e84bfdc502543b5bfa887bf78553a5ec10ad68c5" +
- "d10eff75f7aa495e7d934a55577fdc0aead31aee4522db0259d7d4ea8438a7996d80a787465a298 0457193d1c4bf1a0a1e01741d72e5fc4dfe58475c1c01026b" +

```
"5a3bc973b902280753e9c3226db9cc778e2506c56ee86ae85b4d54dbf05394107329b2d1ee5652
2cb1ce562fb1aa4e592199d9c29f64cc3ab1d757531e209eec" +
"aa138d8388169b5e28c45f5aba267eeaa57f69869f0b6855d82b0eafcde63895251f41e8e676a0ab
12ef3f569bb7de91b79fa46ad9637da01ca004f4d30259c1" +
"f5b00761f6ca9c17721a6718390624a10a11f7f52d7afb71ee5f8338828910e48f94a1347761abac8
7897b2dd0e23f1d325aec5031ef58f2972e8b402e05f8c1" +
ae7053a90380a1ae0d4d06645548c23e13afa31aac8ff83b10f8341418af4114632f6406d6e33076"
391696c9161d63c8bcfd1c625fc737f68198046212d1638a" +
"d2d2d42ff7029c1fcc682a046edc4d4f24862d82c600180b1e8f57ff6a3865dfe9274f9886d00efa523
a1b3b3757c4489200fec3dc5583854c955492336253dd" +
"767f2a60ce3d224afcff9cdc19e9b28830d33affda6af99942a8fe39562055f3e884fd6c1ebc1908ac1
59061f35e9b0da80434ce9673d9c6b87265170077c670" +
"743e37474d7605cd01c44af600f16d9ffaf24acf87fbe5ccf39bac41047a810d210051c87f06147a0b
b8f1427a406700483679638f1af23f1dafb7aa0c468669" +
"71c3a82f535c26cf6cb335e8e915fda393799d3dbe0e04b907ed3612d12ac95783a6876cd986d2a
13b82192532e02c250eaa42f891d2481655fa4494c723fe00" +
"87d224444245eb5b0eade5f741b025db1992a8ad0dce51b0c1af4a18a9e244f9f755891adf0f1917
9c7baa6c32bffc91e0b03c4ed3aaee1978b6a1f03b87ac6a" +
"fc3b9e7030bb212b17de198edfccde29d04224798c1204e47ea235f048724fac62d637d1ba0ee392
2048fcf79c746b6c0c036d882e3491fd72bad6e009c6403e" +
"55876f4d31330caa02aedd0b0c121c3c41e736853a08071f0dd4ddc7412db0bbe274a9ac2932552
bb37c40e72c2ef1d7cca8236942e480d709d3ea9d5ae0a1b7",
),
},
for i, tt := range tests {
cache := make([]uint32, tt.cacheSize/4)
generateCache(cache, tt.epoch, seedHash(tt.epoch*epochLength+1))
dataset := make([]uint32, tt.datasetSize/4)
generateDataset(dataset, tt.epoch, cache)
want := make([]uint32, tt.datasetSize/4)
prepare(want, tt.dataset)
if !reflect.DeepEqual(dataset, want) {
t.Errorf("dataset %d: content mismatch: have %x, want %x", i, dataset, want)
}
```

// Tests whether the hashimoto lookup works for both light as well as the full

```
// datasets.
func TestHashimoto(t *testing.T) {
// Create the verification cache and mining dataset
cache := make([]uint32, 1024/4)
generateCache(cache, 0, make([]byte, 32))
dataset := make([]uint32, 32*1024/4)
generateDataset(dataset, 0, cache)
// Create a block to verify
hash :=
hexutil.MustDecode("0xc9149cc0386e689d789a1c2f3d5d169a61a6218ed30e74414dc736e442ef
3d1f")
nonce := uint64(0)
wantDigest :=
hexutil.MustDecode("0xe4073cffaef931d37117cefd9afd27ea0f1cad6a981dd2605c4a1ac97c51980
0")
wantResult :=
hexutil.MustDecode("0xd3539235ee2e6f8db665c0a72169f55b7f6c605712330b778ec3944f0eb5a
557")
digest, result := hashimotoLight(32*1024, cache, hash, nonce)
if !bytes.Equal(digest, wantDigest) {
t.Errorf("light hashimoto digest mismatch: have %x, want %x", digest, wantDigest)
}
if !bytes.Equal(result, wantResult) {
t.Errorf("light hashimoto result mismatch: have %x, want %x", result, wantResult)
digest, result = hashimotoFull(dataset, hash, nonce)
if !bytes.Equal(digest, wantDigest) {
t.Errorf("full hashimoto digest mismatch: have %x, want %x", digest, wantDigest)
}
if !bytes.Equal(result, wantResult) {
t.Errorf("full hashimoto result mismatch: have %x, want %x", result, wantResult)
}
}
// Tests that caches generated on disk may be done concurrently.
func TestConcurrentDiskCacheGeneration(t *testing.T) {
// Create a temp folder to generate the caches into
cachedir, err := ioutil.TempDir("", "")
```

```
if err != nil {
t.Fatalf("Failed to create temporary cache dir: %v", err)
defer os.RemoveAll(cachedir)
// Define a heavy enough block, one from mainnet should do
block := types.NewBlockWithHeader(&types.Header{
Number:
           big.NewInt(3311058),
ParentHash:
common.HexToHash("0xd783efa4d392943503f28438ad5830b2d5964696ffc285f338585e9fe0a37
a05"),
UncleHash:
common.HexToHash("0x1dcc4de8dec75d7aab85b567b6ccd41ad312451b948a7413f0a142fd40d
49347"),
Coinbase: common.HexToAddress("0xc0ea08a2d404d3172d2add29a45be56da40e2949"),
Root:
common.HexToHash("0x77d14e10470b5850332524f8cd6f69ad21f070ce92dca33ab2858300242e
f2f1"),
TxHash:
common.HexToHash("0x56e81f171bcc55a6ff8345e692c0f86e5b48e01b996cadc001622fb5e363b
421"),
ReceiptHash:
common.HexToHash("0x56e81f171bcc55a6ff8345e692c0f86e5b48e01b996cadc001622fb5e363b
421"),
Difficulty: big.NewInt(167925187834220),
GasLimit: big.NewInt(4015682),
GasUsed: big.NewInt(0),
Time:
         big.NewInt(1488928920),
Extra:
         []byte("www.bw.com"),
MixDigest:
common.HexToHash("0x3e140b0784516af5e5ec6730f2fb20cca22f32be399b9e4ad77d32541f798
cd0"),
Nonce:
          types.EncodeNonce(0xf400cd0006070c49),
})
// Simulate multiple processes sharing the same datadir
var pend sync.WaitGroup
for i := 0; i < 3; i++ {
pend.Add(1)
go func(idx int) {
defer pend.Done()
```

```
ethash := New(cachedir, 0, 1, "", 0, 0)
if err := ethash.VerifySeal(nil, block.Header()); err != nil {
t.Errorf("proc %d: block verification failed: %v", idx, err)
}
}(i)
pend.Wait()
// Benchmarks the cache generation performance.
func BenchmarkCacheGeneration(b *testing.B) {
for i := 0; i < b.N; i++ \{
cache := make([]uint32, cacheSize(1)/4)
generateCache(cache, 0, make([]byte, 32))
}
}
// Benchmarks the dataset (small) generation performance.
func BenchmarkSmallDatasetGeneration(b *testing.B) {
cache := make([]uint32, 65536/4)
generateCache(cache, 0, make([]byte, 32))
b.ResetTimer()
for i := 0; i < b.N; i++ \{
dataset := make([]uint32, 32*65536/4)
generateDataset(dataset, 0, cache)
}
}
// Benchmarks the light verification performance.
func BenchmarkHashimotoLight(b *testing.B) {
cache := make([]uint32, cacheSize(1)/4)
generateCache(cache, 0, make([]byte, 32))
hash :=
hexutil.MustDecode("0xc9149cc0386e689d789a1c2f3d5d169a61a6218ed30e74414dc736e442ef
3d1f")
b.ResetTimer()
for i := 0; i < b.N; i++ \{
hashimotoLight(datasetSize(1), cache, hash, 0)
```

```
}
}
// Benchmarks the full (small) verification performance.
func BenchmarkHashimotoFullSmall(b *testing.B) {
cache := make([]uint32, 65536/4)
generateCache(cache, 0, make([]byte, 32))
dataset := make([]uint32, 32*65536/4)
generateDataset(dataset, 0, cache)
hash :=
hexutil.MustDecode("0xc9149cc0386e689d789a1c2f3d5d169a61a6218ed30e74414dc736e442ef
3d1f")
b.ResetTimer()
for i := 0; i < b.N; i++ \{
hashimotoFull(dataset, hash, 0)
}
33:F:\git\coin\ethereum\go-ethereum\consensus\ethash\consensus.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ethash
import (
"bytes"
"errors"
"fmt"
"math/big"
"runtime"
"time"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/math"
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/consensus/misc"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/params"
set "gopkg.in/fatih/set.v0"
```

```
)
// Ethash proof-of-work protocol constants.
var (
blockReward *big.Int = big.NewInt(5e+18) // Block reward in wei for successfully mining a block
maxUncles
                  = 2
                                // Maximum number of uncles allowed in a single block
)
// Various error messages to mark blocks invalid. These should be private to
// prevent engine specific errors from being referenced in the remainder of the
// codebase, inherently breaking if the engine is swapped out. Please put common
// error types into the consensus package.
var (
errLargeBlockTime = errors.New("timestamp too big")
errZeroBlockTime = errors.New("timestamp equals parent's")
errTooManyUncles = errors.New("too many uncles")
errDuplicateUncle = errors.New("duplicate uncle")
errUncleIsAncestor = errors.New("uncle is ancestor")
errDanglingUncle = errors.New("uncle's parent is not ancestor")
errNonceOutOfRange = errors.New("nonce out of range")
errInvalidDifficulty = errors.New("non-positive difficulty")
errInvalidMixDigest = errors.New("invalid mix digest")
errInvalidPoW
                   = errors.New("invalid proof-of-work")
)
// Author implements consensus. Engine, returning the header's coinbase as the
// proof-of-work verified author of the block.
func (ethash *Ethash) Author(header *types.Header) (common.Address, error) {
return header.Coinbase. nil
}
// VerifyHeader checks whether a header conforms to the consensus rules of the
// stock Ethereum ethash engine.
func (ethash *Ethash) VerifyHeader(chain consensus.ChainReader, header *types.Header, seal
bool) error {
// If we're running a full engine faking, accept any input as valid
if ethash.fakeFull {
return nil
// Short circuit if the header is known, or it's parent not
number := header.Number.Uint64()
if chain.GetHeader(header.Hash(), number) != nil {
```

```
return nil
}
parent := chain.GetHeader(header.ParentHash, number-1)
if parent == nil {
return consensus. ErrUnknown Ancestor
// Sanity checks passed, do a proper verification
return ethash.verifyHeader(chain, header, parent, false, seal)
}
// VerifyHeaders is similar to VerifyHeader, but verifies a batch of headers
// concurrently. The method returns a quit channel to abort the operations and
// a results channel to retrieve the async verifications.
func (ethash *Ethash) VerifyHeaders(chain consensus.ChainReader, headers []*types.Header,
seals []bool) (chan<- struct{}, <-chan error) {</pre>
// If we're running a full engine faking, accept any input as valid
if ethash.fakeFull || len(headers) == 0 {
abort, results := make(chan struct{}), make(chan error, len(headers))
for i := 0; i < len(headers); i++ \{
results <- nil
return abort, results
}
// Spawn as many workers as allowed threads
workers := runtime.GOMAXPROCS(0)
if len(headers) < workers {
workers = len(headers)
// Create a task channel and spawn the verifiers
var (
inputs = make(chan int)
done = make(chan int, workers)
errors = make([]error, len(headers))
abort = make(chan struct{})
)
for i := 0; i < workers; i++ \{
go func() {
for index := range inputs {
errors[index] = ethash.verifyHeaderWorker(chain, headers, seals, index)
done <- index
```

```
}
}()
}
errorsOut := make(chan error, len(headers))
go func() {
defer close(inputs)
var (
in, out = 0, 0
checked = make([]bool, len(headers))
inputs = inputs
)
for {
select {
case inputs <- in:
if in++; in == len(headers) {
// Reached end of headers. Stop sending to workers.
inputs = nil
}
case index := <-done:
for checked[index] = true; checked[out]; out++ {
errorsOut <- errors[out]</pre>
if out == len(headers)-1 {
return
}
case <-abort:
return
}
}()
return abort, errorsOut
}
func (ethash *Ethash) verifyHeaderWorker(chain consensus.ChainReader, headers
[]*types.Header, seals []bool, index int) error {
var parent *types.Header
if index == 0 {
parent = chain.GetHeader(headers[0].ParentHash, headers[0].Number.Uint64()-1)
} else if headers[index-1].Hash() == headers[index].ParentHash {
parent = headers[index-1]
}
```

```
if parent == nil {
return consensus. ErrUnknown Ancestor
if chain.GetHeader(headers[index].Hash(), headers[index].Number.Uint64()) != nil {
return nil // known block
return ethash.verifyHeader(chain, headers[index], parent, false, seals[index])
}
// VerifyUncles verifies that the given block's uncles conform to the consensus
// rules of the stock Ethereum ethash engine.
func (ethash *Ethash) VerifyUncles(chain consensus.ChainReader, block *types.Block) error {
// If we're running a full engine faking, accept any input as valid
if ethash.fakeFull {
return nil
// Verify that there are at most 2 uncles included in this block
if len(block.Uncles()) > maxUncles {
return errTooManyUncles
}
// Gather the set of past uncles and ancestors
uncles, ancestors := set.New(), make(map[common.Hash]*types.Header)
number, parent := block.NumberU64()-1, block.ParentHash()
for i := 0; i < 7; i++ \{
ancestor := chain.GetBlock(parent, number)
if ancestor == nil {
break
ancestors[ancestor.Hash()] = ancestor.Header()
for _, uncle := range ancestor.Uncles() {
uncles.Add(uncle.Hash())
}
parent, number = ancestor.ParentHash(), number-1
}
ancestors[block.Hash()] = block.Header()
uncles.Add(block.Hash())
// Verify each of the uncles that it's recent, but not an ancestor
for _, uncle := range block.Uncles() {
// Make sure every uncle is rewarded only once
hash := uncle.Hash()
```

```
if uncles. Has(hash) {
return errDuplicateUncle
}
uncles.Add(hash)
// Make sure the uncle has a valid ancestry
if ancestors[hash] != nil {
return errUncleIsAncestor
if ancestors[uncle.ParentHash] == nil || uncle.ParentHash == block.ParentHash() {
return errDanglingUncle
}
if err := ethash.verifyHeader(chain, uncle, ancestors[uncle.ParentHash], true, true); err != nil {
return err
return nil
}
// verifyHeader checks whether a header conforms to the consensus rules of the
// stock Ethereum ethash engine.
// See YP section 4.3.4. "Block Header Validity"
func (ethash *Ethash) verifyHeader(chain consensus.ChainReader, header, parent *types.Header,
uncle bool, seal bool) error {
// Ensure that the header's extra-data section is of a reasonable size
if uint64(len(header.Extra)) > params.MaximumExtraDataSize {
return fmt.Errorf("extra-data too long: %d > %d", len(header.Extra),
params.MaximumExtraDataSize)
// Verify the header's timestamp
if uncle {
if header.Time.Cmp(math.MaxBig256) > 0 {
return errLargeBlockTime
} else {
if header.Time.Cmp(big.NewInt(time.Now().Unix())) > 0 {
return consensus.ErrFutureBlock
}
if header.Time.Cmp(parent.Time) <= 0 {
return errZeroBlockTime
}
```

```
// Verify the block's difficulty based in it's timestamp and parent's difficulty
expected := CalcDifficulty(chain.Config(), header.Time.Uint64(), parent)
if expected.Cmp(header.Difficulty) != 0 {
return fmt.Errorf("invalid difficulty: have %v, want %v", header.Difficulty, expected)
}
// Verify that the gas limit is <= 2^63-1
if header.GasLimit.Cmp(math.MaxBig63) > 0 {
return fmt.Errorf("invalid gasLimit: have %v, max %v", header.GasLimit, math.MaxBig63)
}
// Verify that the gasUsed is <= gasLimit
if header.GasUsed.Cmp(header.GasLimit) > 0 {
return fmt.Errorf("invalid gasUsed: have %v, gasLimit %v", header.GasUsed, header.GasLimit)
}
// Verify that the gas limit remains within allowed bounds
diff := new(big.Int).Set(parent.GasLimit)
diff = diff.Sub(diff, header.GasLimit)
diff.Abs(diff)
limit := new(big.Int).Set(parent.GasLimit)
limit = limit.Div(limit, params.GasLimitBoundDivisor)
if diff.Cmp(limit) >= 0 || header.GasLimit.Cmp(params.MinGasLimit) < 0 {
return fmt.Errorf("invalid gas limit: have %v, want %v += %v", header.GasLimit, parent.GasLimit,
limit)
}
// Verify that the block number is parent's +1
if diff := new(big.Int).Sub(header.Number, parent.Number); diff.Cmp(big.NewInt(1))!= 0 {
return consensus.ErrInvalidNumber
// Verify the engine specific seal securing the block
if seal {
if err := ethash.VerifySeal(chain, header); err != nil {
return err
}
}
// If all checks passed, validate any special fields for hard forks
if err := misc.VerifyDAOHeaderExtraData(chain.Config(), header); err != nil {
return err
if err := misc.VerifyForkHashes(chain.Config(), header, uncle); err != nil {
return err
```

```
}
return nil
}
// CalcDifficulty is the difficulty adjustment algorithm. It returns
// the difficulty that a new block should have when created at time
// given the parent block's time and difficulty.
// TODO (karalabe): Move the chain maker into this package and make this private!
func CalcDifficulty(config *params.ChainConfig, time uint64, parent *types.Header) *big.Int {
next := new(big.Int).Add(parent.Number, common.Big1)
switch {
case config.IsHomestead(next):
return calcDifficultyHomestead(time, parent)
default:
return calcDifficultyFrontier(time, parent)
}
}
// Some weird constants to avoid constant memory allocs for them.
var (
expDiffPeriod = big.NewInt(100000)
big10
           = big.NewInt(10)
bigMinus99 = big.NewInt(-99)
)
// calcDifficultyHomestead is the difficulty adjustment algorithm. It returns
// the difficulty that a new block should have when created at time given the
// parent block's time and difficulty. The calculation uses the Homestead rules.
func calcDifficultyHomestead(time uint64, parent *types.Header) *big.Int {
// https://github.com/ethereum/EIPs/blob/master/EIPS/eip-2.mediawiki
// algorithm:
// diff = (parent diff +
//
       (parent_diff / 2048 * max(1 - (block_timestamp - parent_timestamp) // 10, -99))
//
      ) + 2^(periodCount - 2)
bigTime := new(big.Int).SetUint64(time)
bigParentTime := new(big.Int).Set(parent.Time)
// holds intermediate values to make the algo easier to read & audit
x := new(big.Int)
y := new(big.Int)
```

```
// 1 - (block timestamp -parent timestamp) // 10
x.Sub(bigTime, bigParentTime)
x.Div(x, big10)
x.Sub(common.Big1, x)
// max(1 - (block_timestamp - parent_timestamp) // 10, -99)))
if x.Cmp(bigMinus99) < 0 {
x.Set(bigMinus99)
// (parent_diff + parent_diff // 2048 * max(1 - (block_timestamp - parent_timestamp) // 10, -99))
y.Div(parent.Difficulty, params.DifficultyBoundDivisor)
x.Mul(y, x)
x.Add(parent.Difficulty, x)
// minimum difficulty can ever be (before exponential factor)
if x.Cmp(params.MinimumDifficulty) < 0 {
x.Set(params.MinimumDifficulty)
}
// for the exponential factor
periodCount := new(big.Int).Add(parent.Number, common.Big1)
periodCount.Div(periodCount, expDiffPeriod)
// the exponential factor, commonly referred to as "the bomb"
// diff = diff + 2^(periodCount - 2)
if periodCount.Cmp(common.Big1) > 0 {
y.Sub(periodCount, common.Big2)
y.Exp(common.Big2, y, nil)
x.Add(x, y)
return x
}
// calcDifficultyFrontier is the difficulty adjustment algorithm. It returns the
// difficulty that a new block should have when created at time given the parent
// block's time and difficulty. The calculation uses the Frontier rules.
func calcDifficultyFrontier(time uint64, parent *types.Header) *big.Int {
diff := new(big.Int)
adjust := new(big.Int).Div(parent.Difficulty, params.DifficultyBoundDivisor)
bigTime := new(big.Int)
bigParentTime := new(big.Int)
bigTime.SetUint64(time)
```

```
bigParentTime.Set(parent.Time)
if bigTime.Sub(bigTime, bigParentTime).Cmp(params.DurationLimit) < 0 {
diff.Add(parent.Difficulty, adjust)
} else {
diff.Sub(parent.Difficulty, adjust)
if diff.Cmp(params.MinimumDifficulty) < 0 {
diff.Set(params.MinimumDifficulty)
}
periodCount := new(big.Int).Add(parent.Number, common.Big1)
periodCount.Div(periodCount, expDiffPeriod)
if periodCount.Cmp(common.Big1) > 0 {
// diff = diff + 2^(periodCount - 2)
expDiff := periodCount.Sub(periodCount, common.Big2)
expDiff.Exp(common.Big2, expDiff, nil)
diff.Add(diff, expDiff)
diff = math.BigMax(diff, params.MinimumDifficulty)
}
return diff
}
// VerifySeal implements consensus. Engine, checking whether the given block satisfies
// the PoW difficulty requirements.
func (ethash *Ethash) VerifySeal(chain consensus.ChainReader, header *types.Header) error {
// If we're running a fake PoW, accept any seal as valid
if ethash.fakeMode {
time.Sleep(ethash.fakeDelay)
if ethash.fakeFail == header.Number.Uint64() {
return errInvalidPoW
}
return nil
// If we're running a shared PoW, delegate verification to it
if ethash.shared != nil {
return ethash.shared.VerifySeal(chain, header)
}
// Sanity check that the block number is below the lookup table size (60M blocks)
number := header.Number.Uint64()
if number/epochLength >= uint64(len(cacheSizes)) {
// Go < 1.7 cannot calculate new cache/dataset sizes (no fast prime check)
```

```
return errNonceOutOfRange
}
// Ensure that we have a valid difficulty for the block
if header.Difficulty.Sign() <= 0 {
return errInvalidDifficulty
// Recompute the digest and PoW value and verify against the header
cache := ethash.cache(number)
size := datasetSize(number)
if ethash.tester {
size = 32 * 1024
}
digest, result := hashimotoLight(size, cache, header.HashNoNonce().Bytes(),
header.Nonce.Uint64())
if !bytes.Equal(header.MixDigest[:], digest) {
return errInvalidMixDigest
}
target := new(big.Int).Div(maxUint256, header.Difficulty)
if new(big.Int).SetBytes(result).Cmp(target) > 0 {
return errInvalidPoW
}
return nil
}
// Prepare implements consensus. Engine, initializing the difficulty field of a
// header to conform to the ethash protocol. The changes are done inline.
func (ethash *Ethash) Prepare(chain consensus.ChainReader, header *types.Header) error {
parent := chain.GetHeader(header.ParentHash, header.Number.Uint64()-1)
if parent == nil {
return consensus.ErrUnknownAncestor
}
header.Difficulty = CalcDifficulty(chain.Config(), header.Time.Uint64(), parent)
return nil
}
// Finalize implements consensus. Engine, accumulating the block and uncle rewards,
// setting the final state and assembling the block.
func (ethash *Ethash) Finalize(chain consensus.ChainReader, header *types.Header, state
*state.StateDB, txs []*types.Transaction, uncles []*types.Header, receipts []*types.Receipt)
(*types.Block, error) {
```

```
// Accumulate any block and uncle rewards and commit the final state root
AccumulateRewards(state, header, uncles)
header.Root = state.IntermediateRoot(chain.Config().IsEIP158(header.Number))
// Header seems complete, assemble into a block and return
return types.NewBlock(header, txs, uncles, receipts), nil
}
// Some weird constants to avoid constant memory allocs for them.
var (
big8 = big.NewInt(8)
big32 = big.NewInt(32)
)
// AccumulateRewards credits the coinbase of the given block with the mining
// reward. The total reward consists of the static block reward and rewards for
// included uncles. The coinbase of each uncle block is also rewarded.
// TODO (karalabe): Move the chain maker into this package and make this private!
func AccumulateRewards(state *state.StateDB, header *types.Header, uncles []*types.Header) {
reward := new(big.Int).Set(blockReward)
r := new(big.Int)
for _, uncle := range uncles {
r.Add(uncle.Number, big8)
r.Sub(r, header.Number)
r.Mul(r, blockReward)
r.Div(r, big8)
state.AddBalance(uncle.Coinbase, r)
r.Div(blockReward, big32)
reward.Add(reward, r)
}
state.AddBalance(header.Coinbase, reward)
}
34:F:\git\coin\ethereum\go-ethereum\consensus\ethash\consensus_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ethash
import (
"encoding/json"
"math/big"
```

```
"os"
"testing"
"github.com/ethereum/go-ethereum/common/math"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/params"
)
type diffTest struct {
ParentTimestamp uint64
ParentDifficulty *big.Int
CurrentTimestamp uint64
CurrentBlocknumber *big.Int
CurrentDifficulty *big.Int
}
func (d *diffTest) UnmarshalJSON(b []byte) (err error) {
var ext struct {
ParentTimestamp string
ParentDifficulty string
CurrentTimestamp string
CurrentBlocknumber string
CurrentDifficulty string
if err := json.Unmarshal(b, &ext); err != nil {
return err
}
d.ParentTimestamp = math.MustParseUint64(ext.ParentTimestamp)
d.ParentDifficulty = math.MustParseBig256(ext.ParentDifficulty)
d.CurrentTimestamp = math.MustParseUint64(ext.CurrentTimestamp)
d.CurrentBlocknumber = math.MustParseBig256(ext.CurrentBlocknumber)
d.CurrentDifficulty = math.MustParseBig256(ext.CurrentDifficulty)
return nil
}
func TestCalcDifficulty(t *testing.T) {
file, err := os.Open("../../tests/files/BasicTests/difficulty.json")
if err != nil {
t.Fatal(err)
}
```

```
defer file.Close()
tests := make(map[string]diffTest)
err = json.NewDecoder(file).Decode(&tests)
if err != nil {
t.Fatal(err)
}
config := &params.ChainConfig{HomesteadBlock: big.NewInt(1150000)}
for name, test := range tests {
number := new(big.Int).Sub(test.CurrentBlocknumber, big.NewInt(1))
diff := CalcDifficulty(config, test.CurrentTimestamp, &types.Header{
Number:
            number,
Time:
          new(big.Int).SetUint64(test.ParentTimestamp),
Difficulty: test.ParentDifficulty,
})
if diff.Cmp(test.CurrentDifficulty) != 0 {
t.Error(name, "failed. Expected", test.CurrentDifficulty, "and calculated", diff)
}
}
}
35:F:\git\coin\ethereum\go-ethereum\consensus\ethash\ethash.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package ethash implements the ethash proof-of-work consensus engine.
package ethash
import (
"errors"
"fmt"
"math"
"math/big"
"math/rand"
"os"
"path/filepath"
"reflect"
"strconv"
"sync"
"time"
"unsafe"
```

```
mmap "github.com/edsrzf/mmap-go"
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/rpc"
metrics "github.com/rcrowley/go-metrics"
)
var ErrInvalidDumpMagic = errors.New("invalid dump magic")
var (
// maxUint256 is a big integer representing 2^256-1
maxUint256 = new(big.Int).Exp(big.NewInt(2), big.NewInt(256), big.NewInt(0))
// sharedEthash is a full instance that can be shared between multiple users.
sharedEthash = New("", 3, 0, "", 1, 0)
// algorithmRevision is the data structure version used for file naming.
algorithmRevision = 23
// dumpMagic is a dataset dump header to sanity check a data dump.
dumpMagic = []uint32{0xbaddcafe, 0xfee1dead}
)
// isLittleEndian returns whether the local system is running in little or big
// endian byte order.
func isLittleEndian() bool {
n := uint32(0x01020304)
return *(*byte)(unsafe.Pointer(&n)) == 0x04
}
// memoryMap tries to memory map a file of uint32s for read only access.
func memoryMap(path string) (*os.File, mmap.MMap, []uint32, error) {
file, err := os.OpenFile(path, os.O_RDONLY, 0644)
if err != nil {
return nil, nil, nil, err
}
mem, buffer, err := memoryMapFile(file, false)
if err != nil {
file.Close()
return nil, nil, nil, err
}
for i, magic := range dumpMagic {
```

```
if buffer[i] != magic {
mem.Unmap()
file.Close()
return nil, nil, nil, ErrInvalidDumpMagic
}
}
return file, mem, buffer[len(dumpMagic):], err
}
// memoryMapFile tries to memory map an already opened file descriptor.
func memoryMapFile(file *os.File, write bool) (mmap.MMap, []uint32, error) {
// Try to memory map the file
flag := mmap.RDONLY
if write {
flag = mmap.RDWR
}
mem, err := mmap.Map(file, flag, 0)
if err != nil {
return nil, nil, err
}
// Yay, we managed to memory map the file, here be dragons
header := *(*reflect.SliceHeader)(unsafe.Pointer(&mem))
header.Len /= 4
header.Cap /= 4
return mem, *(*[]uint32)(unsafe.Pointer(&header)), nil
}
// memoryMapAndGenerate tries to memory map a temporary file of uint32s for write
// access, fill it with the data from a generator and then move it into the final
// path requested.
func memoryMapAndGenerate(path string, size uint64, generator func(buffer []uint32)) (*os.File,
mmap.MMap, []uint32, error) {
// Ensure the data folder exists
if err := os.MkdirAll(filepath.Dir(path), 0755); err != nil {
return nil, nil, nil, err
}
// Create a huge temporary empty file to fill with data
temp := path + "." + strconv.ltoa(rand.lnt())
dump, err := os.Create(temp)
if err != nil {
```

```
return nil, nil, nil, err
if err = dump.Truncate(int64(len(dumpMagic))*4 + int64(size)); err != nil {
return nil, nil, nil, err
}
// Memory map the file for writing and fill it with the generator
mem, buffer, err := memoryMapFile(dump, true)
if err != nil {
dump.Close()
return nil, nil, nil, err
copy(buffer, dumpMagic)
data := buffer[len(dumpMagic):]
generator(data)
if err := mem.Unmap(); err != nil {
return nil, nil, nil, err
if err := dump.Close(); err != nil {
return nil, nil, nil, err
if err := os.Rename(temp, path); err != nil {
return nil, nil, nil, err
}
return memoryMap(path)
}
// cache wraps an ethash cache with some metadata to allow easier concurrent use.
type cache struct {
epoch uint64 // Epoch for which this cache is relevant
dump *os.File // File descriptor of the memory mapped cache
mmap mmap.MMap // Memory map itself to unmap before releasing
cache []uint32 // The actual cache data content (may be memory mapped)
used time. Time // Timestamp of the last use for smarter eviction
once sync.Once // Ensures the cache is generated only once
lock sync.Mutex // Ensures thread safety for updating the usage time
}
// generate ensures that the cache content is generated before use.
```

```
func (c *cache) generate(dir string, limit int, test bool) {
c.once.Do(func() {
// If we have a testing cache, generate and return
if test {
c.cache = make([]uint32, 1024/4)
generateCache(c.cache, c.epoch, seedHash(c.epoch*epochLength+1))
return
}
// If we don't store anything on disk, generate and return
size := cacheSize(c.epoch*epochLength + 1)
seed := seedHash(c.epoch*epochLength + 1)
if dir == "" {
c.cache = make([]uint32, size/4)
generateCache(c.cache, c.epoch, seed)
return
}
// Disk storage is needed, this will get fancy
var endian string
if !isLittleEndian() {
endian = ".be"
}
path := filepath.Join(dir, fmt.Sprintf("cache-R%d-%x%s", algorithmRevision, seed[:8], endian))
logger := log.New("epoch", c.epoch)
// Try to load the file from disk and memory map it
var err error
c.dump, c.mmap, c.cache, err = memoryMap(path)
if err == nil {
logger.Debug("Loaded old ethash cache from disk")
return
}
logger.Debug("Failed to load old ethash cache", "err", err)
// No previous cache available, create a new cache file to fill
c.dump, c.mmap, c.cache, err = memoryMapAndGenerate(path, size, func(buffer []uint32) {
generateCache(buffer, c.epoch, seed) })
if err != nil {
logger.Error("Failed to generate mapped ethash cache", "err", err)
c.cache = make([]uint32, size/4)
generateCache(c.cache, c.epoch, seed)
```

```
}
// Iterate over all previous instances and delete old ones
for ep := int(c.epoch) - limit; ep >= 0; ep-- {
seed := seedHash(uint64(ep)*epochLength + 1)
path := filepath.Join(dir, fmt.Sprintf("cache-R%d-%x%s", algorithmRevision, seed[:8], endian))
os.Remove(path)
}
})
}
// release closes any file handlers and memory maps open.
func (c *cache) release() {
if c.mmap != nil {
c.mmap.Unmap()
c.mmap = nil
if c.dump != nil {
c.dump.Close()
c.dump = nil
}
}
// dataset wraps an ethash dataset with some metadata to allow easier concurrent use.
type dataset struct {
epoch uint64 // Epoch for which this cache is relevant
dump *os.File // File descriptor of the memory mapped cache
mmap mmap.MMap // Memory map itself to unmap before releasing
dataset []uint32 // The actual cache data content
used time. Time // Timestamp of the last use for smarter eviction
once sync.Once // Ensures the cache is generated only once
lock
      sync.Mutex // Ensures thread safety for updating the usage time
}
// generate ensures that the dataset content is generated before use.
func (d *dataset) generate(dir string, limit int, test bool) {
d.once.Do(func() {
// If we have a testing dataset, generate and return
if test {
cache := make([]uint32, 1024/4)
generateCache(cache, d.epoch, seedHash(d.epoch*epochLength+1))
```

```
d.dataset = make([]uint32, 32*1024/4)
generateDataset(d.dataset, d.epoch, cache)
return
// If we don't store anything on disk, generate and return
csize := cacheSize(d.epoch*epochLength + 1)
dsize := datasetSize(d.epoch*epochLength + 1)
seed := seedHash(d.epoch*epochLength + 1)
if dir == "" {
cache := make([]uint32, csize/4)
generateCache(cache, d.epoch, seed)
d.dataset = make([]uint32, dsize/4)
generateDataset(d.dataset, d.epoch, cache)
}
// Disk storage is needed, this will get fancy
var endian string
if !isLittleEndian() {
endian = ".be"
}
path := filepath.Join(dir, fmt.Sprintf("full-R%d-%x%s", algorithmRevision, seed[:8], endian))
logger := log.New("epoch", d.epoch)
// Try to load the file from disk and memory map it
var err error
d.dump, d.mmap, d.dataset, err = memoryMap(path)
if err == nil {
logger.Debug("Loaded old ethash dataset from disk")
return
logger.Debug("Failed to load old ethash dataset", "err", err)
// No previous dataset available, create a new dataset file to fill
cache := make([]uint32, csize/4)
generateCache(cache, d.epoch, seed)
d.dump, d.mmap, d.dataset, err = memoryMapAndGenerate(path, dsize, func(buffer []uint32) {
generateDataset(buffer, d.epoch, cache) })
if err != nil {
```

```
logger. Error ("Failed to generate mapped ethash dataset", "err", err)
d.dataset = make([]uint32, dsize/2)
generateDataset(d.dataset, d.epoch, cache)
}
// Iterate over all previous instances and delete old ones
for ep := int(d.epoch) - limit; ep >= 0; ep-- {
seed := seedHash(uint64(ep)*epochLength + 1)
path := filepath.Join(dir, fmt.Sprintf("full-R%d-%x%s", algorithmRevision, seed[:8], endian))
os.Remove(path)
}
})
}
// release closes any file handlers and memory maps open.
func (d *dataset) release() {
if d.mmap != nil {
d.mmap.Unmap()
d.mmap = nil
}
if d.dump != nil {
d.dump.Close()
d.dump = nil
}
// MakeCache generates a new ethash cache and optionally stores it to disk.
func MakeCache(block uint64, dir string) {
c := cache{epoch: block / epochLength}
c.generate(dir, math.MaxInt32, false)
c.release()
}
// MakeDataset generates a new ethash dataset and optionally stores it to disk.
func MakeDataset(block uint64, dir string) {
d := dataset{epoch: block / epochLength}
d.generate(dir, math.MaxInt32, false)
d.release()
// Ethash is a consensus engine based on proot-of-work implementing the ethash
// algorithm.
```

```
type Ethash struct {
cachedir
           string // Data directory to store the verification caches
cachesinmem int // Number of caches to keep in memory
cachesondisk int // Number of caches to keep on disk
          string // Data directory to store full mining datasets
dagdir
dagsinmem int // Number of mining datasets to keep in memory
dagsondisk int // Number of mining datasets to keep on disk
caches map[uint64]*cache // In memory caches to avoid regenerating too often
fcache *cache
                       // Pre-generated cache for the estimated future epoch
datasets map[uint64]*dataset // In memory datasets to avoid regenerating too often
fdataset *dataset
                       // Pre-generated dataset for the estimated future epoch
// Mining related fields
rand
       *rand.Rand // Properly seeded random source for nonces
threads int
                 // Number of threads to mine on if mining
update chan struct{} // Notification channel to update mining parameters
hashrate metrics. Meter // Meter tracking the average hashrate
// The fields below are hooks for testing
                  // Flag whether to use a smaller test dataset
tester bool
shared *Ethash
                   // Shared PoW verifier to avoid cache regeneration
fakeMode bool
                    // Flag whether to disable PoW checking
fakeFull bool
                  // Flag whether to disable all consensus rules
fakeFail uint64
                   // Block number which fails PoW check even in fake mode
fakeDelay time.Duration // Time delay to sleep for before returning from verify
lock sync. Mutex // Ensures thread safety for the in-memory caches and mining fields
}
// New creates a full sized ethash PoW scheme.
func New(cachedir string, cachesinmem, cachesondisk int, dagdir string, dagsinmem, dagsondisk
int) *Ethash {
if cachesinmem <= 0 {
log.Warn("One ethash cache must always be in memory", "requested", cachesinmem)
cachesinmem = 1
}
if cachedir != "" && cachesondisk > 0 {
log.Info("Disk storage enabled for ethash caches", "dir", cachedir, "count", cachesondisk)
if dagdir != "" && dagsondisk > 0 {
log.Info("Disk storage enabled for ethash DAGs", "dir", dagdir, "count", dagsondisk)
```

```
}
return &Ethash{
cachedir:
           cachedir,
cachesinmem: cachesinmem,
cachesondisk: cachesondisk,
dagdir:
           dagdir,
dagsinmem: dagsinmem,
dagsondisk: dagsondisk,
           make(map[uint64]*cache),
caches:
datasets:
           make(map[uint64]*dataset),
update:
           make(chan struct{}),
hashrate: metrics.NewMeter(),
}
}
// NewTester creates a small sized ethash PoW scheme useful only for testing
// purposes.
func NewTester() *Ethash {
return &Ethash{
cachesinmem: 1.
           make(map[uint64]*cache),
caches:
datasets:
           make(map[uint64]*dataset),
tester:
         true.
update:
          make(chan struct{}),
hashrate: metrics.NewMeter(),
}
}
// NewFaker creates a ethash consensus engine with a fake PoW scheme that accepts
// all blocks' seal as valid, though they still have to conform to the Ethereum
// consensus rules.
func NewFaker() *Ethash {
return &Ethash{fakeMode: true}
}
// NewFakeFailer creates a ethash consensus engine with a fake PoW scheme that
// accepts all blocks as valid apart from the single one specified, though they
// still have to conform to the Ethereum consensus rules.
func NewFakeFailer(fail uint64) *Ethash {
return &Ethash{fakeMode: true, fakeFail: fail}
}
```

```
// NewFakeDelayer creates a ethash consensus engine with a fake PoW scheme that
// accepts all blocks as valid, but delays verifications by some time, though
// they still have to conform to the Ethereum consensus rules.
func NewFakeDelayer(delay time.Duration) *Ethash {
return &Ethash{fakeMode: true, fakeDelay: delay}
}
// NewFullFaker creates an ethash consensus engine with a full fake scheme that
// accepts all blocks as valid, without checking any consensus rules whatsoever.
func NewFullFaker() *Ethash {
return &Ethash{fakeMode: true, fakeFull: true}
}
// NewShared creates a full sized ethash PoW shared between all requesters running
// in the same process.
func NewShared() *Ethash {
return &Ethash{shared: sharedEthash}
}
// cache tries to retrieve a verification cache for the specified block number
// by first checking against a list of in-memory caches, then against caches
// stored on disk, and finally generating one if none can be found.
func (ethash *Ethash) cache(block uint64) []uint32 {
epoch := block / epochLength
// If we have a PoW for that epoch, use that
ethash.lock.Lock()
current, future := ethash.caches[epoch], (*cache)(nil)
if current == nil {
// No in-memory cache, evict the oldest if the cache limit was reached
for len(ethash.caches) > 0 && len(ethash.caches) >= ethash.cachesinmem {
var evict *cache
for _, cache := range ethash.caches {
if evict == nil || evict.used.After(cache.used) {
evict = cache
}
}
delete(ethash.caches, evict.epoch)
evict.release()
log.Trace("Evicted ethash cache", "epoch", evict.epoch, "used", evict.used)
```

```
}
// If we have the new cache pre-generated, use that, otherwise create a new one
if ethash.fcache != nil && ethash.fcache.epoch == epoch {
log.Trace("Using pre-generated cache", "epoch", epoch)
current, ethash.fcache = ethash.fcache, nil
} else {
log.Trace("Requiring new ethash cache", "epoch", epoch)
current = &cache{epoch: epoch}
ethash.caches[epoch] = current
// If we just used up the future cache, or need a refresh, regenerate
if ethash.fcache == nil || ethash.fcache.epoch <= epoch {
if ethash.fcache != nil {
ethash.fcache.release()
log.Trace("Requiring new future ethash cache", "epoch", epoch+1)
future = &cache{epoch: epoch + 1}
ethash.fcache = future
// New current cache, set its initial timestamp
current.used = time.Now()
}
ethash.lock.Unlock()
// Wait for generation finish, bump the timestamp and finalize the cache
current.generate(ethash.cachedir, ethash.cachesondisk, ethash.tester)
current.lock.Lock()
current.used = time.Now()
current.lock.Unlock()
// If we exhausted the future cache, now's a good time to regenerate it
if future != nil {
go future.generate(ethash.cachedir, ethash.cachesondisk, ethash.tester)
}
return current.cache
}
// dataset tries to retrieve a mining dataset for the specified block number
// by first checking against a list of in-memory datasets, then against DAGs
// stored on disk, and finally generating one if none can be found.
```

```
func (ethash *Ethash) dataset(block uint64) []uint32 {
epoch := block / epochLength
// If we have a PoW for that epoch, use that
ethash.lock.Lock()
current, future := ethash.datasets[epoch], (*dataset)(nil)
if current == nil {
// No in-memory dataset, evict the oldest if the dataset limit was reached
for len(ethash.datasets) > 0 && len(ethash.datasets) >= ethash.dagsinmem {
var evict *dataset
for _, dataset := range ethash.datasets {
if evict == nil || evict.used.After(dataset.used) {
evict = dataset
}
delete(ethash.datasets, evict.epoch)
evict.release()
log.Trace("Evicted ethash dataset", "epoch", evict.epoch, "used", evict.used)
}
// If we have the new cache pre-generated, use that, otherwise create a new one
if ethash.fdataset != nil && ethash.fdataset.epoch == epoch {
log.Trace("Using pre-generated dataset", "epoch", epoch)
current = &dataset{epoch: ethash.fdataset.epoch} // Reload from disk
ethash.fdataset = nil
} else {
log.Trace("Requiring new ethash dataset", "epoch", epoch)
current = &dataset{epoch: epoch}
}
ethash.datasets[epoch] = current
// If we just used up the future dataset, or need a refresh, regenerate
if ethash.fdataset == nil || ethash.fdataset.epoch <= epoch {
if ethash.fdataset != nil {
ethash.fdataset.release()
}
log.Trace("Requiring new future ethash dataset", "epoch", epoch+1)
future = &dataset{epoch: epoch + 1}
ethash.fdataset = future
// New current dataset, set its initial timestamp
```

```
current.used = time.Now()
ethash.lock.Unlock()
// Wait for generation finish, bump the timestamp and finalize the cache
current.generate(ethash.dagdir, ethash.dagsondisk, ethash.tester)
current.lock.Lock()
current.used = time.Now()
current.lock.Unlock()
// If we exhausted the future dataset, now's a good time to regenerate it
if future != nil {
go future.generate(ethash.dagdir, ethash.dagsondisk, ethash.tester)
}
return current.dataset
}
// Threads returns the number of mining threads currently enabled. This doesn't
// necessarily mean that mining is running!
func (ethash *Ethash) Threads() int {
ethash.lock.Lock()
defer ethash.lock.Unlock()
return ethash.threads
}
// SetThreads updates the number of mining threads currently enabled. Calling
// this method does not start mining, only sets the thread count. If zero is
// specified, the miner will use all cores of the machine. Setting a thread
// count below zero is allowed and will cause the miner to idle, without any
// work being done.
func (ethash *Ethash) SetThreads(threads int) {
ethash.lock.Lock()
defer ethash.lock.Unlock()
// If we're running a shared PoW, set the thread count on that instead
if ethash.shared != nil {
ethash.shared.SetThreads(threads)
return
}
// Update the threads and ping any running seal to pull in any changes
```

```
ethash.threads = threads
select {
case ethash.update <- struct{}{}:
default:
// Hashrate implements PoW, returning the measured rate of the search invocations
// per second over the last minute.
func (ethash *Ethash) Hashrate() float64 {
return ethash.hashrate.Rate1()
}
// APIs implements consensus. Engine, returning the user facing RPC APIs. Currently
// that is empty.
func (ethash *Ethash) APIs(chain consensus.ChainReader) []rpc.API {
return nil
}
// SeedHash is the seed to use for generating a verification cache and the mining
// dataset.
func SeedHash(block uint64) []byte {
return seedHash(block)
}
36:F:\git\coin\ethereum\go-ethereum\consensus\ethash\ethash_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ethash
import (
"math/big"
"testing"
"github.com/ethereum/go-ethereum/core/types"
)
// Tests that ethash works correctly in test mode.
func TestTestMode(t *testing.T) {
head := &types.Header{Number: big.NewInt(1), Difficulty: big.NewInt(100)}
ethash := NewTester()
```

```
block, err := ethash.Seal(nil, types.NewBlockWithHeader(head), nil)
if err != nil {
t.Fatalf("failed to seal block: %v", err)
head.Nonce = types.EncodeNonce(block.Nonce())
head.MixDigest = block.MixDigest()
if err := ethash.VerifySeal(nil, head); err != nil {
t.Fatalf("unexpected verification error: %v", err)
}
37:F:\git\coin\ethereum\go-ethereum\consensus\ethash\sealer.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ethash
import (
crand "crypto/rand"
"math"
"math/big"
"math/rand"
"runtime"
"sync"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/log"
)
// Seal implements consensus. Engine, attempting to find a nonce that satisfies
// the block's difficulty requirements.
func (ethash *Ethash) Seal(chain consensus.ChainReader, block *types.Block, stop <-chan
struct()) (*types.Block, error) {
// If we're running a fake PoW, simply return a 0 nonce immediately
if ethash.fakeMode {
header := block.Header()
header.Nonce, header.MixDigest = types.BlockNonce{}, common.Hash{}
return block.WithSeal(header), nil
// If we're running a shared PoW, delegate sealing to it
if ethash.shared != nil {
```

```
return ethash.shared.Seal(chain, block, stop)
}
// Create a runner and the multiple search threads it directs
abort := make(chan struct{})
found := make(chan *types.Block)
ethash.lock.Lock()
threads := ethash.threads
if ethash.rand == nil {
seed, err := crand.Int(crand.Reader, big.NewInt(math.MaxInt64))
if err != nil {
ethash.lock.Unlock()
return nil, err
ethash.rand = rand.New(rand.NewSource(seed.Int64()))
}
ethash.lock.Unlock()
if threads == 0 {
threads = runtime.NumCPU()
if threads < 0 {
threads = 0 // Allows disabling local mining without extra logic around local/remote
}
var pend sync.WaitGroup
for i := 0; i < threads; i++ \{
pend.Add(1)
go func(id int, nonce uint64) {
defer pend.Done()
ethash.mine(block, id, nonce, abort, found)
}(i, uint64(ethash.rand.Int63()))
}
// Wait until sealing is terminated or a nonce is found
var result *types.Block
select {
case <-stop:
// Outside abort, stop all miner threads
close(abort)
case result = <-found:
// One of the threads found a block, abort all others
close(abort)
case <-ethash.update:
// Thread count was changed on user request, restart
```

```
close(abort)
pend.Wait()
return ethash.Seal(chain, block, stop)
// Wait for all miners to terminate and return the block
pend.Wait()
return result, nil
}
// mine is the actual proof-of-work miner that searches for a nonce starting from
// seed that results in correct final block difficulty.
func (ethash *Ethash) mine(block *types.Block, id int, seed uint64, abort chan struct{}, found chan
*types.Block) {
// Extract some data from the header
var (
header = block.Header()
hash = header.HashNoNonce().Bytes()
target = new(big.Int).Div(maxUint256, header.Difficulty)
number = header.Number.Uint64()
dataset = ethash.dataset(number)
)
// Start generating random nonces until we abort or find a good one
var (
attempts = int64(0)
nonce = seed
)
logger := log.New("miner", id)
logger.Trace("Started ethash search for new nonces", "seed", seed)
for {
select {
case <-abort:
// Mining terminated, update stats and abort
logger.Trace("Ethash nonce search aborted", "attempts", nonce-seed)
ethash.hashrate.Mark(attempts)
return
default:
// We don't have to update hash rate on every nonce, so update after after 2^X nonces
attempts++
if (attempts % (1 << 15)) == 0 {
ethash.hashrate.Mark(attempts)
```

```
attempts = 0
}
// Compute the PoW value of this nonce
digest, result := hashimotoFull(dataset, hash, nonce)
if new(big.Int).SetBytes(result).Cmp(target) <= 0 {
// Correct nonce found, create a new header with it
header = types.CopyHeader(header)
header.Nonce = types.EncodeNonce(nonce)
header.MixDigest = common.BytesToHash(digest)
// Seal and return a block (if still needed)
select {
case found <- block.WithSeal(header):</pre>
logger.Trace("Ethash nonce found and reported", "attempts", nonce-seed, "nonce", nonce)
case <-abort:
logger.Trace("Ethash nonce found but discarded", "attempts", nonce-seed, "nonce", nonce)
}
return
nonce++
}
}
38:F:\git\coin\ethereum\go-ethereum\consensus\misc\dao.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package misc
import (
"bytes"
"errors"
"math/big"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/params"
)
var (
// ErrBadProDAOExtra is returned if a header doens't support the DAO fork on a
// pro-fork client.
```

```
ErrBadProDAOExtra = errors.New("bad DAO pro-fork extra-data")
## ErrBadNoDAOExtra is returned if a header does support the DAO fork on a no-
// fork client.
ErrBadNoDAOExtra = errors.New("bad DAO no-fork extra-data")
// VerifyDAOHeaderExtraData validates the extra-data field of a block header to
// ensure it conforms to DAO hard-fork rules.
//
// DAO hard-fork extension to the header validity:
// a) if the node is no-fork, do not accept blocks in the [fork, fork+10] range
     with the fork specific extra-data set
// b) if the node is pro-fork, require blocks in the specific range to have the
     unique extra-data set.
func VerifyDAOHeaderExtraData(config *params.ChainConfig, header *types.Header) error {
// Short circuit validation if the node doesn't care about the DAO fork
if config.DAOForkBlock == nil {
return nil
// Make sure the block is within the fork's modified extra-data range
limit := new(big.Int).Add(config.DAOForkBlock, params.DAOForkExtraRange)
if header.Number.Cmp(config.DAOForkBlock) < 0 || header.Number.Cmp(limit) >= 0 {
return nil
// Depending on whether we support or oppose the fork, validate the extra-data contents
if config.DAOForkSupport {
if !bytes.Equal(header.Extra, params.DAOForkBlockExtra) {
return ErrBadProDAOExtra
} else {
if bytes.Equal(header.Extra, params.DAOForkBlockExtra) {
return ErrBadNoDAOExtra
// All ok, header has the same extra-data we expect
return nil
}
// ApplyDAOHardFork modifies the state database according to the DAO hard-fork
// rules, transferring all balances of a set of DAO accounts to a single refund
// contract.
```

```
func ApplyDAOHardFork(statedb *state.StateDB) {
// Retrieve the contract to refund balances into
if !statedb.Exist(params.DAORefundContract) {
statedb.CreateAccount(params.DAORefundContract)
}
// Move every DAO account and extra-balance account funds into the refund contract
for _, addr := range params.DAODrainList() {
statedb.AddBalance(params.DAORefundContract, statedb.GetBalance(addr))
statedb.SetBalance(addr, new(big.Int))
}
}
39:F:\git\coin\ethereum\go-ethereum\consensus\misc\forks.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package misc
import (
"fmt"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/params"
)
// VerifyForkHashes verifies that blocks conforming to network hard-forks do have
// the correct hashes, to avoid clients going off on different chains. This is an
// optional feature.
func VerifyForkHashes(config *params.ChainConfig, header *types.Header, uncle bool) error {
// We don't care about uncles
if uncle {
return nil
// If the homestead reprice hash is set, validate it
if config.EIP150Block != nil && config.EIP150Block.Cmp(header.Number) == 0 {
if config.EIP150Hash != (common.Hash{}) && config.EIP150Hash != header.Hash() {
return fmt.Errorf("homestead gas reprice fork: have 0x%x, want 0x%x", header.Hash(),
config.EIP150Hash)
}
}
// All ok, return
```

```
return nil
40:F:\git\coin\ethereum\go-ethereum\console\bridge.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package console
import (
"encoding/json"
"fmt"
"io"
"strings"
"time"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/rpc"
"github.com/robertkrimen/otto"
)
// bridge is a collection of JavaScript utility methods to bride the .js runtime
// environment and the Go RPC connection backing the remote method calls.
type bridge struct {
client *rpc.Client // RPC client to execute Ethereum requests through
prompter UserPrompter // Input prompter to allow interactive user feedback
printer io. Writer // Output writer to serialize any display strings to
}
// newBridge creates a new JavaScript wrapper around an RPC client.
func newBridge(client *rpc.Client, prompter UserPrompter, printer io.Writer) *bridge {
return &bridge{
client: client.
prompter: prompter,
printer: printer,
}
}
// NewAccount is a wrapper around the personal.newAccount RPC method that uses a
// non-echoing password prompt to acquire the passphrase and executes the original
// RPC method (saved in jeth.newAccount) with it to actually execute the RPC call.
func (b *bridge) NewAccount(call otto.FunctionCall) (response otto.Value) {
var (
```

```
password string
confirm string
err
      error
)
switch {
// No password was specified, prompt the user for it
case len(call.ArgumentList) == 0:
if password, err = b.prompter.PromptPassword("Passphrase: "); err != nil {
throwJSException(err.Error())
}
if confirm, err = b.prompter.PromptPassword("Repeat passphrase: "); err != nil {
throwJSException(err.Error())
}
if password != confirm {
throwJSException("passphrases don't match!")
}
// A single string password was specified, use that
case len(call.ArgumentList) == 1 && call.Argument(0).lsString():
password, _ = call.Argument(0).ToString()
// Otherwise fail with some error
default:
throwJSException("expected 0 or 1 string argument")
// Password acquired, execute the call and return
ret, err := call.Otto.Call("jeth.newAccount", nil, password)
if err != nil {
throwJSException(err.Error())
return ret
}
// UnlockAccount is a wrapper around the personal.unlockAccount RPC method that
// uses a non-echoing password prompt to acquire the passphrase and executes the
// original RPC method (saved in jeth.unlockAccount) with it to actually execute
// the RPC call.
func (b *bridge) UnlockAccount(call otto.FunctionCall) (response otto.Value) {
// Make sure we have an account specified to unlock
if !call.Argument(0).IsString() {
throwJSException("first argument must be the account to unlock")
}
```

```
account := call.Argument(0)
// If password is not given or is the null value, prompt the user for it
var passwd otto. Value
if call.Argument(1).IsUndefined() || call.Argument(1).IsNull() {
fmt.Fprintf(b.printer, "Unlock account %s\n", account)
if input, err := b.prompter.PromptPassword("Passphrase: "); err != nil {
throwJSException(err.Error())
} else {
passwd, _ = otto.ToValue(input)
}
} else {
if !call.Argument(1).IsString() {
throwJSException("password must be a string")
}
passwd = call.Argument(1)
}
// Third argument is the duration how long the account must be unlocked.
duration := otto.NullValue()
if call.Argument(2).IsDefined() && !call.Argument(2).IsNull() {
if !call.Argument(2).IsNumber() {
throwJSException("unlock duration must be a number")
duration = call.Argument(2)
// Send the request to the backend and return
val, err := call.Otto.Call("jeth.unlockAccount", nil, account, passwd, duration)
if err != nil {
throwJSException(err.Error())
}
return val
}
// Sign is a wrapper around the personal sign RPC method that uses a non-echoing password
// prompt to acquire the passphrase and executes the original RPC method (saved in
// jeth.sign) with it to actually execute the RPC call.
func (b *bridge) Sign(call otto.FunctionCall) (response otto.Value) {
var (
message = call.Argument(0)
account = call.Argument(1)
passwd = call.Argument(2)
```

```
)
if !message.lsString() {
throwJSException("first argument must be the message to sign")
}
if !account.lsString() {
throwJSException("second argument must be the account to sign with")
}
// if the password is not given or null ask the user and ensure password is a string
if passwd.lsUndefined() || passwd.lsNull() {
fmt.Fprintf(b.printer, "Give password for account %s\n", account)
if input, err := b.prompter.PromptPassword("Passphrase: "); err != nil {
throwJSException(err.Error())
} else {
passwd, _ = otto.ToValue(input)
}
}
if !passwd.IsString() {
throwJSException("third argument must be the password to unlock the account")
}
// Send the request to the backend and return
val, err := call.Otto.Call("jeth.sign", nil, message, account, passwd)
if err != nil {
throwJSException(err.Error())
}
return val
// Sleep will block the console for the specified number of seconds.
func (b *bridge) Sleep(call otto.FunctionCall) (response otto.Value) {
if call.Argument(0).IsNumber() {
sleep, _ := call.Argument(0).ToInteger()
time.Sleep(time.Duration(sleep) * time.Second)
return otto.TrueValue()
}
return throwJSException("usage: sleep(<number of seconds>)")
}
// SleepBlocks will block the console for a specified number of new blocks optionally
// until the given timeout is reached.
```

```
func (b *bridge) SleepBlocks(call otto.FunctionCall) (response otto.Value) {
var (
blocks = int64(0)
)
// Parse the input parameters for the sleep
nArgs := len(call.ArgumentList)
if nArgs == 0 {
throwJSException("usage: sleepBlocks(<n blocks>[, max sleep in seconds])")
}
if nArgs >= 1 {
if call.Argument(0).IsNumber() {
blocks, _ = call.Argument(0).ToInteger()
} else {
throwJSException("expected number as first argument")
}
}
if nArgs >= 2 {
if call.Argument(1).IsNumber() {
sleep, _ = call.Argument(1).ToInteger()
} else {
throwJSException("expected number as second argument")
}
}
// go through the console, this will allow web3 to call the appropriate
// callbacks if a delayed response or notification is received.
blockNumber := func() int64 {
result, err := call.Otto.Run("eth.blockNumber")
if err != nil {
throwJSException(err.Error())
}
block, err := result.ToInteger()
if err != nil {
throwJSException(err.Error())
return block
}
// Poll the current block number until either it ot a timeout is reached
targetBlockNr := blockNumber() + blocks
deadline := time.Now().Add(time.Duration(sleep) * time.Second)
for time.Now().Before(deadline) {
```

```
if blockNumber() >= targetBlockNr {
return otto.TrueValue()
time.Sleep(time.Second)
}
return otto.FalseValue()
}
type jsonrpcCall struct {
ld int64
Method string
Params []interface{}
}
// Send implements the web3 provider "send" method.
func (b *bridge) Send(call otto.FunctionCall) (response otto.Value) {
// Remarshal the request into a Go value.
JSON, _ := call.Otto.Object("JSON")
reqVal, err := JSON.Call("stringify", call.Argument(0))
if err != nil {
throwJSException(err.Error())
}
var (
rawReq = reqVal.String()
dec = json.NewDecoder(strings.NewReader(rawReq))
reqs []jsonrpcCall
batch bool
dec.UseNumber() // avoid float64s
if rawReq[0] == '[' {
batch = true
dec.Decode(&reqs)
} else {
batch = false
reqs = make([]jsonrpcCall, 1)
dec.Decode(&reqs[0])
}
// Execute the requests.
resps, _ := call.Otto.Object("new Array()")
for _, req := range reqs {
resp, _ := call.Otto.Object(`({"jsonrpc":"2.0"})`)
```

```
resp.Set("id", req.Id)
var result json.RawMessage
err = b.client.Call(&result, req.Method, req.Params...)
switch err := err.(type) {
case nil:
if result == nil {
// Special case null because it is decoded as an empty
// raw message for some reason.
resp.Set("result", otto.NullValue())
} else {
resultVal, err := JSON.Call("parse", string(result))
if err != nil {
setError(resp, -32603, err.Error())
} else {
resp.Set("result", resultVal)
}
}
case rpc.Error:
setError(resp, err.ErrorCode(), err.Error())
default:
setError(resp, -32603, err.Error())
}
resps.Call("push", resp)
}
// Return the responses either to the callback (if supplied)
// or directly as the return value.
if batch {
response = resps.Value()
} else {
response, _ = resps.Get("0")
}
if fn := call.Argument(1); fn.Class() == "Function" {
fn.Call(otto.NullValue(), otto.NullValue(), response)
return otto.UndefinedValue()
}
return response
}
func setError(resp *otto.Object, code int, msg string) {
resp.Set("error", map[string]interface{}{"code": code, "message": msg})
}
```

```
// throwJSException panics on an otto. Value. The Otto VM will recover from the
// Go panic and throw msg as a JavaScript error.
func throwJSException(msg interface{}) otto.Value {
val, err := otto.ToValue(msg)
if err != nil {
log.Error("Failed to serialize JavaScript exception", "exception", msg, "err", err)
}
panic(val)
}
41:F:\git\coin\ethereum\go-ethereum\console\console.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package console
import (
"fmt"
"io"
"io/ioutil"
"os"
"os/signal"
"path/filepath"
"regexp"
"sort"
"strings"
"github.com/ethereum/go-ethereum/internal/jsre"
"github.com/ethereum/go-ethereum/internal/web3ext"
"github.com/ethereum/go-ethereum/rpc"
"github.com/mattn/go-colorable"
"github.com/peterh/liner"
"github.com/robertkrimen/otto"
)
var (
passwordRegexp = regexp.MustCompile(`personal.[nus]`)
onlyWhitespace = regexp.MustCompile(`^\s*$`)
          = regexp.MustCompile(`^\s*exit\s*;*\s*$`)
exit
)
```

// HistoryFile is the file within the data directory to store input scrollback.

```
const HistoryFile = "history"
// DefaultPrompt is the default prompt line prefix to use for user input querying.
const DefaultPrompt = "> "
// Config is te collection of configurations to fine tune the behavior of the
// JavaScript console.
type Config struct {
DataDir string
                  // Data directory to store the console history at
DocRoot string
                   // Filesystem path from where to load JavaScript files from
Client *rpc.Client // RPC client to execute Ethereum requests through
Prompt string
                   // Input prompt prefix string (defaults to DefaultPrompt)
Prompter UserPrompter // Input prompter to allow interactive user feedback (defaults to
TerminalPrompter)
Printer io.Writer // Output writer to serialize any display strings to (defaults to os.Stdout)
Preload []string
                  // Absolute paths to JavaScript files to preload
}
// Console is a JavaScript interpreted runtime environment. It is a fully fleged
// JavaScript console attached to a running node via an external or in-process RPC
// client.
type Console struct {
client *rpc.Client // RPC client to execute Ethereum requests through
isre
       *jsre.JSRE // JavaScript runtime environment running the interpreter
prompt string
                  // Input prompt prefix string
prompter UserPrompter // Input prompter to allow interactive user feedback
histPath string
                  // Absolute path to the console scrollback history
history []string // Scroll history maintained by the console
printer io. Writer // Output writer to serialize any display strings to
}
func New(config Config) (*Console, error) {
// Handle unset config values gracefully
if config.Prompter == nil {
config.Prompter = Stdin
}
if config.Prompt == "" {
config.Prompt = DefaultPrompt
if config.Printer == nil {
config.Printer = colorable.NewColorableStdout()
}
```

```
// Initialize the console and return
console := &Console{
client: config.Client,
      jsre.New(config.DocRoot, config.Printer),
isre:
prompt: config.Prompt,
prompter: config.Prompter,
printer: config.Printer,
histPath: filepath.Join(config.DataDir, HistoryFile),
if err := console.init(config.Preload); err != nil {
return nil, err
}
return console, nil
}
// init retrieves the available APIs from the remote RPC provider and initializes
// the console's JavaScript namespaces based on the exposed modules.
func (c *Console) init(preload []string) error {
// Initialize the JavaScript <-> Go RPC bridge
bridge := newBridge(c.client, c.prompter, c.printer)
c.jsre.Set("jeth", struct{}{})
jethObj, _ := c.jsre.Get("jeth")
jethObj.Object().Set("send", bridge.Send)
jethObj.Object().Set("sendAsync", bridge.Send)
consoleObj, _ := c.jsre.Get("console")
consoleObj.Object().Set("log", c.consoleOutput)
consoleObj.Object().Set("error", c.consoleOutput)
// Load all the internal utility JavaScript libraries
if err := c.jsre.Compile("bignumber.js", jsre.BigNumber JS); err != nil {
return fmt.Errorf("bignumber.js: %v", err)
if err := c.jsre.Compile("web3.js", jsre.Web3_JS); err != nil {
return fmt.Errorf("web3.js: %v", err)
}
if _, err := c.jsre.Run("var Web3 = require('web3');"); err != nil {
return fmt.Errorf("web3 require: %v", err)
if _, err := c.jsre.Run("var web3 = new Web3(jeth);"); err != nil {
return fmt.Errorf("web3 provider: %v", err)
```

```
}
// Load the supported APIs into the JavaScript runtime environment
apis, err := c.client.SupportedModules()
if err != nil {
return fmt.Errorf("api modules: %v", err)
flatten := "var eth = web3.eth; var personal = web3.personal; "
for api := range apis {
if api == "web3" {
continue // manually mapped or ignore
}
if file, ok := web3ext.Modules[api]; ok {
// Load our extension for the module.
if err = c.jsre.Compile(fmt.Sprintf("%s.js", api), file); err != nil {
return fmt.Errorf("%s.js: %v", api, err)
}
flatten += fmt.Sprintf("var %s = web3.%s; ", api, api)
} else if obj, err := c.jsre.Run("web3." + api); err == nil && obj.lsObject() {
// Enable web3.js built-in extension if available.
flatten += fmt.Sprintf("var %s = web3.%s; ", api, api)
}
}
if _, err = c.jsre.Run(flatten); err != nil {
return fmt.Errorf("namespace flattening: %v", err)
// Initialize the global name register (disabled for now)
//c.jsre.Run(`var GlobalRegistrar = eth.contract(` + registrar.GlobalRegistrarAbi + `); registrar =
GlobalRegistrar.at("` + registrar.GlobalRegistrarAddr + `");`)
// If the console is in interactive mode, instrument password related methods to query the user
if c.prompter != nil {
// Retrieve the account management object to instrument
personal, err := c.jsre.Get("personal")
if err != nil {
return err
}
// Override the unlockAccount, newAccount and sign methods since these require user interaction.
// Assign these method in the Console the original web3 callbacks. These will be called by the
// methods after they got the password from the user and send the original web3 request to the
backend.
if obj := personal.Object(); obj != nil { // make sure the personal api is enabled over the interface
```

```
if , err = c.jsre.Run(`jeth.unlockAccount = personal.unlockAccount;`); err != nil {
return fmt.Errorf("personal.unlockAccount: %v", err)
}
if _, err = c.jsre.Run(`jeth.newAccount = personal.newAccount;`); err != nil {
return fmt.Errorf("personal.newAccount: %v", err)
}
if _, err = c.jsre.Run(`jeth.sign = personal.sign;`); err != nil {
return fmt.Errorf("personal.sign: %v", err)
obj.Set("unlockAccount", bridge.UnlockAccount)
obj.Set("newAccount", bridge.NewAccount)
obj.Set("sign", bridge.Sign)
}
}
// The admin.sleep and admin.sleepBlocks are offered by the console and not by the RPC layer.
admin, err := c.jsre.Get("admin")
if err != nil {
return err
if obj := admin.Object(); obj != nil { // make sure the admin api is enabled over the interface
obj.Set("sleepBlocks", bridge.SleepBlocks)
obj.Set("sleep", bridge.Sleep)
}
// Preload any JavaScript files before starting the console
for _, path := range preload {
if err := c.jsre.Exec(path); err != nil {
failure := err.Error()
if ottoErr, ok := err.(*otto.Error); ok {
failure = ottoErr.String()
return fmt.Errorf("%s: %v", path, failure)
}
}
// Configure the console's input prompter for scrollback and tab completion
if c.prompter != nil {
if content, err := ioutil.ReadFile(c.histPath); err != nil {
c.prompter.SetHistory(nil)
} else {
c.history = strings.Split(string(content), "\n")
c.prompter.SetHistory(c.history)
}
c.prompter.SetWordCompleter(c.AutoCompleteInput)
```

```
}
return nil
}
// consoleOutput is an override for the console.log and console.error methods to
// stream the output into the configured output stream instead of stdout.
func (c *Console) consoleOutput(call otto.FunctionCall) otto.Value {
output := []string{}
for _, argument := range call.ArgumentList {
output = append(output, fmt.Sprintf("%v", argument))
}
fmt.Fprintln(c.printer, strings.Join(output, " "))
return otto.Value{}
}
// AutoCompleteInput is a pre-assembled word completer to be used by the user
// input prompter to provide hints to the user about the methods available.
func (c *Console) AutoCompleteInput(line string, pos int) (string, []string, string) {
// No completions can be provided for empty inputs
if len(line) == 0 || pos == 0 {|}
return "", nil, ""
}
// Chunck data to relevant part for autocompletion
// E.g. in case of nested lines eth.getBalance(eth.coinb<tab><tab>
start := pos - 1
for ; start > 0; start-- {
// Skip all methods and namespaces (i.e. including te dot)
if line[start] == '.' || (line[start] >= 'a' && line[start] <= 'z') || (line[start] >= 'A' && line[start] <= 'Z') {
continue
}
// Handle web3 in a special way (i.e. other numbers aren't auto completed)
if start >= 3 && line[start-3:start] == "web3" {
start -= 3
continue
}
// We've hit an unexpected character, autocomplete form here
start++
break
return line[:start], c.jsre.CompleteKeywords(line[start:pos]), line[pos:]
}
```

```
// Welcome show summary of current Geth instance and some metadata about the
// console's available modules.
func (c *Console) Welcome() {
// Print some generic Geth metadata
fmt.Fprintf(c.printer, "Welcome to the Geth JavaScript console!\n\n")
c.jsre.Run(`
console.log("instance: " + web3.version.node);
console.log("coinbase: " + eth.coinbase);
console.log("at block: " + eth.blockNumber + " (" + new Date(1000 *
eth.getBlock(eth.blockNumber).timestamp) + ")");
console.log(" datadir: " + admin.datadir);
`)
// List all the supported modules for the user to call
if apis, err := c.client.SupportedModules(); err == nil {
modules := make([]string, 0, len(apis))
for api, version := range apis {
modules = append(modules, fmt.Sprintf("%s:%s", api, version))
}
sort.Strings(modules)
fmt.Fprintln(c.printer, " modules:", strings.Join(modules, " "))
}
fmt.Fprintln(c.printer)
}
// Evaluate executes code and pretty prints the result to the specified output
// stream.
func (c *Console) Evaluate(statement string) error {
defer func() {
if r := recover(); r != nil {
fmt.Fprintf(c.printer, "[native] error: %v\n", r)
}
}()
return c.jsre.Evaluate(statement, c.printer)
}
// Interactive starts an interactive user session, where input is propted from
// the configured user prompter.
func (c *Console) Interactive() {
var (
                           // Current prompt line (used for multi-line inputs)
prompt = c.prompt
indents = 0
                       // Current number of input indents (used for multi-line inputs)
                      // Current user input
input
```

```
scheduler = make(chan string) // Channel to send the next prompt on and receive the input
)
// Start a goroutine to listen for promt requests and send back inputs
go func() {
for {
// Read the next user input
line, err := c.prompter.PromptInput(<-scheduler)
if err != nil {
// In case of an error, either clear the prompt or fail
if err == liner.ErrPromptAborted { // ctrl-C
prompt, indents, input = c.prompt, 0, ""
scheduler <- ""
continue
close(scheduler)
return
// User input retrieved, send for interpretation and loop
scheduler <- line
}
}()
// Monitor Ctrl-C too in case the input is empty and we need to bail
abort := make(chan os.Signal, 1)
signal.Notify(abort, os.Interrupt)
// Start sending prompts to the user and reading back inputs
for {
// Send the next prompt, triggering an input read and process the result
scheduler <- prompt
select {
case <-abort:
// User forcefully quite the console
fmt.Fprintln(c.printer, "caught interrupt, exiting")
return
case line, ok := <-scheduler:
// User input was returned by the prompter, handle special cases
if !ok || (indents <= 0 && exit.MatchString(line)) {
return
}
if onlyWhitespace.MatchString(line) {
continue
```

```
}
// Append the line to the input and check for multi-line interpretation
input += line + "\n"
indents = countIndents(input)
if indents <= 0 {
prompt = c.prompt
} else {
prompt = strings.Repeat(".", indents*3) + " "
}
// If all the needed lines are present, save the command and run
if indents <= 0 {
if len(input) > 0 && input[0] != ' ' && !passwordRegexp.MatchString(input) {
if command := strings.TrimSpace(input); len(c.history) == 0 || command != c.history[len(c.history)-
1] {
c.history = append(c.history, command)
if c.prompter != nil {
c.prompter.AppendHistory(command)
}
}
c.Evaluate(input)
input = ""
}
}
}
// countIndents returns the number of identations for the given input.
// In case of invalid input such as var a = } the result can be negative.
func countIndents(input string) int {
var (
indents = 0
inString = false
strOpenChar = ' ' // keep track of the string open char to allow var str = "I'm ....";
charEscaped = false // keep track if the previous char was the '\' char, allow var str = "abc\"def";
)
for _, c := range input {
switch c {
case '\\':
// indicate next char as escaped when in string and previous char isn't escaping this backslash
```

```
if !charEscaped && inString {
charEscaped = true
}
case \", "":
if inString && !charEscaped && strOpenChar == c { // end string
inString = false
} else if !inString && !charEscaped { // begin string
inString = true
strOpenChar = c
}
charEscaped = false
case '{', '(':
if !inString { // ignore brackets when in string, allow var str = "a{"; without indenting
indents++
}
charEscaped = false
case '}', ')':
if !inString {
indents--
charEscaped = false
default:
charEscaped = false
}
return indents
}
// Execute runs the JavaScript file specified as the argument.
func (c *Console) Execute(path string) error {
return c.jsre.Exec(path)
}
// Stop cleans up the console and terminates the runtime envorinment.
func (c *Console) Stop(graceful bool) error {
if err := ioutil.WriteFile(c.histPath, []byte(strings.Join(c.history, "\n")), 0600); err != nil {
return err
if err := os.Chmod(c.histPath, 0600); err != nil { // Force 0600, even if it was different previously
return err
}
```

```
c.jsre.Stop(graceful)
return nil
}
42:F:\git\coin\ethereum\go-ethereum\console\console_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package console
import (
"bytes"
"errors"
"fmt"
"io/ioutil"
"os"
"strings"
"testing"
"time"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core"
"github.com/ethereum/go-ethereum/eth"
"github.com/ethereum/go-ethereum/internal/jsre"
"github.com/ethereum/go-ethereum/node"
)
const (
testInstance = "console-tester"
testAddress = "0x8605cdbbdb6d264aa742e77020dcbc58fcdce182"
)
// hookedPrompter implements UserPrompter to simulate use input via channels.
type hookedPrompter struct {
scheduler chan string
}
func (p *hookedPrompter) PromptInput(prompt string) (string, error) {
// Send the prompt to the tester
select {
case p.scheduler <- prompt:
case <-time.After(time.Second):
return "", errors.New("prompt timeout")
```

```
}
// Retrieve the response and feed to the console
select {
case input := <-p.scheduler:
return input, nil
case <-time.After(time.Second):
return "", errors.New("input timeout")
}
}
func (p *hookedPrompter) PromptPassword(prompt string) (string, error) {
return "", errors.New("not implemented")
}
func (p *hookedPrompter) PromptConfirm(prompt string) (bool, error) {
return false, errors.New("not implemented")
}
func (p *hookedPrompter) SetHistory(history []string)
                                                             {}
func (p *hookedPrompter) AppendHistory(command string)
                                                                   {}
func (p *hookedPrompter) SetWordCompleter(completer WordCompleter) {}
// tester is a console test environment for the console tests to operate on.
type tester struct {
workspace string
stack
        *node.Node
ethereum *eth.Ethereum
console *Console
input *hookedPrompter
output *bytes.Buffer
lastConfirm string
}
// newTester creates a test environment based on which the console can operate.
// Please ensure you call Close() on the returned tester to avoid leaks.
func newTester(t *testing.T, confOverride func(*eth.Config)) *tester {
// Create a temporary storage for the node keys and initialize it
workspace, err := ioutil.TempDir("", "console-tester-")
if err != nil {
t.Fatalf("failed to create temporary keystore: %v", err)
}
// Create a networkless protocol stack and start an Ethereum service within
```

```
stack, err := node.New(&node.Config{DataDir: workspace, UseLightweightKDF: true, Name:
testInstance})
if err != nil {
t.Fatalf("failed to create node: %v", err)
}
ethConf := &eth.Config{
Genesis: core.DevGenesisBlock(),
Etherbase: common.HexToAddress(testAddress),
PowTest: true,
}
if confOverride != nil {
confOverride(ethConf)
}
if err = stack.Register(func(ctx *node.ServiceContext) (node.Service, error) { return eth.New(ctx,
ethConf) }); err != nil {
t.Fatalf("failed to register Ethereum protocol: %v", err)
}
// Start the node and assemble the JavaScript console around it
if err = stack.Start(); err != nil {
t.Fatalf("failed to start test stack: %v", err)
}
client, err := stack.Attach()
if err != nil {
t.Fatalf("failed to attach to node: %v", err)
prompter := &hookedPrompter{scheduler: make(chan string)}
printer := new(bytes.Buffer)
console, err := New(Config{
DataDir: stack.DataDir(),
DocRoot: "testdata",
Client: client,
Prompter: prompter,
Printer: printer,
Preload: []string{"preload.js"},
})
if err != nil {
t.Fatalf("failed to create JavaScript console: %v", err)
// Create the final tester and return
var ethereum *eth.Ethereum
stack.Service(&ethereum)
```

```
return &tester{
workspace: workspace,
        stack,
stack:
ethereum: ethereum,
console: console,
input: prompter,
output: printer,
}
// Close cleans up any temporary data folders and held resources.
func (env *tester) Close(t *testing.T) {
if err := env.console.Stop(false); err != nil {
t.Errorf("failed to stop embedded console: %v", err)
}
if err := env.stack.Stop(); err != nil {
t.Errorf("failed to stop embedded node: %v", err)
os.RemoveAll(env.workspace)
}
// Tests that the node lists the correct welcome message, notably that it contains
// the instance name, coinbase account, block number, data directory and supported
// console modules.
func TestWelcome(t *testing.T) {
tester := newTester(t, nil)
defer tester.Close(t)
tester.console.Welcome()
output := string(tester.output.Bytes())
if want := "Welcome"; !strings.Contains(output, want) {
t.Fatalf("console output missing welcome message: have\n%s\nwant also %s", output, want)
if want := fmt.Sprintf("instance: %s", testInstance); !strings.Contains(output, want) {
t.Fatalf("console output missing instance: have\n%s\nwant also %s", output, want)
}
if want := fmt.Sprintf("coinbase: %s", testAddress); !strings.Contains(output, want) {
t.Fatalf("console output missing coinbase: have\n%s\nwant also %s", output, want)
}
if want := "at block: 0"; !strings.Contains(output, want) {
```

```
t.Fatalf("console output missing sync status: have\n%s\nwant also %s", output, want)
}
if want := fmt.Sprintf("datadir: %s", tester.workspace); !strings.Contains(output, want) {
t.Fatalf("console output missing coinbase: have\n%s\nwant also %s", output, want)
}
}
// Tests that JavaScript statement evaluation works as intended.
func TestEvaluate(t *testing.T) {
tester := newTester(t, nil)
defer tester.Close(t)
tester.console.Evaluate("2 + 2")
if output := string(tester.output.Bytes()); !strings.Contains(output, "4") {
t.Fatalf("statement evaluation failed: have %s, want %s", output, "4")
}
}
// Tests that the console can be used in interactive mode.
func TestInteractive(t *testing.T) {
// Create a tester and run an interactive console in the background
tester := newTester(t, nil)
defer tester.Close(t)
go tester.console.Interactive()
// Wait for a promt and send a statement back
select {
case <-tester.input.scheduler:
case <-time.After(time.Second):
t.Fatalf("initial prompt timeout")
}
select {
case tester.input.scheduler <- "2+2":
case <-time.After(time.Second):
t.Fatalf("input feedback timeout")
}
// Wait for the second promt and ensure first statement was evaluated
select {
case <-tester.input.scheduler:
case <-time.After(time.Second):
t.Fatalf("secondary prompt timeout")
```

```
}
if output := string(tester.output.Bytes()); !strings.Contains(output, "4") {
t.Fatalf("statement evaluation failed: have %s, want %s", output, "4")
}
}
// Tests that preloaded JavaScript files have been executed before user is given
// input.
func TestPreload(t *testing.T) {
tester := newTester(t, nil)
defer tester.Close(t)
tester.console.Evaluate("preloaded")
if output := string(tester.output.Bytes()); !strings.Contains(output, "some-preloaded-string") {
t.Fatalf("preloaded variable missing: have %s, want %s", output, "some-preloaded-string")
}
}
// Tests that JavaScript scripts can be executes from the configured asset path.
func TestExecute(t *testing.T) {
tester := newTester(t, nil)
defer tester.Close(t)
tester.console.Execute("exec.js")
tester.console.Evaluate("execed")
if output := string(tester.output.Bytes()); !strings.Contains(output, "some-executed-string") {
t.Fatalf("execed variable missing: have %s, want %s", output, "some-executed-string")
}
}
// Tests that the JavaScript objects returned by statement executions are properly
// pretty printed instead of just displaing "[object]".
func TestPrettyPrint(t *testing.T) {
tester := newTester(t, nil)
defer tester.Close(t)
tester.console.Evaluate("obj = {int: 1, string: 'two', list: [3, 3, 3], obj: {null: null, func: function(){}}}")
// Define some specially formatted fields
var (
one = jsre.NumberColor("1")
```

```
two = jsre.StringColor("\"two\"")
three = jsre.NumberColor("3")
null = jsre.SpecialColor("null")
fun = jsre.FunctionColor("function()")
)
// Assemble the actual output we're after and verify
want := `{
 int: ` + one + `,
 list: [` + three + `, ` + three + `, ` + three + `],
 obj: {
  null: \ + null + \,
  func: ` + fun + `
 },
 string: \ + two + \
if output := string(tester.output.Bytes()); output != want {
t.Fatalf("pretty print mismatch: have %s, want %s", output, want)
}
}
// Tests that the JavaScript exceptions are properly formatted and colored.
func TestPrettyError(t *testing.T) {
tester := newTester(t, nil)
defer tester.Close(t)
tester.console.Evaluate("throw 'hello'")
want := jsre.ErrorColor("hello") + "\n"
if output := string(tester.output.Bytes()); output != want {
t.Fatalf("pretty error mismatch: have %s, want %s", output, want)
}
}
// Tests that tests if the number of indents for JS input is calculated correct.
func TestIndenting(t *testing.T) {
testCases := []struct {
input
               string
expectedIndentCount int
}{
{\text{`var a} = 1; `, 0},
{`"some string"`, 0},
{`"some string with (parentesis`, 0},
```

```
{"some string with newline
("`, 0},
{`function v(a,b) {}`, 0},
{`function f(a,b) { var str = "asd("; };`, 0},
{`function f(a) {`, 1},
{`function f(a, function(b) {`, 2},
{`function f(a, function(b) {
    var str = "a)}";
 });`, 0},
{`function f(a,b) {
  var str = "a{b(" + a, ", " + b;}
  }`, 0},
{\text{`var str} = "\"{"`, 0},}
{`var str = "'("`, 0},
{\text{`var str} = "\{"`, 0},}
{\text{`var str} = "\\\{"`, 0},}
{\text{`var str} = 'a"{\hat{,} 0},}
{\text{`var obj}} = {\text{`}}, 1{\text{}},
{\text{`var obj}} = { \{a:1`, 2\}, }
{\text{`var obj}} = {\{a:1\}`, 1\},
{\text{`var obj} = \{ \{a:1\}, b:2\}`, 0\},}
\{ \text{var obj} = \{ \} \}, 0 \},
{`var obj = {
a: 1, b: 2
}`, 0},
{\text{`var test} = \text{`}, -1},
{\text{`var str} = "a\""; var obj = {`, 1},}
}
for i, tt := range testCases {
counted := countIndents(tt.input)
if counted != tt.expectedIndentCount {
t.Errorf("test %d: invalid indenting: have %d, want %d", i, counted, tt.expectedIndentCount)
}
}
}
43:F:\git\coin\ethereum\go-ethereum\console\prompter.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
```

package console

```
import (
"fmt"
"strings"
"github.com/peterh/liner"
// Stdin holds the stdin line reader (also using stdout for printing prompts).
// Only this reader may be used for input because it keeps an internal buffer.
var Stdin = newTerminalPrompter()
// UserPrompter defines the methods needed by the console to promt the user for
// various types of inputs.
type UserPrompter interface {
// PromptInput displays the given prompt to the user and requests some textual
// data to be entered, returning the input of the user.
PromptInput(prompt string) (string, error)
// PromptPassword displays the given prompt to the user and requests some textual
// data to be entered, but one which must not be echoed out into the terminal.
// The method returns the input provided by the user.
PromptPassword(prompt string) (string, error)
// PromptConfirm displays the given prompt to the user and requests a boolean
// choice to be made, returning that choice.
PromptConfirm(prompt string) (bool, error)
// SetHistory sets the the input scrollback history that the prompter will allow
// the user to scroll back to.
SetHistory(history []string)
// AppendHistory appends an entry to the scrollback history. It should be called
// if and only if the prompt to append was a valid command.
AppendHistory(command string)
// SetWordCompleter sets the completion function that the prompter will call to
// fetch completion candidates when the user presses tab.
SetWordCompleter(completer WordCompleter)
}
// WordCompleter takes the currently edited line with the cursor position and
// returns the completion candidates for the partial word to be completed. If
```

```
// the line is "Hello, wo!!!" and the cursor is before the first '!', ("Hello,
// wo!!!", 9) is passed to the completer which may returns ("Hello, ", {"world",
// "Word"}, "!!!") to have "Hello, world!!!".
type WordCompleter func(line string, pos int) (string, []string, string)
// terminalPrompter is a UserPrompter backed by the liner package. It supports
// prompting the user for various input, among others for non-echoing password
// input.
type terminalPrompter struct {
*liner.State
warned
          bool
supported bool
normalMode liner.ModeApplier
rawMode liner.ModeApplier
}
// newTerminalPrompter creates a liner based user input prompter working off the
// standard input and output streams.
func newTerminalPrompter() *terminalPrompter {
p := new(terminalPrompter)
// Get the original mode before calling NewLiner.
// This is usually regular "cooked" mode where characters echo.
normalMode, := liner.TerminalMode()
// Turn on liner. It switches to raw mode.
p.State = liner.NewLiner()
rawMode, err := liner.TerminalMode()
if err != nil || !liner.TerminalSupported() {
p.supported = false
} else {
p.supported = true
p.normalMode = normalMode
p.rawMode = rawMode
// Switch back to normal mode while we're not prompting.
normalMode.ApplyMode()
}
p.SetCtrlCAborts(true)
p.SetTabCompletionStyle(liner.TabPrints)
p.SetMultiLineMode(true)
return p
}
```

// PromptInput displays the given prompt to the user and requests some textual

```
// data to be entered, returning the input of the user.
func (p *terminalPrompter) PromptInput(prompt string) (string, error) {
if p.supported {
p.rawMode.ApplyMode()
defer p.normalMode.ApplyMode()
} else {
// liner tries to be smart about printing the prompt
// and doesn't print anything if input is redirected.
// Un-smart it by printing the prompt always.
fmt.Print(prompt)
prompt = ""
defer fmt.Println()
}
return p.State.Prompt(prompt)
}
// PromptPassword displays the given prompt to the user and requests some textual
// data to be entered, but one which must not be echoed out into the terminal.
// The method returns the input provided by the user.
func (p *terminalPrompter) PromptPassword(prompt string) (passwd string, err error) {
if p.supported {
p.rawMode.ApplyMode()
defer p.normalMode.ApplyMode()
return p.State.PasswordPrompt(prompt)
}
if !p.warned {
fmt.Println("!! Unsupported terminal, password will be echoed.")
p.warned = true
// Just as in Prompt, handle printing the prompt here instead of relying on liner.
fmt.Print(prompt)
passwd, err = p.State.Prompt("")
fmt.Println()
return passwd, err
}
// PromptConfirm displays the given prompt to the user and requests a boolean
// choice to be made, returning that choice.
func (p *terminalPrompter) PromptConfirm(prompt string) (bool, error) {
input, err := p.Prompt(prompt + "[y/N]")
if len(input) > 0 && strings.ToUpper(input[:1]) == "Y" {
return true, nil
```

```
}
return false, err
}
// SetHistory sets the the input scrollback history that the prompter will allow
// the user to scroll back to.
func (p *terminalPrompter) SetHistory(history []string) {
p.State.ReadHistory(strings.NewReader(strings.Join(history, "\n")))
}
// AppendHistory appends an entry to the scrollback history. It should be called
// if and only if the prompt to append was a valid command.
func (p *terminalPrompter) AppendHistory(command string) {
p.State.AppendHistory(command)
}
// SetWordCompleter sets the completion function that the prompter will call to
// fetch completion candidates when the user presses tab.
func (p *terminalPrompter) SetWordCompleter(completer WordCompleter) {
p.State.SetWordCompleter(liner.WordCompleter(completer))
}
44:F:\git\coin\ethereum\go-ethereum\contracts\chequebook\api.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package chequebook
import (
"errors"
"math/big"
"github.com/ethereum/go-ethereum/common"
)
const Version = "1.0"
var errNoChequebook = errors.New("no chequebook")
type Api struct {
chequebookf func() *Chequebook
}
```

```
func NewApi(ch func() *Chequebook) *Api {
return &Api{ch}
}
func (self *Api) Balance() (string, error) {
ch := self.chequebookf()
if ch == nil {
return "", errNoChequebook
return ch.Balance().String(), nil
}
func (self *Api) Issue(beneficiary common.Address, amount *big.Int) (cheque *Cheque, err error) {
ch := self.chequebookf()
if ch == nil {
return nil, errNoChequebook
}
return ch.Issue(beneficiary, amount)
}
func (self *Api) Cash(cheque *Cheque) (txhash string, err error) {
ch := self.chequebookf()
if ch == nil {
return "", errNoChequebook
return ch.Cash(cheque)
}
func (self *Api) Deposit(amount *big.Int) (txhash string, err error) {
ch := self.chequebookf()
if ch == nil {
return "", errNoChequebook
}
return ch.Deposit(amount)
}
45:F:\git\coin\ethereum\go-ethereum\contracts\chequebook\cheque.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package chequebook package wraps the 'chequebook' Ethereum smart contract.
//
// The functions in this package allow using chequebook for
```

```
// issuing, receiving, verifying cheques in ether; (auto)cashing cheques in ether
// as well as (auto)depositing ether to the chequebook contract.
package chequebook
//go:generate abigen --sol contract/chequebook.sol --pkg contract --out contract/chequebook.go
//go:generate go run ./gencode.go
import (
"bytes"
"context"
"crypto/ecdsa"
"encoding/json"
"fmt"
"io/ioutil"
"math/big"
"os"
"sync"
"time"
"github.com/ethereum/go-ethereum/accounts/abi/bind"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/hexutil"
"github.com/ethereum/go-ethereum/contracts/chequebook/contract"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/swarm/services/swap/swap"
)
// TODO(zelig): watch peer solvency and notify of bouncing cheques
// TODO(zelig): enable paying with cheque by signing off
// Some functionality requires interacting with the blockchain:
// * setting current balance on peer's chequebook
// * sending the transaction to cash the cheque
// * depositing ether to the chequebook
// * watching incoming ether
var (
gasToCash = big.NewInt(2000000) // gas cost of a cash transaction using chequebook
// gasToDeploy = big.NewInt(3000000)
)
```

```
// Backend wraps all methods required for chequebook operation.
type Backend interface {
bind.ContractBackend
TransactionReceipt(ctx context.Context, txHash common.Hash) (*types.Receipt, error)
BalanceAt(ctx context, Context, address common.Address, blockNum *big.Int) (*big.Int, error)
}
// Cheque represents a payment promise to a single beneficiary.
type Cheque struct {
Contract common.Address // address of chequebook, needed to avoid cross-contract
submission
Beneficiary common. Address
Amount
           *big.Int // cumulative amount of all funds sent
Sia
        []byte // signature Sign(Keccak256(contract, beneficiary, amount), prvKey)
}
func (self *Cheque) String() string {
return fmt.Sprintf("contract: %s, beneficiary: %s, amount: %v, signature: %x", self.Contract.Hex(),
self.Beneficiary.Hex(), self.Amount, self.Sig)
}
type Params struct {
ContractCode, ContractAbi string
}
var ContractParams = &Params{contract.ChequebookBin, contract.ChequebookABI}
// Chequebook can create and sign cheques from a single contract to multiple beneficiaries.
// It is the outgoing payment handler for peer to peer micropayments.
type Chequebook struct {
path
                          // path to chequebook file
       string
prvKey *ecdsa.PrivateKey
                                 // private key to sign cheque with
                            //
lock
      sync.Mutex
backend Backend
                               // blockchain API
                           // when closed causes autodeposit to stop
     chan bool
quit
                                  // owner address (derived from pubkey)
owner common.Address
contract *contract.Chequebook
                                  // abigen binding
session *contract.ChequebookSession // abigen binding with Tx Opts
// persisted fields
balance
           *big.Int
                              // not synced with blockchain
```

```
// contract address
contractAddr common.Address
         map[common.Address]*big.Int //tallies for beneficiaries
sent
txhash
        string // tx hash of last deposit tx
threshold *big.Int // threshold that triggers autodeposit if not nil
buffer
        *big.Int // buffer to keep on top of balance for fork protection
log log.Logger // contextual logger with the contract address embedded
}
func (self *Chequebook) String() string {
return fmt.Sprintf("contract: %s, owner: %s, balance: %v, signer: %x", self.contractAddr.Hex(),
self.owner.Hex(), self.balance, self.prvKey.PublicKey)
}
// NewChequebook creates a new Chequebook.
func NewChequebook(path string, contractAddr common.Address, prvKey *ecdsa.PrivateKey,
backend Backend) (self *Chequebook, err error) {
balance := new(big.Int)
sent := make(map[common.Address]*big.Int)
chbook, err := contract.NewChequebook(contractAddr, backend)
if err != nil {
return nil, err
transactOpts := bind.NewKeyedTransactor(prvKey)
session := &contract.ChequebookSession{
Contract:
            chbook.
TransactOpts: *transactOpts,
self = &Chequebook{
prvKey:
           prvKey,
balance:
            balance.
contractAddr: contractAddr,
sent:
          sent,
path:
          path,
backend:
            backend,
           transactOpts.From,
owner:
contract:
           chbook,
session:
           session,
         log.New("contract", contractAddr),
log:
```

```
}
if (contractAddr != common.Address{}) {
self.setBalanceFromBlockChain()
self.log.Trace("New chequebook initialised", "owner", self.owner, "balance", self.balance)
}
return
}
func (self *Chequebook) setBalanceFromBlockChain() {
balance, err := self.backend.BalanceAt(context.TODO(), self.contractAddr, nil)
if err != nil {
log.Error("Failed to retrieve chequebook balance", "err", err)
} else {
self.balance.Set(balance)
}
}
// LoadChequebook loads a chequebook from disk (file path).
func LoadChequebook(path string, prvKey *ecdsa.PrivateKey, backend Backend, checkBalance
bool) (self *Chequebook, err error) {
var data []byte
data, err = ioutil.ReadFile(path)
if err != nil {
return
}
self, _ = NewChequebook(path, common.Address{}, prvKey, backend)
err = json.Unmarshal(data, self)
if err != nil {
return nil, err
}
if checkBalance {
self.setBalanceFromBlockChain()
log.Trace("Loaded chequebook from disk", "path", path)
return
// chequebookFile is the JSON representation of a chequebook.
type chequebookFile struct {
```

```
Balance string
Contract string
Owner string
Sent
        map[string]string
}
// UnmarshalJSON deserialises a chequebook.
func (self *Chequebook) UnmarshalJSON(data []byte) error {
var file chequebookFile
err := json.Unmarshal(data, &file)
if err != nil {
return err
}
_, ok := self.balance.SetString(file.Balance, 10)
if !ok {
return fmt.Errorf("cumulative amount sent: unable to convert string to big integer: %v",
file.Balance)
}
self.contractAddr = common.HexToAddress(file.Contract)
for addr, sent := range file.Sent {
self.sent[common.HexToAddress(addr)], ok = new(big.Int).SetString(sent, 10)
if !ok {
return fmt.Errorf("beneficiary %v cumulative amount sent: unable to convert string to big integer:
%v", addr, sent)
}
}
return nil
}
// MarshalJSON serialises a chequebook.
func (self *Chequebook) MarshalJSON() ([]byte, error) {
var file = &chequebookFile{
Balance: self.balance.String(),
Contract: self.contractAddr.Hex(),
Owner: self.owner.Hex(),
Sent:
        make(map[string]string),
}
for addr, sent := range self.sent {
file.Sent[addr.Hex()] = sent.String()
}
return json.Marshal(file)
}
```

```
// Save persists the chequebook on disk, remembering balance, contract address and
// cumulative amount of funds sent for each beneficiary.
func (self *Chequebook) Save() (err error) {
data, err := json.MarshalIndent(self, "", " ")
if err != nil {
return err
}
self.log.Trace("Saving chequebook to disk", self.path)
return ioutil.WriteFile(self.path, data, os.ModePerm)
}
// Stop quits the autodeposit go routine to terminate
func (self *Chequebook) Stop() {
defer self.lock.Unlock()
self.lock.Lock()
if self.quit != nil {
close(self.quit)
self.quit = nil
}
}
// Issue creates a cheque signed by the chequebook owner's private key. The
// signer commits to a contract (one that they own), a beneficiary and amount.
func (self *Chequebook) Issue(beneficiary common.Address, amount *big.Int) (ch *Cheque, err
error) {
defer self.lock.Unlock()
self.lock.Lock()
if amount.Sign() <= 0 {
return nil, fmt.Errorf("amount must be greater than zero (%v)", amount)
}
if self.balance.Cmp(amount) < 0 {
err = fmt.Errorf("insufficient funds to issue cheque for amount: %v. balance: %v", amount,
self.balance)
} else {
var sig []byte
sent, found := self.sent[beneficiary]
if !found {
sent = new(big.Int)
self.sent[beneficiary] = sent
```

```
}
sum := new(big.Int).Set(sent)
sum.Add(sum, amount)
sig, err = crypto.Sign(sigHash(self.contractAddr, beneficiary, sum), self.prvKey)
if err == nil {
ch = &Cheque{
Contract: self.contractAddr,
Beneficiary: beneficiary,
Amount:
            sum,
Sig:
         sig,
}
sent.Set(sum)
self.balance.Sub(self.balance, amount) // subtract amount from balance
}
}
// auto deposit if threshold is set and balance is less then threshold
// note this is called even if issuing cheque fails
// so we reattempt depositing
if self.threshold != nil {
if self.balance.Cmp(self.threshold) < 0 {
send := new(big.Int).Sub(self.buffer, self.balance)
self.deposit(send)
}
}
return
}
// Cash is a convenience method to cash any cheque.
func (self *Chequebook) Cash(ch *Cheque) (txhash string, err error) {
return ch.Cash(self.session)
}
// data to sign: contract address, beneficiary, cumulative amount of funds ever sent
func sigHash(contract, beneficiary common.Address, sum *big.Int) []byte {
bigamount := sum.Bytes()
if len(bigamount) > 32 {
return nil
}
var amount32 [32]byte
```

```
copy(amount32[32-len(bigamount):32], bigamount)
input := append(contract.Bytes(), beneficiary.Bytes()...)
input = append(input, amount32[:]...)
return crypto.Keccak256(input)
}
// Balance returns the current balance of the chequebook.
func (self *Chequebook) Balance() *big.Int {
defer self.lock.Unlock()
self.lock.Lock()
return new(big.Int).Set(self.balance)
}
// Owner returns the owner account of the chequebook.
func (self *Chequebook) Owner() common.Address {
return self.owner
}
// Address returns the on-chain contract address of the chequebook.
func (self *Chequebook) Address() common.Address {
return self.contractAddr
}
// Deposit deposits money to the chequebook account.
func (self *Chequebook) Deposit(amount *big.Int) (string, error) {
defer self.lock.Unlock()
self.lock.Lock()
return self.deposit(amount)
}
// deposit deposits amount to the chequebook account.
// The caller must hold self.lock.
func (self *Chequebook) deposit(amount *big.Int) (string, error) {
// since the amount is variable here, we do not use sessions
depositTransactor := bind.NewKeyedTransactor(self.prvKey)
depositTransactor.Value = amount
chbookRaw := &contract.ChequebookRaw{Contract: self.contract}
tx, err := chbookRaw.Transfer(depositTransactor)
if err != nil {
self.log.Warn("Failed to fund chequebook", "amount", amount, "balance", self.balance, "target",
self.buffer, "err", err)
return "", err
```

```
}
// assume that transaction is actually successful, we add the amount to balance right away
self.balance.Add(self.balance, amount)
self.log.Trace("Deposited funds to chequebook", "amount", amount, "balance", self.balance,
"target", self.buffer)
return tx.Hash().Hex(), nil
}
// AutoDeposit (re)sets interval time and amount which triggers sending funds to the
// chequebook. Contract backend needs to be set if threshold is not less than buffer, then
// deposit will be triggered on every new cheque issued.
func (self *Chequebook) AutoDeposit(interval time.Duration, threshold, buffer *big.Int) {
defer self.lock.Unlock()
self.lock.Lock()
self.threshold = threshold
self.buffer = buffer
self.autoDeposit(interval)
}
// autoDeposit starts a goroutine that periodically sends funds to the chequebook
// contract caller holds the lock the go routine terminates if Chequebook.quit is closed.
func (self *Chequebook) autoDeposit(interval time.Duration) {
if self.quit != nil {
close(self.quit)
self.quit = nil
}
// if threshold >= balance autodeposit after every cheque issued
if interval == time.Duration(0) || self.threshold != nil && self.buffer != nil &&
self.threshold.Cmp(self.buffer) >= 0 {
return
}
ticker := time.NewTicker(interval)
self.quit = make(chan bool)
quit := self.quit
go func() {
FOR:
for {
select {
case <-quit:
break FOR
case <-ticker.C:
```

```
self.lock.Lock()
if self.balance.Cmp(self.buffer) < 0 {
amount := new(big.Int).Sub(self.buffer, self.balance)
txhash, err := self.deposit(amount)
if err == nil {
self.txhash = txhash
}
}
self.lock.Unlock()
}
}
}()
return
}
// Outbox can issue cheques from a single contract to a single beneficiary.
type Outbox struct {
chequeBook *Chequebook
beneficiary common. Address
}
// NewOutbox creates an outbox.
func NewOutbox(chbook *Chequebook, beneficiary common.Address) *Outbox {
return &Outbox{chbook, beneficiary}
}
// Issue creates cheque.
func (self *Outbox) Issue(amount *big.Int) (swap.Promise, error) {
return self.chequeBook.lssue(self.beneficiary, amount)
}
// AutoDeposit enables auto-deposits on the underlying chequebook.
func (self *Outbox) AutoDeposit(interval time.Duration, threshold, buffer *big.Int) {
self.chequeBook.AutoDeposit(interval, threshold, buffer)
}
// Stop helps satisfy the swap.OutPayment interface.
func (self *Outbox) Stop() {}
// String implements fmt. Stringer.
func (self *Outbox) String() string {
return fmt.Sprintf("chequebook: %v, beneficiary: %s, balance: %v",
```

```
self.chequeBook.Address().Hex(), self.beneficiary.Hex(), self.chequeBook.Balance())
}
// Inbox can deposit, verify and cash cheques from a single contract to a single
// beneficiary. It is the incoming payment handler for peer to peer micropayments.
type Inbox struct {
lock
        sync.Mutex
contract common.Address
                                   // peer's chequebook contract
beneficiary common.Address
                                    // local peer's receiving address
sender common.Address
                                    // local peer's address to send cashing tx from
signer *ecdsa.PublicKey
                                  // peer's public key
txhash string
                             // tx hash of last cashing tx
          bind.ContractBackend
abigen
                                    // blockchain API
session
          *contract.ChequebookSession // abi contract backend with tx opts
                             // when closed causes autocash to stop
        chan bool
auit
maxUncashed *big.Int
                                 // threshold that triggers autocashing
cashed
          *big.Int
                             // cumulative amount cashed
cheque
          *Cheque
                                // last cheque, nil if none yet received
log
        log.Logger
                             // contextual logger with the contract address embedded
}
// NewInbox creates an Inbox. An Inboxes is not persisted, the cumulative sum is updated
// from blockchain when first cheque is received.
func NewInbox(prvKey *ecdsa.PrivateKey, contractAddr, beneficiary common.Address, signer
*ecdsa.PublicKey, abigen bind.ContractBackend) (self *Inbox, err error) {
if signer == nil {
return nil, fmt.Errorf("signer is null")
}
chbook, err := contract.NewChequebook(contractAddr, abigen)
if err != nil {
return nil. err
}
transactOpts := bind.NewKeyedTransactor(prvKey)
transactOpts.GasLimit = gasToCash
session := &contract.ChequebookSession{
Contract:
            chbook,
TransactOpts: *transactOpts,
}
sender := transactOpts.From
self = &Inbox{
          contractAddr,
contract:
```

```
beneficiary: beneficiary,
sender: sender,
signer:
          signer,
session: session,
           new(big.Int).Set(common.Big0),
cashed:
         log.New("contract", contractAddr),
log:
}
self.log.Trace("New chequebook inbox initialized", "beneficiary", self.beneficiary, "signer",
hexutil.Bytes(crypto.FromECDSAPub(signer)))
return
}
func (self *Inbox) String() string {
return fmt.Sprintf("chequebook: %v, beneficiary: %s, balance: %v", self.contract.Hex(),
self.beneficiary.Hex(), self.cheque.Amount)
}
// Stop guits the autocash goroutine.
func (self *Inbox) Stop() {
defer self.lock.Unlock()
self.lock.Lock()
if self.quit != nil {
close(self.quit)
self.quit = nil
}
}
// Cash attempts to cash the current cheque.
func (self *Inbox) Cash() (txhash string, err error) {
if self.cheque != nil {
txhash, err = self.cheque.Cash(self.session)
self.log.Trace("Cashing in chequebook cheque", "amount", self.cheque.Amount, "beneficiary",
self.beneficiary)
self.cashed = self.cheque.Amount
}
return
}
// AutoCash (re)sets maximum time and amount which triggers cashing of the last uncashed
// cheque if maxUncashed is set to 0, then autocash on receipt.
func (self *Inbox) AutoCash(cashInterval time.Duration, maxUncashed *big.Int) {
defer self.lock.Unlock()
```

```
self.lock.Lock()
self.maxUncashed = maxUncashed
self.autoCash(cashInterval)
}
// autoCash starts a loop that periodically clears the last cheque
// if the peer is trusted. Clearing period could be 24h or a week.
// The caller must hold self.lock.
func (self *Inbox) autoCash(cashInterval time.Duration) {
if self.quit != nil {
close(self.quit)
self.quit = nil
}
// if maxUncashed is set to 0, then autocash on receipt
if cashInterval == time.Duration(0) || self.maxUncashed != nil && self.maxUncashed.Sign() == 0 {
return
}
ticker := time.NewTicker(cashInterval)
self.quit = make(chan bool)
quit := self.quit
go func() {
FOR:
for {
select {
case <-quit:
break FOR
case <-ticker.C:
self.lock.Lock()
if self.cheque != nil && self.cheque.Amount.Cmp(self.cashed) != 0 {
txhash, err := self.Cash()
if err == nil {
self.txhash = txhash
}
}
self.lock.Unlock()
}
}
}()
return
}
```

```
// Receive is called to deposit the latest cheque to the incoming Inbox.
// The given promise must be a *Cheque.
func (self *Inbox) Receive(promise swap.Promise) (*big.Int, error) {
ch := promise.(*Cheque)
defer self.lock.Unlock()
self.lock.Lock()
var sum *big.Int
if self.cheque == nil {
// the sum is checked against the blockchain once a cheque is received
tally, err := self.session.Sent(self.beneficiary)
if err != nil {
return nil, fmt.Errorf("inbox: error calling backend to set amount: %v", err)
}
sum = tally
} else {
sum = self.cheque.Amount
amount, err := ch.Verify(self.signer, self.contract, self.beneficiary, sum)
var uncashed *big.Int
if err == nil {
self.cheque = ch
if self.maxUncashed != nil {
uncashed = new(big.Int).Sub(ch.Amount, self.cashed)
if self.maxUncashed.Cmp(uncashed) < 0 {
self.Cash()
}
self.log.Trace("Received cheque in chequebook inbox", "amount", amount, "uncashed", uncashed)
}
return amount, err
}
// Verify verifies cheque for signer, contract, beneficiary, amount, valid signature.
func (self *Cheque) Verify(signerKey *ecdsa.PublicKey, contract, beneficiary common.Address,
sum *big.Int) (*big.Int, error) {
log.Trace("Verifying chequebook cheque", "cheque", self, "sum", sum)
if sum == nil {
```

```
return nil, fmt.Errorf("invalid amount")
}
if self.Beneficiary != beneficiary {
return nil, fmt.Errorf("beneficiary mismatch: %v != %v", self.Beneficiary.Hex(), beneficiary.Hex())
}
if self.Contract != contract {
return nil, fmt.Errorf("contract mismatch: %v != %v", self.Contract.Hex(), contract.Hex())
}
amount := new(big.Int).Set(self.Amount)
if sum != nil {
amount.Sub(amount, sum)
if amount.Sign() <= 0 {
return nil, fmt.Errorf("incorrect amount: %v <= 0", amount)
}
}
pubKey, err := crypto.SigToPub(sigHash(self.Contract, beneficiary, self.Amount), self.Sig)
if err != nil {
return nil, fmt.Errorf("invalid signature: %v", err)
}
if !bytes.Equal(crypto.FromECDSAPub(pubKey), crypto.FromECDSAPub(signerKey)) {
return nil, fmt.Errorf("signer mismatch: %x != %x", crypto.FromECDSAPub(pubKey),
crypto.FromECDSAPub(signerKey))
}
return amount, nil
}
// v/r/s representation of signature
func sig2vrs(sig []byte) (v byte, r, s [32]byte) {
v = sig[64] + 27
copy(r[:], sig[:32])
copy(s[:], sig[32:64])
return
}
// Cash cashes the cheque by sending an Ethereum transaction.
func (self *Cheque) Cash(session *contract.ChequebookSession) (string, error) {
v, r, s := sig2vrs(self.Sig)
tx, err := session.Cash(self.Beneficiary, self.Amount, v, r, s)
if err != nil {
```

```
return "", err
return tx.Hash().Hex(), nil
}
// ValidateCode checks that the on-chain code at address matches the expected chequebook
// contract code. This is used to detect suicided chequebooks.
func ValidateCode(ctx context.Context, b Backend, address common.Address) (ok bool, err error)
code, err := b.CodeAt(ctx, address, nil)
if err != nil {
return false, err
return bytes.Equal(code, common.FromHex(contract.ContractDeployedCode)), nil
}
46:F:\git\coin\ethereum\go-ethereum\contracts\chequebook\cheque_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package chequebook
import (
"crypto/ecdsa"
"math/big"
"os"
"path/filepath"
"testing"
"time"
"github.com/ethereum/go-ethereum/accounts/abi/bind"
"github.com/ethereum/go-ethereum/accounts/abi/bind/backends"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/contracts/chequebook/contract"
"github.com/ethereum/go-ethereum/core"
"github.com/ethereum/go-ethereum/crypto"
)
var (
key0, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
key1, _ =
```

```
crypto.HexToECDSA("8a1f9a8f95be41cd7ccb6168179afb4504aefe388d1e14474d32c45c72ce7b
7a")
key2, _ =
crypto.HexToECDSA("49a7b37aa6f6645917e7b807e9d1c00d4fa71f18343b0d4122a4d2df64dd6f
ee")
addr0 = crypto.PubkeyToAddress(key0.PublicKey)
addr1 = crypto.PubkeyToAddress(key1.PublicKey)
addr2 = crypto.PubkeyToAddress(key2.PublicKey)
func newTestBackend() *backends.SimulatedBackend {
return backends.NewSimulatedBackend(core.GenesisAlloc{
addr0: {Balance: big.NewInt(1000000000)},
addr1: {Balance: big.NewInt(1000000000)},
addr2: {Balance: big.NewInt(1000000000)},
})
}
func deploy(prvKey *ecdsa.PrivateKey, amount *big.Int, backend *backends.SimulatedBackend)
(common.Address, error) {
deployTransactor := bind.NewKeyedTransactor(prvKey)
deployTransactor.Value = amount
addr, _, _, err := contract.DeployChequebook(deployTransactor, backend)
if err != nil {
return common.Address{}, err
}
backend.Commit()
return addr, nil
}
func TestIssueAndReceive(t *testing.T) {
path := filepath.Join(os.TempDir(), "chequebook-test.json")
backend := newTestBackend()
addr0, err := deploy(key0, big.NewInt(0), backend)
if err != nil {
t.Fatalf("deploy contract: expected no error, got %v", err)
}
chbook, err := NewChequebook(path, addr0, key0, backend)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
chbook.sent[addr1] = new(big.Int).SetUint64(42)
```

```
amount := common.Big1
if _, err = chbook.lssue(addr1, amount); err == nil {
t.Fatalf("expected insufficient funds error, got none")
}
chbook.balance = new(big.Int).Set(common.Big1)
if chbook.Balance().Cmp(common.Big1) != 0 {
t.Fatalf("expected: %v, got %v", "0", chbook.Balance())
}
ch, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
if chbook.Balance().Sign() != 0 {
t.Errorf("expected: %v, got %v", "0", chbook.Balance())
}
chbox, err := NewInbox(key1, addr0, addr1, &key0.PublicKey, backend)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
received, err := chbox.Receive(ch)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
if received.Cmp(big.NewInt(43)) != 0 {
t.Errorf("expected: %v, got %v", "43", received)
}
}
func TestCheckbookFile(t *testing.T) {
path := filepath.Join(os.TempDir(), "chequebook-test.json")
backend := newTestBackend()
chbook, err := NewChequebook(path, addr0, key0, backend)
if err != nil {
t.Fatalf("expected no error, got %v", err)
```

```
}
chbook.sent[addr1] = new(big.Int).SetUint64(42)
chbook.balance = new(big.Int).Set(common.Big1)
chbook.Save()
chbook, err = LoadChequebook(path, key0, backend, false)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
if chbook.Balance().Cmp(common.Big1) != 0 {
t.Errorf("expected: %v, got %v", "0", chbook.Balance())
}
var ch *Cheque
if ch, err = chbook.lssue(addr1, common.Big1); err != nil {
t.Fatalf("expected no error, got %v", err)
}
if ch.Amount.Cmp(new(big.Int).SetUint64(43)) != 0 {
t.Errorf("expected: %v, got %v", "0", ch.Amount)
}
err = chbook.Save()
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
}
func TestVerifyErrors(t *testing.T) {
path0 := filepath.Join(os.TempDir(), "chequebook-test-0.json")
backend := newTestBackend()
contr0, err := deploy(key0, common.Big2, backend)
if err != nil {
t.Errorf("expected no error, got %v", err)
chbook0, err := NewChequebook(path0, contr0, key0, backend)
if err != nil {
t.Errorf("expected no error, got %v", err)
}
path1 := filepath.Join(os.TempDir(), "chequebook-test-1.json")
contr1, _ := deploy(key1, common.Big2, backend)
```

```
chbook1, err := NewChequebook(path1, contr1, key1, backend)
if err != nil {
t.Errorf("expected no error, got %v", err)
}
chbook0.sent[addr1] = new(big.Int).SetUint64(42)
chbook0.balance = new(big.Int).Set(common.Big2)
chbook1.balance = new(big.Int).Set(common.Big1)
amount := common.Big1
ch0, err := chbook0.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
time.Sleep(5)
chbox, err := NewInbox(key1, contr0, addr1, &key0.PublicKey, backend)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
received, err := chbox.Receive(ch0)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
if received.Cmp(big.NewInt(43)) != 0 {
t.Errorf("expected: %v, got %v", "43", received)
}
ch1, err := chbook0.lssue(addr2, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
received, err = chbox.Receive(ch1)
t.Logf("correct error: %v", err)
if err == nil {
t.Fatalf("expected receiver error, got none")
}
ch2, err := chbook1.lssue(addr1, amount)
if err != nil {
```

```
t.Fatalf("expected no error, got %v", err)
}
received, err = chbox.Receive(ch2)
t.Logf("correct error: %v", err)
if err == nil {
t.Fatalf("expected sender error, got none")
}
_, err = chbook1.lssue(addr1, new(big.lnt).SetInt64(-1))
t.Logf("correct error: %v", err)
if err == nil {
t.Fatalf("expected incorrect amount error, got none")
}
received, err = chbox.Receive(ch0)
t.Logf("correct error: %v", err)
if err == nil {
t.Fatalf("expected incorrect amount error, got none")
}
}
func TestDeposit(t *testing.T) {
path0 := filepath.Join(os.TempDir(), "chequebook-test-0.json")
backend := newTestBackend()
contr0, _ := deploy(key0, new(big.Int), backend)
chbook, err := NewChequebook(path0, contr0, key0, backend)
if err != nil {
t.Errorf("expected no error, got %v", err)
}
balance := new(big.Int).SetUint64(42)
chbook.Deposit(balance)
backend.Commit()
if chbook.balance.Cmp(balance) != 0 {
t.Fatalf("expected balance %v, got %v", balance, chbook.balance)
}
amount := common.Big1
_, err = chbook.lssue(addr1, amount)
if err != nil {
```

```
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
exp := new(big.Int).SetUint64(41)
if chbook.balance.Cmp(exp) != 0 {
t.Fatalf("expected balance %v, got %v", exp, chbook.balance)
}
// autodeposit on each issue
chbook.AutoDeposit(0, balance, balance)
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
if chbook.balance.Cmp(balance) != 0 {
t.Fatalf("expected balance %v, got %v", balance, chbook.balance)
}
// autodeposit off
chbook.AutoDeposit(0, common.Big0, balance)
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
exp = new(big.Int).SetUint64(40)
if chbook.balance.Cmp(exp) != 0 {
t.Fatalf("expected balance %v, got %v", exp, chbook.balance)
}
```

```
// autodeposit every 10ms if new cheque issued
interval := 30 * time.Millisecond
chbook.AutoDeposit(interval, common.Big1, balance)
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
exp = new(big.Int).SetUint64(38)
if chbook.balance.Cmp(exp) != 0 {
t.Fatalf("expected balance %v, got %v", exp, chbook.balance)
}
time.Sleep(3 * interval)
backend.Commit()
if chbook.balance.Cmp(balance) != 0 {
t.Fatalf("expected balance %v, got %v", balance, chbook.balance)
}
exp = new(big.Int).SetUint64(40)
chbook.AutoDeposit(4*interval, exp, balance)
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
time.Sleep(3 * interval)
backend.Commit()
if chbook.balance.Cmp(exp) != 0 {
t.Fatalf("expected balance %v, got %v", exp, chbook.balance)
}
```

```
_, err = chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
time.Sleep(1 * interval)
backend.Commit()
if chbook.balance.Cmp(balance) != 0 {
t.Fatalf("expected balance %v, got %v", balance, chbook.balance)
}
chbook.AutoDeposit(1*interval, common.Big0, balance)
chbook.Stop()
_, err = chbook.lssue(addr1, common.Big1)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
_, err = chbook.lssue(addr1, common.Big2)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
time.Sleep(1 * interval)
backend.Commit()
exp = new(big.Int).SetUint64(39)
if chbook.balance.Cmp(exp) != 0 {
t.Fatalf("expected balance %v, got %v", exp, chbook.balance)
}
}
func TestCash(t *testing.T) {
path := filepath.Join(os.TempDir(), "chequebook-test.json")
backend := newTestBackend()
contr0, _ := deploy(key0, common.Big2, backend)
chbook, err := NewChequebook(path, contr0, key0, backend)
if err != nil {
```

```
t.Errorf("expected no error, got %v", err)
}
chbook.sent[addr1] = new(big.Int).SetUint64(42)
amount := common.Big1
chbook.balance = new(big.Int).Set(common.Big1)
ch, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
chbox, err := NewInbox(key1, contr0, addr1, &key0.PublicKey, backend)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
// cashing latest cheque
if _, err = chbox.Receive(ch); err != nil {
t.Fatalf("expected no error, got %v", err)
if _, err = ch.Cash(chbook.session); err != nil {
t.Fatal("Cash failed:", err)
}
backend.Commit()
chbook.balance = new(big.Int).Set(common.Big3)
ch0, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
ch1, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
interval := 10 * time.Millisecond
// setting autocash with interval of 10ms
chbox.AutoCash(interval, nil)
_, err = chbox.Receive(ch0)
if err != nil {
t.Fatalf("expected no error, got %v", err)
```

```
}
_, err = chbox.Receive(ch1)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
// after 3x interval time and 2 cheques received, exactly one cashing tx is sent
time.Sleep(4 * interval)
backend.Commit()
// after stopping autocash no more tx are sent
ch2, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
chbox.Stop()
_, err = chbox.Receive(ch2)
if err != nil {
t.Fatalf("expected no error, got %v", err)
time.Sleep(2 * interval)
backend.Commit()
// autocash below 1
chbook.balance = big.NewInt(2)
chbox.AutoCash(0, common.Big1)
ch3, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
ch4, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
_, err = chbox.Receive(ch3)
if err != nil {
t.Fatalf("expected no error, got %v", err)
```

```
}
backend.Commit()
_, err = chbox.Receive(ch4)
if err != nil {
t.Fatalf("expected no error, got %v", err)
backend.Commit()
// autochash on receipt when maxUncashed is 0
chbook.balance = new(big.Int).Set(common.Big2)
chbox.AutoCash(0, common.Big0)
ch5, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
ch6, err := chbook.lssue(addr1, amount)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
_, err = chbox.Receive(ch5)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
_, err = chbox.Receive(ch6)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
backend.Commit()
}
47:F:\git\coin\ethereum\go-ethereum\contracts\chequebook\contract\chequebook.go
// ChequebookABI is the input ABI used to generate the binding from.
const ChequebookABI =
`[{"constant":false,"inputs":[],"name":"kill","outputs":[],"type":"function"},{"constant":true,"inputs":[{"n
```

```
ame":"","type":"address"}],"name":"sent","outputs":[{"name":"","type":"uint256"}],"type":"function"},{" constant":false,"inputs":[{"name":"beneficiary","type":"address"},{"name":"amount","type":"uint256"},{"name":"sig_v","type":"uint8"},{"name":"sig_r","type":"bytes32"},{"name":"sig_s","type":"bytes32"}],"name":"cash","outputs":[],"type":"function"},{"anonymous":false,"inputs":[{"indexed":false,"name":" deadbeat","type":"address"}],"name":"Overdraft","type":"event"}]`
```

// ChequebookBin is the compiled bytecode used for deploying new contracts. const ChequebookBin =

`0x606060405260008054600160a060020a031916331790556101ff806100246000396000f360606
0405260e060020a600035046341c0e1b581146100315780637bf786f814610059578063fbf788d61
4610071575b005b61002f60005433600160a060020a03908116911614156100bd5760005460016
0a060020a0316ff5b6100ab60043560016020526000908152604090205481565b61002f60043560
2435604435606435608435600160a060020a038516600090815260016020526040812054851161
00bf575b50505050505050565b60408051918252519081900360200190f35b565b50604080516c010
000000000000000000000000000030600160a060020a039081168202835288160260148201526028810
1869052815190819003604801812080825260ff8616602083810191909152828401869052606083
01859052925190926001926080818101939182900301816000866161da5a03f115610002575050
60405151600054600160a060020a0390811691161461015a576100a3565b600160a060020a0386
81166000908152600160205260409020543090911631908603106101b357604060008181208790
559051600160a060020a03881691908190818181818188881f19350505050515156100a357610002
565b60005460408051600160a060020a03929092168252517f2250e2993c15843b32621c89447cc
589ee7a9f049c026986e545d3c2c0c6f9789181900360200190a185600160a060020a0316ff

```
// DeployChequebook deploys a new Ethereum contract, binding an instance of Chequebook to it.
func DeployChequebook(auth *bind.TransactOpts, backend bind.ContractBackend)
(common.Address, *types.Transaction, *Chequebook, error) {
parsed, err := abi.JSON(strings.NewReader(ChequebookABI))
if err != nil {
return common.Address{}, nil, nil, err
address, tx, contract, err := bind.DeployContract(auth, parsed,
common.FromHex(ChequebookBin), backend)
if err != nil {
return common.Address{}, nil, nil, err
return address, tx, &Chequebook(ChequebookCaller: ChequebookCaller(contract: contract),
ChequebookTransactor: ChequebookTransactor{contract: contract}}, nil
}
// Chequebook is an auto generated Go binding around an Ethereum contract.
type Chequebook struct {
ChequebookCaller // Read-only binding to the contract
```

```
ChequebookTransactor // Write-only binding to the contract
}
// ChequebookCaller is an auto generated read-only Go binding around an Ethereum contract.
type ChequebookCaller struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ChequebookTransactor is an auto generated write-only Go binding around an Ethereum
contract.
type ChequebookTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ChequebookSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type ChequebookSession struct {
Contract
          *Chequebook
                            // Generic contract binding to set the session for
CallOpts
           bind.CallOpts // Call options to use throughout this session
TransactOpts bind. TransactOpts // Transaction auth options to use throughout this session
}
// ChequebookCallerSession is an auto generated read-only Go binding around an Ethereum
contract,
// with pre-set call options.
type ChequebookCallerSession struct {
Contract *ChequebookCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts // Call options to use throughout this session
}
// ChequebookTransactorSession is an auto generated write-only Go binding around an Ethereum
contract.
// with pre-set transact options.
type ChequebookTransactorSession struct {
           *ChequebookTransactor // Generic contract transactor binding to set the session for
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// ChequebookRaw is an auto generated low-level Go binding around an Ethereum contract.
type ChequebookRaw struct {
Contract *Chequebook // Generic contract binding to access the raw methods on
}
```

```
// ChequebookCallerRaw is an auto generated low-level read-only Go binding around an
Ethereum contract.
type ChequebookCallerRaw struct {
Contract *ChequebookCaller // Generic read-only contract binding to access the raw methods on
}
// ChequebookTransactorRaw is an auto generated low-level write-only Go binding around an
Ethereum contract.
type ChequebookTransactorRaw struct {
Contract *ChequebookTransactor // Generic write-only contract binding to access the raw methods
on
}
// NewChequebook creates a new instance of Chequebook, bound to a specific deployed contract.
func NewChequebook(address common.Address, backend bind.ContractBackend) (*Chequebook,
error) {
contract, err := bindChequebook(address, backend, backend)
if err != nil {
return nil, err
return &Chequebook{ChequebookCaller: ChequebookCaller{contract: contract},
ChequebookTransactor: ChequebookTransactor{contract: contract}}, nil
}
// NewChequebookCaller creates a new read-only instance of Chequebook, bound to a specific
deployed contract.
func NewChequebookCaller(address common.Address, caller bind.ContractCaller)
(*ChequebookCaller, error) {
contract, err := bindChequebook(address, caller, nil)
if err != nil {
return nil, err
}
return &ChequebookCaller{contract: contract}, nil
}
// NewChequebookTransactor creates a new write-only instance of Chequebook, bound to a
specific deployed contract.
func NewChequebookTransactor(address common.Address, transactor bind.ContractTransactor)
(*ChequebookTransactor, error) {
contract, err := bindChequebook(address, nil, transactor)
if err != nil {
```

```
return nil. err
return &ChequebookTransactor{contract: contract}, nil
}
// bindChequebook binds a generic wrapper to an already deployed contract.
func bindChequebook(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(ChequebookABI))
if err != nil {
return nil, err
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_Chequebook *ChequebookRaw) Call(opts *bind.CallOpts, result interface{}, method string,
params ...interface{}) error {
return _Chequebook.Contract.ChequebookCaller.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_Chequebook *ChequebookRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction,
error) {
return _Chequebook.Contract.ChequebookTransactor.contract.Transfer(opts)
// Transact invokes the (paid) contract method with params as input values.
func (_Chequebook *ChequebookRaw) Transact(opts *bind.TransactOpts, method string, params
...interface{}) (*types.Transaction, error) {
return _Chequebook.Contract.ChequebookTransactor.contract.Transact(opts, method, params...)
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_Chequebook *ChequebookCallerRaw) Call(opts *bind.CallOpts, result interface{}, method
```

```
string, params ...interface()) error (
return _Chequebook.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_Chequebook *ChequebookTransactorRaw) Transfer(opts *bind.TransactOpts)
(*types.Transaction, error) {
return Chequebook.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_Chequebook *ChequebookTransactorRaw) Transact(opts *bind.TransactOpts, method
string, params ...interface{}) (*types.Transaction, error) {
return _Chequebook.Contract.contract.Transact(opts, method, params...)
}
// Sent is a free data retrieval call binding the contract method 0x7bf786f8.
//
// Solidity: function sent( address) constant returns(uint256)
func (_Chequebook *ChequebookCaller) Sent(opts *bind.CallOpts, arg0 common.Address)
(*big.Int, error) {
var (
ret0 = new(*big.Int)
out := ret0
err := _Chequebook.contract.Call(opts, out, "sent", arg0)
return *ret0, err
// Sent is a free data retrieval call binding the contract method 0x7bf786f8.
//
// Solidity: function sent( address) constant returns(uint256)
func (_Chequebook *ChequebookSession) Sent(arg0 common.Address) (*big.Int, error) {
return _Chequebook.Contract.Sent(&_Chequebook.CallOpts, arg0)
}
// Sent is a free data retrieval call binding the contract method 0x7bf786f8.
//
// Solidity: function sent( address) constant returns(uint256)
func (_Chequebook *ChequebookCallerSession) Sent(arg0 common.Address) (*big.Int, error) {
return _Chequebook.Contract.Sent(&_Chequebook.CallOpts, arg0)
```

```
}
// Cash is a paid mutator transaction binding the contract method 0xfbf788d6.
//
// Solidity: function cash(beneficiary address, amount uint256, sig_v uint8, sig_r bytes32, sig_s
bytes32) returns()
func (_Chequebook *ChequebookTransactor) Cash(opts *bind.TransactOpts, beneficiary
common.Address, amount *big.Int, sig_v uint8, sig_r [32]byte, sig_s [32]byte) (*types.Transaction,
error) {
return _Chequebook.contract.Transact(opts, "cash", beneficiary, amount, sig_v, sig_r, sig_s)
}
// Cash is a paid mutator transaction binding the contract method 0xfbf788d6.
// Solidity: function cash(beneficiary address, amount uint256, sig_v uint8, sig_r bytes32, sig_s
bytes32) returns()
func (_Chequebook *ChequebookSession) Cash(beneficiary common.Address, amount *big.Int,
sig_v uint8, sig_r [32]byte, sig_s [32]byte) (*types.Transaction, error) {
return _Chequebook.Contract.Cash(&_Chequebook.TransactOpts, beneficiary, amount, sig_v,
sig_r, sig_s)
}
// Cash is a paid mutator transaction binding the contract method 0xfbf788d6.
// Solidity: function cash(beneficiary address, amount uint256, sig_v uint8, sig_r bytes32, sig_s
bytes32) returns()
func (_Chequebook *ChequebookTransactorSession) Cash(beneficiary common.Address, amount
*big.Int, sig_v uint8, sig_r [32]byte, sig_s [32]byte) (*types.Transaction, error) {
return _Chequebook.Contract.Cash(&_Chequebook.TransactOpts, beneficiary, amount, sig_v,
sig_r, sig_s)
}
// Kill is a paid mutator transaction binding the contract method 0x41c0e1b5.
//
// Solidity: function kill() returns()
func (_Chequebook *ChequebookTransactor) Kill(opts *bind.TransactOpts) (*types.Transaction,
error) {
return _Chequebook.contract.Transact(opts, "kill")
}
// Kill is a paid mutator transaction binding the contract method 0x41c0e1b5.
//
```

```
// Solidity: function kill() returns()
func (_Chequebook *ChequebookSession) Kill() (*types.Transaction, error) {
return _Chequebook.Contract.Kill(&_Chequebook.TransactOpts)
}
// Kill is a paid mutator transaction binding the contract method 0x41c0e1b5.
//
// Solidity: function kill() returns()
func ( Chequebook *ChequebookTransactorSession) Kill() (*types.Transaction, error) {
return _Chequebook.Contract.Kill(&_Chequebook.TransactOpts)
}
// MortalABI is the input ABI used to generate the binding from.
const MortalABI = `[{"constant":false,"inputs":[],"name":"kill","outputs":[],"type":"function"}]`
// MortalBin is the compiled bytecode used for deploying new contracts.
const MortalBin =
`0x606060405260008054600160a060020a03191633179055605c8060226000396000f360606040
// DeployMortal deploys a new Ethereum contract, binding an instance of Mortal to it.
func DeployMortal(auth *bind.TransactOpts, backend bind.ContractBackend) (common.Address,
*types.Transaction, *Mortal, error) {
parsed, err := abi.JSON(strings.NewReader(MortalABI))
if err != nil {
return common.Address{}, nil, nil, err
}
address, tx, contract, err := bind.DeployContract(auth, parsed, common.FromHex(MortalBin),
backend)
if err != nil {
return common.Address{}, nil, nil, err
}
return address, tx, &Mortal{MortalCaller: MortalCaller{contract: contract}, MortalTransactor:
MortalTransactor{contract: contract}}, nil
}
// Mortal is an auto generated Go binding around an Ethereum contract.
type Mortal struct {
             // Read-only binding to the contract
MortalCaller
MortalTransactor // Write-only binding to the contract
}
```

```
// MortalCaller is an auto generated read-only Go binding around an Ethereum contract.
type MortalCaller struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// MortalTransactor is an auto generated write-only Go binding around an Ethereum contract.
type MortalTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// MortalSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type MortalSession struct {
Contract
           *Mortal
                         // Generic contract binding to set the session for
CallOpts
                            // Call options to use throughout this session
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// MortalCallerSession is an auto generated read-only Go binding around an Ethereum contract,
// with pre-set call options.
type MortalCallerSession struct {
Contract *MortalCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts // Call options to use throughout this session
}
// MortalTransactorSession is an auto generated write-only Go binding around an Ethereum
contract.
// with pre-set transact options.
type MortalTransactorSession struct {
           *MortalTransactor // Generic contract transactor binding to set the session for
Contract
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// MortalRaw is an auto generated low-level Go binding around an Ethereum contract.
type MortalRaw struct {
Contract *Mortal // Generic contract binding to access the raw methods on
}
// MortalCallerRaw is an auto generated low-level read-only Go binding around an Ethereum
contract.
type MortalCallerRaw struct {
```

```
Contract *MortalCaller // Generic read-only contract binding to access the raw methods on
}
// MortalTransactorRaw is an auto generated low-level write-only Go binding around an Ethereum
contract.
type MortalTransactorRaw struct {
Contract *MortalTransactor // Generic write-only contract binding to access the raw methods on
}
// NewMortal creates a new instance of Mortal, bound to a specific deployed contract.
func NewMortal(address common.Address, backend bind.ContractBackend) (*Mortal, error) {
contract, err := bindMortal(address, backend, backend)
if err != nil {
return nil, err
}
return &MortalCaller: MortalCaller(contract: contract), MortalTransactor:
MortalTransactor{contract: contract}}, nil
}
// NewMortalCaller creates a new read-only instance of Mortal, bound to a specific deployed
contract.
func NewMortalCaller(address common.Address, caller bind.ContractCaller) (*MortalCaller, error)
{
contract, err := bindMortal(address, caller, nil)
if err != nil {
return nil. err
}
return &MortalCaller{contract: contract}, nil
}
// NewMortalTransactor creates a new write-only instance of Mortal, bound to a specific deployed
contract.
func NewMortalTransactor(address common.Address, transactor bind.ContractTransactor)
(*MortalTransactor, error) {
contract, err := bindMortal(address, nil, transactor)
if err != nil {
return nil, err
}
return &MortalTransactor{contract: contract}, nil
}
// bindMortal binds a generic wrapper to an already deployed contract.
```

```
func bindMortal(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(MortalABI))
if err != nil {
return nil, err
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_Mortal *MortalRaw) Call(opts *bind.CallOpts, result interface{}, method string, params
...interface(}) error {
return _Mortal.Contract.MortalCaller.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_Mortal *MortalRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction, error) {
return _Mortal.Contract.MortalTransactor.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func ( Mortal *MortalRaw) Transact(opts *bind.TransactOpts, method string, params ...interface{})
(*types.Transaction, error) {
return _Mortal.Contract.MortalTransactor.contract.Transact(opts, method, params...)
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_Mortal *MortalCallerRaw) Call(opts *bind.CallOpts, result interface{}, method string, params
...interface{}) error {
return _Mortal.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_Mortal *MortalTransactorRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction,
```

```
error) {
return _Mortal.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (Mortal *MortalTransactorRaw) Transact(opts *bind.TransactOpts, method string, params
...interface{}) (*types.Transaction, error) {
return _Mortal.Contract.contract.Transact(opts, method, params...)
}
// Kill is a paid mutator transaction binding the contract method 0x41c0e1b5.
//
// Solidity: function kill() returns()
func (_Mortal *MortalTransactor) Kill(opts *bind.TransactOpts) (*types.Transaction, error) {
return Mortal.contract.Transact(opts, "kill")
}
// Kill is a paid mutator transaction binding the contract method 0x41c0e1b5.
//
// Solidity: function kill() returns()
func (_Mortal *MortalSession) Kill() (*types.Transaction, error) {
return _Mortal.Contract.Kill(&_Mortal.TransactOpts)
}
// Kill is a paid mutator transaction binding the contract method 0x41c0e1b5.
//
// Solidity: function kill() returns()
func (_Mortal *MortalTransactorSession) Kill() (*types.Transaction, error) {
return _Mortal.Contract.Kill(&_Mortal.TransactOpts)
}
// OwnedABI is the input ABI used to generate the binding from.
const OwnedABI = `[{"inputs":[],"type":"constructor"}]`
// OwnedBin is the compiled bytecode used for deploying new contracts.
const OwnedBin =
`0x606060405260008054600160a060020a0319163317905560068060226000396000f360606040
5200`
// DeployOwned deploys a new Ethereum contract, binding an instance of Owned to it.
func DeployOwned(auth *bind.TransactOpts, backend bind.ContractBackend) (common.Address,
*types.Transaction, *Owned, error) {
```

```
parsed, err := abi.JSON(strings.NewReader(OwnedABI))
if err != nil {
return common.Address{}, nil, nil, err
address, tx, contract, err := bind.DeployContract(auth, parsed, common.FromHex(OwnedBin),
backend)
if err != nil {
return common.Address{}, nil, nil, err
return address, tx, &Owned{OwnedCaller: OwnedCaller{contract: contract}, OwnedTransactor:
OwnedTransactor{contract: contract}}, nil
}
// Owned is an auto generated Go binding around an Ethereum contract.
type Owned struct {
OwnedCaller
               // Read-only binding to the contract
OwnedTransactor // Write-only binding to the contract
}
// OwnedCaller is an auto generated read-only Go binding around an Ethereum contract.
type OwnedCaller struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// OwnedTransactor is an auto generated write-only Go binding around an Ethereum contract.
type OwnedTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// OwnedSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type OwnedSession struct {
Contract
          *Owned
                          // Generic contract binding to set the session for
CallOpts
           bind.CallOpts
                          // Call options to use throughout this session
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// OwnedCallerSession is an auto generated read-only Go binding around an Ethereum contract,
// with pre-set call options.
type OwnedCallerSession struct {
Contract *OwnedCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts // Call options to use throughout this session
```

```
}
// OwnedTransactorSession is an auto generated write-only Go binding around an Ethereum
contract,
// with pre-set transact options.
type OwnedTransactorSession struct {
Contract *OwnedTransactor // Generic contract transactor binding to set the session for
TransactOpts bind. TransactOpts // Transaction auth options to use throughout this session
}
// OwnedRaw is an auto generated low-level Go binding around an Ethereum contract.
type OwnedRaw struct {
Contract *Owned // Generic contract binding to access the raw methods on
// OwnedCallerRaw is an auto generated low-level read-only Go binding around an Ethereum
contract.
type OwnedCallerRaw struct {
Contract *OwnedCaller // Generic read-only contract binding to access the raw methods on
}
// OwnedTransactorRaw is an auto generated low-level write-only Go binding around an Ethereum
contract.
type OwnedTransactorRaw struct {
Contract *OwnedTransactor // Generic write-only contract binding to access the raw methods on
}
// NewOwned creates a new instance of Owned, bound to a specific deployed contract.
func NewOwned(address common.Address, backend bind.ContractBackend) (*Owned, error) {
contract, err := bindOwned(address, backend, backend)
if err != nil {
return nil, err
}
return &Owned{OwnedCaller: OwnedCaller{contract: contract}, OwnedTransactor:
OwnedTransactor{contract: contract}}, nil
}
// NewOwnedCaller creates a new read-only instance of Owned, bound to a specific deployed
contract.
func NewOwnedCaller(address common.Address, caller bind.ContractCaller) (*OwnedCaller,
error) {
contract, err := bindOwned(address, caller, nil)
```

```
if err != nil {
return nil, err
return &OwnedCaller{contract: contract}, nil
}
// NewOwnedTransactor creates a new write-only instance of Owned, bound to a specific
deployed contract.
func NewOwnedTransactor(address common.Address, transactor bind.ContractTransactor)
(*OwnedTransactor, error) {
contract, err := bindOwned(address, nil, transactor)
if err != nil {
return nil, err
return &OwnedTransactor{contract: contract}, nil
}
// bindOwned binds a generic wrapper to an already deployed contract.
func bindOwned(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(OwnedABI))
if err != nil {
return nil, err
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (Owned *OwnedRaw) Call(opts *bind.CallOpts, result interface{}, method string, params
...interface{}) error {
return _Owned.Contract.OwnedCaller.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_Owned *OwnedRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction, error) {
return _Owned.Contract.OwnedTransactor.contract.Transfer(opts)
}
```

```
// Transact invokes the (paid) contract method with params as input values.
func (_Owned *OwnedRaw) Transact(opts *bind.TransactOpts, method string, params
...interface{}) (*types.Transaction, error) {
return Owned.Contract.OwnedTransactor.contract.Transact(opts, method, params...)
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_Owned *OwnedCallerRaw) Call(opts *bind.CallOpts, result interface{}, method string,
params ...interface()) error (
return _Owned.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func ( Owned *OwnedTransactorRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction,
error) {
return Owned.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_Owned *OwnedTransactorRaw) Transact(opts *bind.TransactOpts, method string, params
...interface{}) (*types.Transaction, error) {
return Owned.Contract.contract.Transact(opts, method, params...)
}
48:F:\qit\coin\ethereum\go-ethereum\contracts\chequebook\contract\code.go
49:F:\git\coin\ethereum\go-ethereum\contracts\chequebook\gencode.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// +build none
// This program generates contract/code.go, which contains the chequebook code
// after deployment.
package main
import (
"fmt"
"io/ioutil"
```

```
"math/big"
"github.com/ethereum/go-ethereum/accounts/abi/bind"
"github.com/ethereum/go-ethereum/accounts/abi/bind/backends"
"github.com/ethereum/go-ethereum/contracts/chequebook/contract"
"github.com/ethereum/go-ethereum/core"
"github.com/ethereum/go-ethereum/crypto"
)
var (
testKey, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
testAccount = core.GenesisAccount{
Address: crypto.PubkeyToAddress(testKey.PublicKey),
Balance: big.NewInt(50000000000),
}
)
func main() {
backend := backends.NewSimulatedBackend(testAccount)
auth := bind.NewKeyedTransactor(testKey)
// Deploy the contract, get the code.
addr, _, _, err := contract.DeployChequebook(auth, backend)
if err != nil {
panic(err)
}
backend.Commit()
code, err := backend.CodeAt(nil, addr, nil)
if err != nil {
panic(err)
}
if len(code) == 0 {
panic("empty code")
}
// Write the output file.
content := fmt.Sprintf(`package contract
// ContractDeployedCode is used to detect suicides. This constant needs to be
// updated when the contract code is changed.
```

```
const ContractDeployedCode = "%#x"
`, code)
if err := ioutil.WriteFile("contract/code.go", []byte(content), 0644); err != nil {
   panic(err)
}
}
```

50:F:\git\coin\ethereum\go-ethereum\contract\ens.go // ENSABI is the input ABI used to generate the binding from. const ENSABI =

[{"constant":true,"inputs":[{"name":"node","type":"bytes32"}],"name":"resolver","outputs":[{"name":" ","type":"address"}],"type":"function"},{"constant":true,"inputs":[{"name":"node","type":"bytes32"}],"name":"owner","outputs":[{"name":"","type":"address"}],"type":"function"},{"constant":false,"inputs":[{"name":"node","type":"bytes32"},{"name":"bytes32"},{"name":"owner","type":"address"}],"name":"setSubnodeOwner","outputs":[],"type":"function"},{"constant":false,"inputs":[{"name":"node","type":"bytes32"},{"name":"setResolver","outputs":[],"type":"address"}],"name":"setResolver","outputs":[],"type":"ddress"}],"name":"owner","type":"address"}],"name":"owner","type":"address"}],"name":"setOwner","outputs":[],"type":"function"},{"inputs":[{"name":"owner","type":"address"}],"name":"owner","type":"bytes32"},{"indexed":true,"name":"owner","type":"bytes32"},{"indexed":true,"name":"owner","type":"address"}],"name":"NewOwner","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"Transfer","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"Transfer","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"Transfer","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"Transfer","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"Transfer","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"Transfer","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"Transfer","type":"event"},{"anonymous":false,"inputs":[{"indexed":true,"name":"NewResolver","type":"event"}])

// ENSBin is the compiled bytecode used for deploying new contracts. const ENSBin =

`0x606060405260405160208061032683395060806040525160008080526020527fad3228b676f7 d3cd4284a5443f17f1962b36e491b30a40b2405849e597ba5fb58054600160a060020a031916821 79055506102c88061005e6000396000f3606060405260e060020a60003504630178b8bf81146100 4757806302571be31461006e57806306ab5923146100915780631896f70a146100c85780635b0fc 9c3146100fc575b005b610130600435600081815260208190526040902060010154600160a06002 0a03165b919050565b610130600435600081815260208190526040902054600160a060020a0316 610069565b6100456004356024356044356000838152602081905260408120548490600160a060 020a0390811633919091161461014d57610002565b610045600435602435600082815260208190 5260409020548290600160a060020a039081163391909116146101e757610002565b6100456004 35602435600082815260208190 5260409020548290600160a060020a0390811633919091161461 025957610002565b60408051600160a060020a03929092168252519081900360200190f35b6040 8051868152602081810187905282519182900383018220600160a060020a038716835292519294 50869288927fce0457fe73731f824cc272376169235128c118b49d344817417c6d108d155e829290 8290030190a3826000600050600084600019168152602001908152602001600020600050600001 60006101000a815481600160a060020a0302191690830217905555050505050505050565b6040805160

```
// DeployENS deploys a new Ethereum contract, binding an instance of ENS to it.
func DeployENS(auth *bind.TransactOpts, backend bind.ContractBackend, owner
common.Address) (common.Address, *types.Transaction, *ENS, error) {
parsed, err := abi.JSON(strings.NewReader(ENSABI))
if err != nil {
return common.Address{}, nil, nil, err
address, tx, contract, err := bind.DeployContract(auth, parsed, common.FromHex(ENSBin),
backend, owner)
if err != nil {
return common.Address{}, nil, nil, err
return address, tx, &ENS{ENSCaller: ENSCaller{contract: contract}, ENSTransactor:
ENSTransactor{contract: contract}}, nil
}
// ENS is an auto generated Go binding around an Ethereum contract.
type ENS struct {
ENSCaller
             // Read-only binding to the contract
ENSTransactor // Write-only binding to the contract
}
// ENSCaller is an auto generated read-only Go binding around an Ethereum contract.
type ENSCaller struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ENSTransactor is an auto generated write-only Go binding around an Ethereum contract.
type ENSTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ENSSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type ENSSession struct {
```

```
Contract
           *ENS
                         // Generic contract binding to set the session for
CallOpts
           bind.CallOpts
                           // Call options to use throughout this session
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// ENSCallerSession is an auto generated read-only Go binding around an Ethereum contract,
// with pre-set call options.
type ENSCallerSession struct {
Contract *ENSCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts // Call options to use throughout this session
}
// ENSTransactorSession is an auto generated write-only Go binding around an Ethereum
contract,
// with pre-set transact options.
type ENSTransactorSession struct {
Contract
           *ENSTransactor // Generic contract transactor binding to set the session for
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// ENSRaw is an auto generated low-level Go binding around an Ethereum contract.
type ENSRaw struct {
Contract *ENS // Generic contract binding to access the raw methods on
}
## ENSCallerRaw is an auto generated low-level read-only Go binding around an Ethereum
contract.
type ENSCallerRaw struct {
Contract *ENSCaller // Generic read-only contract binding to access the raw methods on
}
// ENSTransactorRaw is an auto generated low-level write-only Go binding around an Ethereum
contract.
type ENSTransactorRaw struct {
Contract *ENSTransactor // Generic write-only contract binding to access the raw methods on
}
// NewENS creates a new instance of ENS, bound to a specific deployed contract.
func NewENS(address common.Address, backend bind.ContractBackend) (*ENS, error) {
contract, err := bindENS(address, backend, backend)
if err != nil {
return nil, err
```

```
}
return &ENS{ENSCaller: ENSCaller{contract: contract}, ENSTransactor: ENSTransactor{contract:
contract}}, nil
}
// NewENSCaller creates a new read-only instance of ENS, bound to a specific deployed contract.
func NewENSCaller(address common.Address, caller bind.ContractCaller) (*ENSCaller, error) {
contract, err := bindENS(address, caller, nil)
if err != nil {
return nil, err
return &ENSCaller{contract: contract}, nil
}
// NewENSTransactor creates a new write-only instance of ENS, bound to a specific deployed
contract.
func NewENSTransactor(address common.Address, transactor bind.ContractTransactor)
(*ENSTransactor, error) {
contract, err := bindENS(address, nil, transactor)
if err != nil {
return nil, err
}
return &ENSTransactor{contract: contract}, nil
}
// bindENS binds a generic wrapper to an already deployed contract.
func bindENS(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(ENSABI))
if err != nil {
return nil, err
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_ENS *ENSRaw) Call(opts *bind.CallOpts, result interface{}, method string, params
...interface{}) error {
return _ENS.Contract.ENSCaller.contract.Call(opts, result, method, params...)
```

```
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_ENS *ENSRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction, error) {
return ENS.Contract.ENSTransactor.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_ENS *ENSRaw) Transact(opts *bind.TransactOpts, method string, params ...interface{})
(*types.Transaction, error) {
return _ENS.Contract.ENSTransactor.contract.Transact(opts, method, params...)
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_ENS *ENSCallerRaw) Call(opts *bind.CallOpts, result interface{}, method string, params
...interface{}) error {
return _ENS.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_ENS *ENSTransactorRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction, error) {
return _ENS.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_ENS *ENSTransactorRaw) Transact(opts *bind.TransactOpts, method string, params
...interface{}) (*types.Transaction, error) {
return _ENS.Contract.contract.Transact(opts, method, params...)
}
// Owner is a free data retrieval call binding the contract method 0x02571be3.
//
// Solidity: function owner(node bytes32) constant returns(address)
func (_ENS *ENSCaller) Owner(opts *bind.CallOpts, node [32]byte) (common.Address, error) {
var (
ret0 = new(common.Address)
)
```

```
out := ret0
err := _ENS.contract.Call(opts, out, "owner", node)
return *ret0, err
}
// Owner is a free data retrieval call binding the contract method 0x02571be3.
//
// Solidity: function owner(node bytes32) constant returns(address)
func (ENS *ENSSession) Owner(node [32]byte) (common.Address, error) {
return _ENS.Contract.Owner(&_ENS.CallOpts, node)
}
// Owner is a free data retrieval call binding the contract method 0x02571be3.
// Solidity: function owner(node bytes32) constant returns(address)
func (_ENS *ENSCallerSession) Owner(node [32]byte) (common.Address, error) {
return _ENS.Contract.Owner(&_ENS.CallOpts, node)
}
// Resolver is a free data retrieval call binding the contract method 0x0178b8bf.
//
// Solidity: function resolver(node bytes32) constant returns(address)
func (ENS *ENSCaller) Resolver(opts *bind.CallOpts, node [32]byte) (common.Address, error) {
var (
ret0 = new(common.Address)
)
out := ret0
err := _ENS.contract.Call(opts, out, "resolver", node)
return *ret0, err
// Resolver is a free data retrieval call binding the contract method 0x0178b8bf.
//
// Solidity: function resolver(node bytes32) constant returns(address)
func (_ENS *ENSSession) Resolver(node [32]byte) (common.Address, error) {
return _ENS.Contract.Resolver(&_ENS.CallOpts, node)
}
// Resolver is a free data retrieval call binding the contract method 0x0178b8bf.
// Solidity: function resolver(node bytes32) constant returns(address)
func (_ENS *ENSCallerSession) Resolver(node [32]byte) (common.Address, error) {
```

```
return ENS.Contract.Resolver(& ENS.CallOpts, node)
}
// SetOwner is a paid mutator transaction binding the contract method 0x5b0fc9c3.
//
// Solidity: function setOwner(node bytes32, owner address) returns()
func (_ENS *ENSTransactor) SetOwner(opts *bind.TransactOpts, node [32]byte, owner
common.Address) (*types.Transaction, error) {
return ENS.contract.Transact(opts, "setOwner", node, owner)
}
// SetOwner is a paid mutator transaction binding the contract method 0x5b0fc9c3.
//
// Solidity: function setOwner(node bytes32, owner address) returns()
func (ENS *ENSSession) SetOwner(node [32]byte, owner common.Address)
(*types.Transaction, error) {
return _ENS.Contract.SetOwner(&_ENS.TransactOpts, node, owner)
}
// SetOwner is a paid mutator transaction binding the contract method 0x5b0fc9c3.
//
// Solidity: function setOwner(node bytes32, owner address) returns()
func (ENS *ENSTransactorSession) SetOwner(node [32]byte, owner common.Address)
(*types.Transaction, error) {
return _ENS.Contract.SetOwner(&_ENS.TransactOpts, node, owner)
}
// SetResolver is a paid mutator transaction binding the contract method 0x1896f70a.
//
// Solidity: function setResolver(node bytes32, resolver address) returns()
func (ENS *ENSTransactor) SetResolver(opts *bind.TransactOpts, node [32]byte, resolver
common.Address) (*types.Transaction, error) {
return _ENS.contract.Transact(opts, "setResolver", node, resolver)
}
// SetResolver is a paid mutator transaction binding the contract method 0x1896f70a.
//
// Solidity: function setResolver(node bytes32, resolver address) returns()
func (_ENS *ENSSession) SetResolver(node [32]byte, resolver common.Address)
(*types.Transaction, error) {
return _ENS.Contract.SetResolver(&_ENS.TransactOpts, node, resolver)
}
```

```
// SetResolver is a paid mutator transaction binding the contract method 0x1896f70a.
//
// Solidity: function setResolver(node bytes32, resolver address) returns()
func (_ENS *ENSTransactorSession) SetResolver(node [32]byte, resolver common.Address)
(*types.Transaction, error) {
return _ENS.Contract.SetResolver(&_ENS.TransactOpts, node, resolver)
}
// SetSubnodeOwner is a paid mutator transaction binding the contract method 0x06ab5923.
//
// Solidity: function setSubnodeOwner(node bytes32, label bytes32, owner address) returns()
func (_ENS *ENSTransactor) SetSubnodeOwner(opts *bind.TransactOpts, node [32]byte, label
[32]byte, owner common.Address) (*types.Transaction, error) {
return _ENS.contract.Transact(opts, "setSubnodeOwner", node, label, owner)
}
// SetSubnodeOwner is a paid mutator transaction binding the contract method 0x06ab5923.
//
// Solidity: function setSubnodeOwner(node bytes32, label bytes32, owner address) returns()
func (_ENS *ENSSession) SetSubnodeOwner(node [32]byte, label [32]byte, owner
common.Address) (*types.Transaction, error) {
return ENS.Contract.SetSubnodeOwner(& ENS.TransactOpts, node, label, owner)
}
// SetSubnodeOwner is a paid mutator transaction binding the contract method 0x06ab5923.
//
// Solidity: function setSubnodeOwner(node bytes32, label bytes32, owner address) returns()
func (ENS *ENSTransactorSession) SetSubnodeOwner(node [32]byte, label [32]byte, owner
common.Address) (*types.Transaction, error) {
return _ENS.Contract.SetSubnodeOwner(&_ENS.TransactOpts, node, label, owner)
}
// FIFSRegistrarABI is the input ABI used to generate the binding from.
const FIFSRegistrarABI =
`[{"constant":false,"inputs":[{"name":"subnode","type":"bytes32"},{"name":"owner","type":"address"}
],"name":"register","outputs":[],"type":"function"},{"inputs":[{"name":"ensAddr","type":"address"},{"na
me":"node","type":"bytes32"}],"type":"constructor"}]`
// FIFSRegistrarBin is the compiled bytecode used for deploying new contracts.
const FIFSRegistrarBin =
`0x6060604081815280610620833960a090525160805160008054600160a060020a03191683179
```

0558160a0610367806100878339018082600160a060020a0316815260200191505060405180910 3906000f0600160006101000a815481600160a060020a030219169083021790555080600260005 0819055505050610232806103ee6000396000f3606060405260405160208061036783395060806 040525160008054600160a060020a0319168217905550610330806100376000396000f36060604 052361561004b5760e060020a60003504632dff694181146100535780633b3b57de146100755780 6341b9dc2b146100a0578063c3d014d614610139578063d5fa2b00146101b2575b61022b6100025 65b61022d6004356000818152600260205260408120549081141561027057610002565b61023f6 00435600081815260016020526040812054600160a060020a03169081141561027057610002565 0000000000821480156100f05750600083815260016020526040812054600160a060020a03161 000082148015610132575060008381526002602052604081205414155b9392505050565b61022b 600435602435600080546040805160e060020a6302571be3028152600481018690529051859360 0160a060020a033381169416926302571be3926024828101936020938390039091019082908761 61da5a03f11561000257505060405151600160a060020a03169190911490506102755761000256 5b61022b600435602435600080546040805160e060020a6302571be30281526004810186905290 518593600160a060020a033381169416926302571be39260248281019360209383900390910190 8290876161da5a03f11561000257505060405151600160a060020a03169190911490506102c157 610002565b005b60408051918252519081900360200190f35b60408051600160a060020a039290 92168252519081900360200190f35b604080519115158252519081900360200190f35b919050565 b6000838152600260209081526040918290208490558151848152915185927f0424b6fe0d9c3bdb ece0e7879dc241bb0c22e900be8b6c168b4ee08bd9bf83bc92908290030190a2505050565b60008 0a060020a0385168152915185927f52d7d861f09ab3d26239d492e8968629f95e9e318cf0b73bfddc 441522a15fd292908290030190a250505056606060405260e060020a6000350463d22057a98114 61001b575b005b6100196004356024356002546040805191825260208281018590526000805483 000000865260048601819052935193949193600160a060020a03909116926302571be392602481 81019391829003018187876161da5a03f11561000257505060405151915050600160a060020a03 81166000148015906100d4575033600160a060020a031681600160a060020a031614155b156100 00000000000000000000000845260048401526024830188905230600160a060020a0390811660 4485015293519316926306ab5923926064818101939291829003018183876161da5a03f1156100 0000000000000000815260048101889052600160a060020a03928316602482015290519290911 69350631896f70a926044828101939192829003018183876161da5a03f115610002575050600080 260048101879052600160a060020a0388811660248301529151929091169350635b0fc9c3926044 828101939192829003018183876161da5a03f1156100025750505050505050505

// DeployFIFSRegistrar deploys a new Ethereum contract, binding an instance of FIFSRegistrar to it.

```
func DeployFIFSRegistrar(auth *bind.TransactOpts, backend bind.ContractBackend, ensAddr
common.Address, node [32]byte) (common.Address, *types.Transaction, *FIFSRegistrar, error) {
parsed, err := abi.JSON(strings.NewReader(FIFSRegistrarABI))
if err != nil {
return common.Address{}, nil, nil, err
address, tx, contract, err := bind.DeployContract(auth, parsed,
common.FromHex(FIFSRegistrarBin), backend, ensAddr, node)
if err != nil {
return common.Address{}, nil, nil, err
}
return address, tx, &FIFSRegistrar{FIFSRegistrarCaller: FIFSRegistrarCaller{contract: contract},
FIFSRegistrarTransactor: FIFSRegistrarTransactor{contract: contract}}, nil
}
// FIFSRegistrar is an auto generated Go binding around an Ethereum contract.
type FIFSRegistrar struct {
                      // Read-only binding to the contract
FIFSRegistrarCaller
FIFSRegistrarTransactor // Write-only binding to the contract
}
// FIFSRegistrarCaller is an auto generated read-only Go binding around an Ethereum contract.
type FIFSRegistrarCaller struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// FIFSRegistrarTransactor is an auto generated write-only Go binding around an Ethereum
contract.
type FIFSRegistrarTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// FIFSRegistrarSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type FIFSRegistrarSession struct {
           *FIFSRegistrar // Generic contract binding to set the session for
Contract
           bind.CallOpts // Call options to use throughout this session
CallOpts
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// FIFSRegistrarCallerSession is an auto generated read-only Go binding around an Ethereum
contract.
```

```
// with pre-set call options.
type FIFSRegistrarCallerSession struct {
Contract *FIFSRegistrarCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts
                         // Call options to use throughout this session
}
// FIFSRegistrarTransactorSession is an auto generated write-only Go binding around an
Ethereum contract,
// with pre-set transact options.
type FIFSRegistrarTransactorSession struct {
Contract *FIFSRegistrarTransactor // Generic contract transactor binding to set the session for
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// FIFSRegistrarRaw is an auto generated low-level Go binding around an Ethereum contract.
type FIFSRegistrarRaw struct {
Contract *FIFSRegistrar // Generic contract binding to access the raw methods on
}
// FIFSRegistrarCallerRaw is an auto generated low-level read-only Go binding around an
Ethereum contract.
type FIFSRegistrarCallerRaw struct {
Contract *FIFSRegistrarCaller // Generic read-only contract binding to access the raw methods on
}
// FIFSRegistrarTransactorRaw is an auto generated low-level write-only Go binding around an
Ethereum contract.
type FIFSRegistrarTransactorRaw struct {
Contract *FIFSRegistrarTransactor // Generic write-only contract binding to access the raw
methods on
}
// NewFIFSRegistrar creates a new instance of FIFSRegistrar, bound to a specific deployed
contract.
func NewFIFSRegistrar(address common.Address, backend bind.ContractBackend)
(*FIFSRegistrar, error) {
contract, err := bindFIFSRegistrar(address, backend, backend)
if err != nil {
return nil, err
return &FIFSRegistrar{FIFSRegistrarCaller: FIFSRegistrarCaller{contract: contract},
FIFSRegistrarTransactor: FIFSRegistrarTransactor{contract: contract}}, nil
```

```
}
// NewFIFSRegistrarCaller creates a new read-only instance of FIFSRegistrar, bound to a specific
deployed contract.
func NewFIFSRegistrarCaller(address common.Address, caller bind.ContractCaller)
(*FIFSRegistrarCaller, error) {
contract, err := bindFIFSRegistrar(address, caller, nil)
if err != nil {
return nil. err
}
return &FIFSRegistrarCaller{contract: contract}, nil
}
// NewFIFSRegistrarTransactor creates a new write-only instance of FIFSRegistrar, bound to a
specific deployed contract.
func NewFIFSRegistrarTransactor(address common.Address, transactor bind.ContractTransactor)
(*FIFSRegistrarTransactor, error) {
contract, err := bindFIFSRegistrar(address, nil, transactor)
if err != nil {
return nil, err
}
return &FIFSRegistrarTransactor{contract: contract}, nil
}
// bindFIFSRegistrar binds a generic wrapper to an already deployed contract.
func bindFIFSRegistrar(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(FIFSRegistrarABI))
if err != nil {
return nil, err
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_FIFSRegistrar *FIFSRegistrarRaw) Call(opts *bind.CallOpts, result interface{}, method
string, params ...interface{}) error {
return _FIFSRegistrar.Contract.FIFSRegistrarCaller.contract.Call(opts, result, method, params...)
}
```

```
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (FIFSRegistrar *FIFSRegistrarRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction,
error) {
return FIFSRegistrar.Contract.FIFSRegistrarTransactor.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_FIFSRegistrar *FIFSRegistrarRaw) Transact(opts *bind.TransactOpts, method string,
params ...interface{}) (*types.Transaction, error) {
return FIFSRegistrar.Contract.FIFSRegistrarTransactor.contract.Transact(opts, method,
params...)
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_FIFSRegistrar *FIFSRegistrarCallerRaw) Call(opts *bind.CallOpts, result interface{},
method string, params ...interface{}) error {
return _FIFSRegistrar.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_FIFSRegistrar *FIFSRegistrarTransactorRaw) Transfer(opts *bind.TransactOpts)
(*types.Transaction, error) {
return _FIFSRegistrar.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_FIFSRegistrar *FIFSRegistrarTransactorRaw) Transact(opts *bind.TransactOpts, method
string, params ...interface{}) (*types.Transaction, error) {
return _FIFSRegistrar.Contract.contract.Transact(opts, method, params...)
}
// Register is a paid mutator transaction binding the contract method 0xd22057a9.
//
// Solidity: function register(subnode bytes32, owner address) returns()
func (_FIFSRegistrar *FIFSRegistrarTransactor) Register(opts *bind.TransactOpts, subnode
[32]byte, owner common.Address) (*types.Transaction, error) {
```

```
return FIFSRegistrar.contract.Transact(opts, "register", subnode, owner)
}
// Register is a paid mutator transaction binding the contract method 0xd22057a9.
//
// Solidity: function register(subnode bytes32, owner address) returns()
func (_FIFSRegistrar *FIFSRegistrarSession) Register(subnode [32]byte, owner
common.Address) (*types.Transaction, error) {
return FIFSRegistrar.Contract.Register(& FIFSRegistrar.TransactOpts, subnode, owner)
}
// Register is a paid mutator transaction binding the contract method 0xd22057a9.
//
// Solidity: function register(subnode bytes32, owner address) returns()
func (FIFSRegistrar *FIFSRegistrarTransactorSession) Register(subnode [32]byte, owner
common.Address) (*types.Transaction, error) {
return _FIFSRegistrar.Contract.Register(&_FIFSRegistrar.TransactOpts, subnode, owner)
}
// PublicResolverABI is the input ABI used to generate the binding from.
const PublicResolverABI =
`[{"constant":true,"inputs":[{"name":"node","type":"bytes32"}],"name":"content","outputs":[{"name":"r
et","type":"bytes32"}],"type":"function"},{"constant":true,"inputs":[{"name":"node","type":"bytes32"}],"
name":"addr","outputs":[{"name":"ret","type":"address"}],"type":"function"},{"constant":false,"inputs":
[{"name":"node","type":"bytes32"},{"name":"kind","type":"bytes32"}],"name":"has","outputs":[{"name
":"","type":"bool"}],"type":"function"},{"constant":false,"inputs":[{"name":"node","type":"bytes32"},{"n
ame":"hash","type":"bytes32"}],"name":"setContent","outputs":[],"type":"function"},{"constant":false,
"inputs":[{"name":"node","type":"bytes32"},{"name":"addr","type":"address"}],"name":"setAddr","out
puts":[],"type":"function"},{"inputs":[{"name":"ensAddr","type":"address"}],"type":"constructor"},{"ano
nymous":false,"inputs":[{"indexed":true,"name":"node","type":"bytes32"},{"indexed":false,"name":"a
","type":"address"}],"name":"AddrChanged","type":"event"},{"anonymous":false,"inputs":[{"indexed"
:true, "name": "node", "type": "bytes32"}, {"indexed":false, "name": "hash", "type": "bytes32"}], "name": "C
ontentChanged", "type": "event" }]`
// PublicResolverBin is the compiled bytecode used for deploying new contracts.
const PublicResolverBin =
`0x606060405260405160208061036783395060806040525160008054600160a060020a0319168
217905550610330806100376000396000f36060604052361561004b5760e060020a60003504632
dff694181146100535780633b3b57de1461007557806341b9dc2b146100a0578063c3d014d61461
0139578063d5fa2b00146101b2575b61022b610002565b61022d60043560008181526002602052
```

60408120549081141561027057610002565b61023f600435600081815260016020526040812054 600160a060020a03169081141561027057610002565b61025c60043560243560007f6164647200

815260016020526040812054600160a060020a031614155b8061013257507f636f6e74656e74000 2602052604081205414155b9392505050565b61022b600435602435600080546040805160e0600 20a6302571be30281526004810186905290518593600160a060020a033381169416926302571be 392602482810193602093839003909101908290876161da5a03f11561000257505060405151600 160a060020a031691909114905061027557610002565b61022b600435602435600080546040805 160e060020a6302571be30281526004810186905290518593600160a060020a033381169416926 302571be392602482810193602093839003909101908290876161da5a03f115610002575050604 05151600160a060020a03169190911490506102c157610002565b005b604080519182525190819 00360200190f35b60408051600160a060020a03929092168252519081900360200190f35b604080 519115158252519081900360200190f35b919050565b6000838152600260209081526040918290 208490558151848152915185927f0424b6fe0d9c3bdbece0e7879dc241bb0c22e900be8b6c168b4 ee08bd9bf83bc92908290030190a2505050565b600083815260016020908152604091829020805 861f09ab3d26239d492e8968629f95e9e318cf0b73bfddc441522a15fd292908290030190a2505050 56`

```
// DeployPublicResolver deploys a new Ethereum contract, binding an instance of PublicResolver
to it.
func DeployPublicResolver(auth *bind.TransactOpts, backend bind.ContractBackend, ensAddr
common.Address) (common.Address, *types.Transaction, *PublicResolver, error) {
parsed, err := abi.JSON(strings.NewReader(PublicResolverABI))
if err != nil {
return common.Address{}, nil, nil, err
}
address, tx, contract, err := bind.DeployContract(auth, parsed,
common.FromHex(PublicResolverBin), backend, ensAddr)
if err != nil {
return common.Address{}, nil, nil, err
}
return address, tx, &PublicResolver{PublicResolverCaller: PublicResolverCaller{contract:
contract}, PublicResolverTransactor: PublicResolverTransactor{contract: contract}}, nil
}
// PublicResolver is an auto generated Go binding around an Ethereum contract.
type PublicResolver struct {
PublicResolverCaller
                      // Read-only binding to the contract
PublicResolverTransactor // Write-only binding to the contract
}
```

// PublicResolverCaller is an auto generated read-only Go binding around an Ethereum contract.

```
type PublicResolverCaller struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// PublicResolverTransactor is an auto generated write-only Go binding around an Ethereum
contract.
type PublicResolverTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// PublicResolverSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type PublicResolverSession struct {
           *PublicResolver // Generic contract binding to set the session for
Contract
CallOpts
           bind.CallOpts // Call options to use throughout this session
TransactOpts bind. TransactOpts // Transaction auth options to use throughout this session
}
// PublicResolverCallerSession is an auto generated read-only Go binding around an Ethereum
contract.
// with pre-set call options.
type PublicResolverCallerSession struct {
Contract *PublicResolverCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts
                          // Call options to use throughout this session
}
// PublicResolverTransactorSession is an auto generated write-only Go binding around an
Ethereum contract.
// with pre-set transact options.
type PublicResolverTransactorSession struct {
Contract *PublicResolverTransactor // Generic contract transactor binding to set the session for
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// PublicResolverRaw is an auto generated low-level Go binding around an Ethereum contract.
type PublicResolverRaw struct {
Contract *PublicResolver // Generic contract binding to access the raw methods on
}
// PublicResolverCallerRaw is an auto generated low-level read-only Go binding around an
Ethereum contract.
type PublicResolverCallerRaw struct {
```

```
Contract *PublicResolverCaller // Generic read-only contract binding to access the raw methods
on
}
// PublicResolverTransactorRaw is an auto generated low-level write-only Go binding around an
Ethereum contract.
type PublicResolverTransactorRaw struct {
Contract *PublicResolverTransactor // Generic write-only contract binding to access the raw
methods on
}
// NewPublicResolver creates a new instance of PublicResolver, bound to a specific deployed
contract.
func NewPublicResolver(address common.Address, backend bind.ContractBackend)
(*PublicResolver, error) {
contract, err := bindPublicResolver(address, backend, backend)
if err != nil {
return nil, err
return & Public Resolver { Public Resolver Caller: Public Resolver Caller { contract: contract},
PublicResolverTransactor: PublicResolverTransactor{contract: contract}}, nil
}
// NewPublicResolverCaller creates a new read-only instance of PublicResolver, bound to a
specific deployed contract.
func NewPublicResolverCaller(address common.Address, caller bind.ContractCaller)
(*PublicResolverCaller, error) {
contract, err := bindPublicResolver(address, caller, nil)
if err != nil {
return nil, err
return & Public Resolver Caller {contract: contract}, nil
}
// NewPublicResolverTransactor creates a new write-only instance of PublicResolver, bound to a
specific deployed contract.
func NewPublicResolverTransactor(address common.Address, transactor
bind.ContractTransactor) (*PublicResolverTransactor, error) {
contract, err := bindPublicResolver(address, nil, transactor)
if err != nil {
return nil, err
}
```

```
return & Public Resolver Transactor {contract: contract}, nil
}
// bindPublicResolver binds a generic wrapper to an already deployed contract.
func bindPublicResolver(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(PublicResolverABI))
if err != nil {
return nil. err
}
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_PublicResolver *PublicResolverRaw) Call(opts *bind.CallOpts, result interface{}, method
string, params ...interface{}) error {
return _PublicResolver.Contract.PublicResolverCaller.contract.Call(opts, result, method,
params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_PublicResolver *PublicResolverRaw) Transfer(opts *bind.TransactOpts)
(*types.Transaction, error) {
return _PublicResolver.Contract.PublicResolverTransactor.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func ( PublicResolver *PublicResolverRaw) Transact(opts *bind.TransactOpts, method string,
params ...interface{}) (*types.Transaction, error) {
return _PublicResolver.Contract.PublicResolverTransactor.contract.Transact(opts, method,
params...)
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_PublicResolver *PublicResolverCallerRaw) Call(opts *bind.CallOpts, result interface{},
```

```
method string, params ...interface()) error (
return _PublicResolver.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_PublicResolver *PublicResolverTransactorRaw) Transfer(opts *bind.TransactOpts)
(*types.Transaction, error) {
return PublicResolver.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_PublicResolver *PublicResolverTransactorRaw) Transact(opts *bind.TransactOpts, method
string, params ...interface{}) (*types.Transaction, error) {
return _PublicResolver.Contract.contract.Transact(opts, method, params...)
}
// Addr is a free data retrieval call binding the contract method 0x3b3b57de.
// Solidity: function addr(node bytes32) constant returns(ret address)
func (_PublicResolver *PublicResolverCaller) Addr(opts *bind.CallOpts, node [32]byte)
(common.Address, error) {
var (
ret0 = new(common.Address)
out := ret0
err := _PublicResolver.contract.Call(opts, out, "addr", node)
return *ret0, err
// Addr is a free data retrieval call binding the contract method 0x3b3b57de.
//
// Solidity: function addr(node bytes32) constant returns(ret address)
func (_PublicResolver *PublicResolverSession) Addr(node [32]byte) (common.Address, error) {
return _PublicResolver.Contract.Addr(&_PublicResolver.CallOpts, node)
}
// Addr is a free data retrieval call binding the contract method 0x3b3b57de.
//
// Solidity: function addr(node bytes32) constant returns(ret address)
func (_PublicResolver *PublicResolverCallerSession) Addr(node [32]byte) (common.Address,
error) {
```

```
return PublicResolver.Contract.Addr(& PublicResolver.CallOpts, node)
}
// Content is a free data retrieval call binding the contract method 0x2dff6941.
//
// Solidity: function content(node bytes32) constant returns(ret bytes32)
func (_PublicResolver *PublicResolverCaller) Content(opts *bind.CallOpts, node [32]byte)
([32]byte, error) {
var (
ret0 = new([32]byte)
out := ret0
err := _PublicResolver.contract.Call(opts, out, "content", node)
return *ret0, err
}
// Content is a free data retrieval call binding the contract method 0x2dff6941.
//
// Solidity: function content(node bytes32) constant returns(ret bytes32)
func (_PublicResolver *PublicResolverSession) Content(node [32]byte) ([32]byte, error) {
return _PublicResolver.Contract.Content(&_PublicResolver.CallOpts, node)
}
// Content is a free data retrieval call binding the contract method 0x2dff6941.
//
// Solidity: function content(node bytes32) constant returns(ret bytes32)
func (_PublicResolver *PublicResolverCallerSession) Content(node [32]byte) ([32]byte, error) {
return _PublicResolver.Contract.Content(&_PublicResolver.CallOpts, node)
}
// Has is a paid mutator transaction binding the contract method 0x41b9dc2b.
//
// Solidity: function has(node bytes32, kind bytes32) returns(bool)
func (_PublicResolver *PublicResolverTransactor) Has(opts *bind.TransactOpts, node [32]byte,
kind [32]byte) (*types.Transaction, error) {
return _PublicResolver.contract.Transact(opts, "has", node, kind)
}
// Has is a paid mutator transaction binding the contract method 0x41b9dc2b.
// Solidity: function has(node bytes32, kind bytes32) returns(bool)
func (_PublicResolver *PublicResolverSession) Has(node [32]byte, kind [32]byte)
```

```
(*types.Transaction, error) {
return _PublicResolver.Contract.Has(&_PublicResolver.TransactOpts, node, kind)
}
// Has is a paid mutator transaction binding the contract method 0x41b9dc2b.
//
// Solidity: function has(node bytes32, kind bytes32) returns(bool)
func (_PublicResolver *PublicResolverTransactorSession) Has(node [32]byte, kind [32]byte)
(*types.Transaction, error) {
return _PublicResolver.Contract.Has(&_PublicResolver.TransactOpts, node, kind)
}
// SetAddr is a paid mutator transaction binding the contract method 0xd5fa2b00.
//
// Solidity: function setAddr(node bytes32, addr address) returns()
func (_PublicResolver *PublicResolverTransactor) SetAddr(opts *bind.TransactOpts, node
[32]byte, addr common.Address) (*types.Transaction, error) {
return PublicResolver.contract.Transact(opts, "setAddr", node, addr)
}
// SetAddr is a paid mutator transaction binding the contract method 0xd5fa2b00.
//
// Solidity: function setAddr(node bytes32, addr address) returns()
func (_PublicResolver *PublicResolverSession) SetAddr(node [32]byte, addr common.Address)
(*types.Transaction, error) {
return PublicResolver.Contract.SetAddr(& PublicResolver.TransactOpts, node, addr)
}
// SetAddr is a paid mutator transaction binding the contract method 0xd5fa2b00.
//
// Solidity: function setAddr(node bytes32, addr address) returns()
func ( PublicResolver *PublicResolverTransactorSession) SetAddr(node [32]byte, addr
common.Address) (*types.Transaction, error) {
return _PublicResolver.Contract.SetAddr(&_PublicResolver.TransactOpts, node, addr)
}
// SetContent is a paid mutator transaction binding the contract method 0xc3d014d6.
//
// Solidity: function setContent(node bytes32, hash bytes32) returns()
func (_PublicResolver *PublicResolverTransactor) SetContent(opts *bind.TransactOpts, node
[32]byte, hash [32]byte) (*types.Transaction, error) {
return _PublicResolver.contract.Transact(opts, "setContent", node, hash)
```

```
}
// SetContent is a paid mutator transaction binding the contract method 0xc3d014d6.
//
// Solidity: function setContent(node bytes32, hash bytes32) returns()
func ( PublicResolver *PublicResolverSession) SetContent(node [32]byte, hash [32]byte)
(*types.Transaction, error) {
return _PublicResolver.Contract.SetContent(&_PublicResolver.TransactOpts, node, hash)
}
// SetContent is a paid mutator transaction binding the contract method 0xc3d014d6.
//
// Solidity: function setContent(node bytes32, hash bytes32) returns()
func (_PublicResolver *PublicResolverTransactorSession) SetContent(node [32]byte, hash
[32]byte) (*types.Transaction, error) {
return _PublicResolver.Contract.SetContent(&_PublicResolver.TransactOpts, node, hash)
}
// ResolverABI is the input ABI used to generate the binding from.
const ResolverABI =
`[{"constant":true,"inputs":[{"name":"node","type":"bytes32"}],"name":"content","outputs":[{"name":"r
et","type":"bytes32"}],"type":"function"},{"constant":true,"inputs":[{"name":"node","type":"bytes32"}],"
name":"addr","outputs":[{"name":"ret","type":"address"}],"type":"function"},{"constant":false,"inputs":
[{"name":"node","type":"bytes32"},{"name":"kind","type":"bytes32"}],"name":"has","outputs":[{"name
":"","type":"bool"}],"type":"function"},{"anonymous":false,"inputs":[{"indexed":true,"name":"node","ty
pe":"bytes32"},{"indexed":false,"name":"a","type":"address"}],"name":"AddrChanged","type":"event"
},{"anonymous":false,"inputs":[{"indexed":true,"name":"node","type":"bytes32"},{"indexed":false,"na
me":"hash","type":"bytes32"}],"name":"ContentChanged","type":"event"}]`
// ResolverBin is the compiled bytecode used for deploying new contracts.
const ResolverBin = `0x`
// DeployResolver deploys a new Ethereum contract, binding an instance of Resolver to it.
func DeployResolver(auth *bind.TransactOpts, backend bind.ContractBackend)
(common.Address, *types.Transaction, *Resolver, error) {
parsed, err := abi.JSON(strings.NewReader(ResolverABI))
if err != nil {
return common.Address{}, nil, nil, err
address, tx, contract, err := bind.DeployContract(auth, parsed, common.FromHex(ResolverBin),
backend)
if err != nil {
```

```
return common.Address{}, nil, nil, err
}
return address, tx, &Resolver{ResolverCaller: ResolverCaller{contract: contract},
ResolverTransactor: ResolverTransactor{contract: contract}}, nil
}
// Resolver is an auto generated Go binding around an Ethereum contract.
type Resolver struct {
ResolverCaller
                // Read-only binding to the contract
ResolverTransactor // Write-only binding to the contract
}
// ResolverCaller is an auto generated read-only Go binding around an Ethereum contract.
type ResolverCaller struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ResolverTransactor is an auto generated write-only Go binding around an Ethereum contract.
type ResolverTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ResolverSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type ResolverSession struct {
Contract *Resolver
                          // Generic contract binding to set the session for
CallOpts
           bind.CallOpts // Call options to use throughout this session
TransactOpts bind. TransactOpts // Transaction auth options to use throughout this session
}
// ResolverCallerSession is an auto generated read-only Go binding around an Ethereum contract,
// with pre-set call options.
type ResolverCallerSession struct {
Contract *ResolverCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts // Call options to use throughout this session
}
// ResolverTransactorSession is an auto generated write-only Go binding around an Ethereum
contract.
// with pre-set transact options.
type ResolverTransactorSession struct {
Contract
          *ResolverTransactor // Generic contract transactor binding to set the session for
```

```
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// ResolverRaw is an auto generated low-level Go binding around an Ethereum contract.
type ResolverRaw struct {
Contract *Resolver // Generic contract binding to access the raw methods on
}
// ResolverCallerRaw is an auto generated low-level read-only Go binding around an Ethereum
contract.
type ResolverCallerRaw struct {
Contract *ResolverCaller // Generic read-only contract binding to access the raw methods on
}
// ResolverTransactorRaw is an auto generated low-level write-only Go binding around an
Ethereum contract.
type ResolverTransactorRaw struct {
Contract *ResolverTransactor // Generic write-only contract binding to access the raw methods on
}
// NewResolver creates a new instance of Resolver, bound to a specific deployed contract.
func NewResolver(address common.Address, backend bind.ContractBackend) (*Resolver, error) {
contract, err := bindResolver(address, backend, backend)
if err != nil {
return nil, err
return &Resolver{ResolverCaller: ResolverCaller{contract: contract}, ResolverTransactor:
ResolverTransactor{contract: contract}}, nil
}
// NewResolverCaller creates a new read-only instance of Resolver, bound to a specific deployed
contract.
func NewResolverCaller(address common.Address, caller bind.ContractCaller) (*ResolverCaller,
contract, err := bindResolver(address, caller, nil)
if err != nil {
return nil, err
}
return &ResolverCaller{contract: contract}, nil
}
// NewResolverTransactor creates a new write-only instance of Resolver, bound to a specific
```

```
deployed contract.
func NewResolverTransactor(address common.Address, transactor bind.ContractTransactor)
(*ResolverTransactor, error) {
contract, err := bindResolver(address, nil, transactor)
if err != nil {
return nil, err
return &ResolverTransactor{contract: contract}, nil
}
// bindResolver binds a generic wrapper to an already deployed contract.
func bindResolver(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(ResolverABI))
if err != nil {
return nil, err
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_Resolver *ResolverRaw) Call(opts *bind.CallOpts, result interface{}, method string, params
...interface{}) error {
return _Resolver.Contract.ResolverCaller.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (Resolver *ResolverRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction, error) {
return _Resolver.Contract.ResolverTransactor.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_Resolver *ResolverRaw) Transact(opts *bind.TransactOpts, method string, params
...interface{}) (*types.Transaction, error) {
return _Resolver.Contract.ResolverTransactor.contract.Transact(opts, method, params...)
}
// Call invokes the (constant) contract method with params as input values and
```

```
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (Resolver *ResolverCallerRaw) Call(opts *bind.CallOpts, result interface{}, method string,
params ...interface{}) error {
return _Resolver.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_Resolver *ResolverTransactorRaw) Transfer(opts *bind.TransactOpts) (*types.Transaction,
error) {
return _Resolver.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_Resolver *ResolverTransactorRaw) Transact(opts *bind.TransactOpts, method string,
params ...interface{}) (*types.Transaction, error) {
return _Resolver.Contract.contract.Transact(opts, method, params...)
}
// Addr is a free data retrieval call binding the contract method 0x3b3b57de.
//
// Solidity: function addr(node bytes32) constant returns(ret address)
func (_Resolver *ResolverCaller) Addr(opts *bind.CallOpts, node [32]byte) (common.Address,
error) {
var (
ret0 = new(common.Address)
out := ret0
err := _Resolver.contract.Call(opts, out, "addr", node)
return *ret0, err
}
// Addr is a free data retrieval call binding the contract method 0x3b3b57de.
//
// Solidity: function addr(node bytes32) constant returns(ret address)
func (_Resolver *ResolverSession) Addr(node [32]byte) (common.Address, error) {
return _Resolver.Contract.Addr(&_Resolver.CallOpts, node)
}
// Addr is a free data retrieval call binding the contract method 0x3b3b57de.
```

```
//
// Solidity: function addr(node bytes32) constant returns(ret address)
func (Resolver *ResolverCallerSession) Addr(node [32]byte) (common.Address, error) {
return _Resolver.Contract.Addr(&_Resolver.CallOpts, node)
}
// Content is a free data retrieval call binding the contract method 0x2dff6941.
//
// Solidity: function content(node bytes32) constant returns(ret bytes32)
func (_Resolver *ResolverCaller) Content(opts *bind.CallOpts, node [32]byte) ([32]byte, error) {
var (
ret0 = new([32]byte)
out := ret0
err := _Resolver.contract.Call(opts, out, "content", node)
return *ret0, err
}
// Content is a free data retrieval call binding the contract method 0x2dff6941.
//
// Solidity: function content(node bytes32) constant returns(ret bytes32)
func (_Resolver *ResolverSession) Content(node [32]byte) ([32]byte, error) {
return _Resolver.Contract.Content(&_Resolver.CallOpts, node)
}
// Content is a free data retrieval call binding the contract method 0x2dff6941.
//
// Solidity: function content(node bytes32) constant returns(ret bytes32)
func (Resolver *ResolverCallerSession) Content(node [32]byte) ([32]byte, error) {
return _Resolver.Contract.Content(&_Resolver.CallOpts, node)
}
// Has is a paid mutator transaction binding the contract method 0x41b9dc2b.
//
// Solidity: function has(node bytes32, kind bytes32) returns(bool)
func (_Resolver *ResolverTransactor) Has(opts *bind.TransactOpts, node [32]byte, kind [32]byte)
(*types.Transaction, error) {
return _Resolver.contract.Transact(opts, "has", node, kind)
}
// Has is a paid mutator transaction binding the contract method 0x41b9dc2b.
//
```

```
// Solidity: function has(node bytes32, kind bytes32) returns(bool)
func (_Resolver *ResolverSession) Has(node [32]byte, kind [32]byte) (*types.Transaction, error) {
return _Resolver.Contract.Has(&_Resolver.TransactOpts, node, kind)
}
// Has is a paid mutator transaction binding the contract method 0x41b9dc2b.
//
// Solidity: function has(node bytes32, kind bytes32) returns(bool)
func (Resolver *ResolverTransactorSession) Has(node [32]byte, kind [32]byte)
(*types.Transaction, error) {
return _Resolver.Contract.Has(&_Resolver.TransactOpts, node, kind)
}
51:F:\git\coin\ethereum\go-ethereum\contracts\ens\ens.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ens
//go:generate abigen --sol contract/ens.sol --pkg contract --out contract/ens.go
import (
"math/big"
"strings"
"github.com/ethereum/go-ethereum/accounts/abi/bind"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/contracts/ens/contract"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/crypto"
)
var (
MainNetAddress =
common.HexToAddress("0x314159265dD8dbb310642f98f50C066173C1259b")
TestNetAddress = common.HexToAddress("0x112234455c3a32fd11230c42e7bccd4a84e02010")
)
// swarm domain name registry and resolver
type ENS struct {
*contract.ENSSession
contractBackend bind.ContractBackend
}
```

```
// NewENS creates a struct exposing convenient high-level operations for interacting with
// the Ethereum Name Service.
func NewENS(transactOpts *bind.TransactOpts, contractAddr common.Address, contractBackend
bind.ContractBackend) (*ENS, error) {
ens, err := contract.NewENS(contractAddr, contractBackend)
if err != nil {
return nil, err
}
return &ENS{
&contract.ENSSession{
Contract:
            ens,
TransactOpts: *transactOpts,
},
contractBackend,
}, nil
}
// DeployENS deploys an instance of the ENS nameservice, with a 'first-in, first-served' root
registrar.
func DeployENS(transactOpts *bind.TransactOpts, contractBackend bind.ContractBackend)
(*ENS, error) {
// Deploy the ENS registry
ensAddr, _, _, err := contract.DeployENS(transactOpts, contractBackend, transactOpts.From)
if err != nil {
return nil, err
}
ens, err := NewENS(transactOpts, ensAddr, contractBackend)
if err != nil {
return nil, err
}
// Deploy the registrar
regAddr, _, _, err := contract.DeployFIFSRegistrar(transactOpts, contractBackend, ensAddr,
[32]byte{})
if err != nil {
return nil, err
}
// Set the registrar as owner of the ENS root
```

```
_, err = ens.SetOwner([32]byte{}, regAddr)
if err != nil {
return nil, err
}
return ens, nil
}
func ensParentNode(name string) (common.Hash, common.Hash) {
parts := strings.SplitN(name, ".", 2)
label := crypto.Keccak256Hash([]byte(parts[0]))
if len(parts) == 1 {
return [32]byte{}, label
} else {
parentNode, parentLabel := ensParentNode(parts[1])
return crypto.Keccak256Hash(parentNode[:], parentLabel[:]), label
}
}
func ensNode(name string) common.Hash {
parentNode, parentLabel := ensParentNode(name)
return crypto.Keccak256Hash(parentNode[:], parentLabel[:])
}
func (self *ENS) getResolver(node [32]byte) (*contract.PublicResolverSession, error) {
resolverAddr, err := self.Resolver(node)
if err != nil {
return nil, err
}
resolver, err := contract.NewPublicResolver(resolverAddr, self.contractBackend)
if err != nil {
return nil, err
return &contract.PublicResolverSession{
Contract:
            resolver.
TransactOpts: self.TransactOpts,
}, nil
}
func (self *ENS) getRegistrar(node [32]byte) (*contract.FIFSRegistrarSession, error) {
```

```
registrarAddr, err := self.Owner(node)
if err != nil {
return nil, err
}
registrar, err := contract.NewFIFSRegistrar(registrarAddr, self.contractBackend)
if err != nil {
return nil, err
}
return &contract.FIFSRegistrarSession{
Contract:
            registrar,
TransactOpts: self.TransactOpts,
}, nil
}
// Resolve is a non-transactional call that returns the content hash associated with a name.
func (self *ENS) Resolve(name string) (common.Hash, error) {
node := ensNode(name)
resolver, err := self.getResolver(node)
if err != nil {
return common.Hash{}, err
}
ret, err := resolver.Content(node)
if err != nil {
return common.Hash{}, err
}
return common.BytesToHash(ret[:]), nil
}
// Register registers a new domain name for the caller, making them the owner of the new name.
// Only works if the registrar for the parent domain implements the FIFS registrar protocol.
func (self *ENS) Register(name string) (*types.Transaction, error) {
parentNode, label := ensParentNode(name)
registrar, err := self.getRegistrar(parentNode)
if err != nil {
return nil, err
}
```

```
opts := self.TransactOpts
opts.GasLimit = big.NewInt(200000)
return registrar.Contract.Register(&opts, label, self.TransactOpts.From)
}
// SetContentHash sets the content hash associated with a name. Only works if the caller
// owns the name, and the associated resolver implements a `setContent` function.
func (self *ENS) SetContentHash(name string, hash common.Hash) (*types.Transaction, error) {
node := ensNode(name)
resolver, err := self.getResolver(node)
if err != nil {
return nil, err
opts := self.TransactOpts
opts.GasLimit = big.NewInt(200000)
return resolver.Contract.SetContent(&opts, node, hash)
}
52:F:\git\coin\ethereum\go-ethereum\contracts\ens\ens_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package ens
import (
"math/big"
"testing"
"github.com/ethereum/go-ethereum/accounts/abi/bind"
"github.com/ethereum/go-ethereum/accounts/abi/bind/backends"
"github.com/ethereum/go-ethereum/core"
"github.com/ethereum/go-ethereum/crypto"
)
var (
key, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
name = "my name on ENS"
hash = crypto.Keccak256Hash([]byte("my content"))
```

```
addr = crypto.PubkeyToAddress(key.PublicKey)
)
func TestENS(t *testing.T) {
contractBackend := backends.NewSimulatedBackend(core.GenesisAlloc{addr: {Balance:
big.NewInt(100000000)}})
transactOpts := bind.NewKeyedTransactor(key)
// Workaround for bug estimating gas in the call to Register
transactOpts.GasLimit = big.NewInt(1000000)
ens, err := DeployENS(transactOpts, contractBackend)
if err != nil {
t.Fatalf("expected no error, got %v", err)
contractBackend.Commit()
_, err = ens.Register(name)
if err != nil {
t.Fatalf("expected no error, got %v", err)
contractBackend.Commit()
_, err = ens.SetContentHash(name, hash)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
contractBackend.Commit()
vhost, err := ens.Resolve(name)
if err != nil {
t.Fatalf("expected no error, got %v", err)
}
if vhost != hash {
t.Fatalf("resolve error, expected %v, got %v", hash.Hex(), vhost.Hex())
}
}
53:F:\git\coin\ethereum\go-ethereum\contracts\release\contract.go
// ReleaseOracleABI is the input ABI used to generate the binding from.
const ReleaseOracleABI =
`[{"constant":true,"inputs":[],"name":"proposedVersion","outputs":[{"name":"major","type":"uint32"},{
```

"name":"minor","type":"uint32"},("name":"patch","type":"uint32"},("name":"commit","type":"bytes20"}, {"name":"pass","type":"address[]"}, {"name":"fail","type":"address[]"}], "type":"function"}, {"constant":true,"inputs":[], "name":"user", "type":"address"}], "name":"demote", "outputs":[], "type":"function"}, {"constant":true, "inputs":[{"name":"user", "type":"address"}], "name":"authVotes", "outputs":[{"name":"promote", "type":"address"}], "name":"authVotes", "outputs":[{"name":"promote", "type":"address[]"}, "type":"function"}, {"constant":true, "inputs":[], "name":"demote", "type":"address[]"}], "type":"function"}, {"constant":true, "inputs":[], "name":"currentVersion", "outputs":[{"name":"major", "type":"uint32"}, {"name":"minor", "type":"uint32"}, {"name":"time", "type":"uint32"}, {"name":"false, "inputs":[], "name":"nuke", "outputs":[], "type":"function"}, {"constant":false, "inputs":[], "name":"nuke", "outputs":[], "type":"function"}, {"constant":false, "inputs":[{"name":"user", "type":"address"}], "name":"promote", "outputs":[], "type":"function"}, {"constant":false, "inputs":[{"name":"user", "type":"address"}], "name":"promote", "outputs":[], "type":"uint32"}, {"name":"promote", "outputs":[], "type":"uint32"}, {"name":"rommit", "type":"uint32"}, {"name":"r

// ReleaseOracleBin is the compiled bytecode used for deploying new contracts. const ReleaseOracleBin =

`0x606060405260405161135338038061135383398101604052805101600081516000141561008 457600160a060020a0333168152602081905260408120805460ff19166001908117909155805480 820180835582818380158290116100ff576000838152602090206100ff9181019083015b80821115 61012f5760008155600101610070565b5060005b815181101561011f57600160006000506000848 48151811015610002576020908102909101810151600160a060020a03168252810191909152604 001600020805460ff19169091179055600180548082018083558281838015829011610133576000 83815260209020610133918101908301610070565b505050600092835250602090912001805460 0160a060020a031916331790555b50506111df806101746000396000f35b5090565b50505091909 060005260206000209001600084848151811015610002575050506020838102850101518154600 160a060020a0319161790555060010161008856606060405236156100775760e060020a6000350 46326db7648811461007957806346f0975a1461019e5780635c3d005d1461020a57806364ed31fe 146102935780639d888e861461038d578063bc8fbbf8146103b2578063bf8ecf9c146103fc578063d 0e0813a14610468578063d67cbec914610479575b005b610496604080516020818101835260008 083528351808301855281815260045460068054875181870281018701909852808852939687968 796879691959463fffffff818116956401000000008304821695604060020a8404909216946060600 20a938490049093029390926007929184919083018282801561012657602002820191906000526 020600020905b8154600160a060020a0316815260019190910190602001808311610107575b505 561018357602002820191906000526020600020905b8154600160a060020a03168152600191909 10190602001808311610164575b5050505050509050955095509550955095509091929394955 65b604080516020818101835260008252600180548451818402810184019095528085526105589 4928301828280156101ff57602002820191906000526020600020905b8154600160a060020a0316 8152600191909101906020018083116101e0575b505050505050505b90565b6100776004356106 6d8160005b600160a060020a033316600090815260208190526040812054819060ff16156107005 7600160a060020a038416815260026020526040812091505b8154811015610706578154600160a 060020a033316908390839081101561000257600091825260209091200154600160a060020a031 6141561075157610700565b6105a26004356040805160208181018352600080835283518083018 552818152600160a060020a0386168252600283529084902080548551818502810185019096528 086529394919390926001840192918491830182828015610320576020028201919060005260206 00020905b8154600160a060020a0316815260019190910190602001808311610301575b5050505 050915080805480602002602001604051908101604052809291908181526020018280548015610 37d57602002820191906000526020600020905b8154600160a060020a031681526001919091019 060200180831161035e575b50505050505090509150915091565b61062760006000600060006 000600060086000508054905060001415610670576106f1565b6100776106f96000808080805b60 0160a060020a033316600090815260208190526040812054819060ff16156111b65782158015610 3f257506006546000145b15610c2e576111b6565b6040805160208181018352600082526003805 484518184028101840190955280855261055894928301828280156101ff57602002820191906000 526020600020908154600160a060020a03168152600191909101906020018083116101e0575b50 505050509050610207565b61007760043561066d816001610217565b6100776004356024356044 356064356107008484848460016103bf565b604051808763fffffff1681526020018663fffffff168152 6020018563fffffff168152602001846bfffffffffffffffffffffff191681526020018060200180602001838103 8352858181518152602001915080519060200190602002808383829060006004602084601f0104 600302600f01f150905001838103825284818151815260200191508051906020019060200280838 3829060006004602084601f0104600302600f01f150905001985050505050505050506040518091 0390f35b6040518080602001828103825283818151815260200191508051906020019060200280 8383829060006004602084601f0104600302600f01f1509050019250505060405180910390f35b60 405180806020018060200183810383528581815181526020019150805190602001906020028083 83829060006004602084601f0104600302600f01f15090500183810382528481815181526020019 15080519060200190602002808383829060006004602084601f0104600302600f01f15090500194 505050505060405180910390f35b6040805163fffffff968716815294861660208601529290941683 8301526bfffffffffffffffffff19166060830152608082019290925290519081900360a00190f35b5056 5b600880546000198101908110156100025760009182526004027ff3f7a9fe364faab93b216da50a 3214154f22a0a2b415b23a84c8169e8b636ee30190508054600182015463fffffff82811699506401 0000000830481169850604060020a8304169650606060020a91829004909102945067ffffffffffff 16925090505b509091929394565b565b505050505050505050565b5060005b6001820154811015 6107595733600160a060020a031682600101600050828154811015610002576000918252602090 91200154600160a060020a031614156107a357610700565b600101610252565b81546000148015 61076e575060018201546000145b156107cb576003805460018101808355828183801582901161 07ab578183600052602060002091820191016107ab9190610851565b60010161070a565b505050 6000928352506020909120018054600160a060020a031916851790555b82156108695781546001 8101808455839190828183801582901161089e5760008381526020902061089e91810190830161 0851565b5050506000928352506020909120018054600160a060020a031916851790555b600160 a060020a038416600090815260026020908152604082208054838255818452918320909291610b 2f91908101905b808211156108655760008155600101610851565b5090565b8160010160005080 548060010182818154818355818115116109505781836000526020600020918201910161095091 90610851565b5050506000928352506020909120018054600160a060020a031916331790556001

548254600290910490116108d257610700565b8280156108f85750600160a060020a0384166000 9081526020819052604090205460ff16155b1561098757600160a060020a0384166000908152602 081905260409020805460ff19166001908117909155805480820180835582818380158290116108 00578183600052602060002091820191016108009190610851565b505050600092835250602090 9120018054600160a060020a031916331790556001805490830154600290910490116108d25761 0700565b821580156109ad5750600160a060020a03841660009081526020819052604090205460 ff165b156108205750600160a060020a0383166000908152602081905260408120805460ff191690 555b6001548110156108205783600160a060020a03166001600050828154811015610002576000 91825260209091200154600160a060020a03161415610aa3576001805460001981019081101561 00025760206000908120929052600180549290910154600160a060020a03169183908110156100 0257906000526020600020900160006101000a815481600160a060020a03021916908302179055 5060016000508054809190600190039090815481835581811511610aab57600083815260209020 610aab918101908301610851565b6001016109d4565b5050600060048181556005805467fffffffffff ffff19169055600680548382558184529194509192508290610b05907ff652222313e28459528d920 b65115c16c04f3efc82aaedc97be59f3f377c0d3f90810190610851565b5060018201805460008083 559182526020909120610b2591810190610851565b5050505050610820565b5060018201805460 008083559182526020909120610b4f91810190610851565b506000925050505b60035481101561 07005783600160a060020a03166003600050828154811015610002576000918252602090912001 54600160a060020a03161415610c26576003805460001981019081101561000257602060009081 20929052600380549290910154600160a060020a03169183908110156100025790600052602060 0020900160006101000a815481600160a060020a03021916908302179055506003600050805480 91906001900390908154818355818115116106fb576000838152602090206106fb9181019083016 10851565b600101610b57565b60065460001415610c8c576004805463ffffffff1916881767fffffff000 0000019166401000000008802176bfffffff000000000000001916604060020a8702176bfffffffffff fffffffff16606060020a808704021790555b828015610d08575060045463fffffff88811691161415806 10cc1575060045463ffffffff8781166401000000009092041614155b80610cde575060045463ffffffff8 ffffff1990811690851614155b15610d12576111b6565b506006905060005b8154811015610d5b578 154600160a060020a033316908390839081101561000257600091825260209091200154600160a 060020a03161415610da6576111b6565b5060005b6001820154811015610dae5733600160a0600 20a03168260010160005082815481101561000257600091825260209091200154600160a060020 a03161415610de3576111b6565b600101610d1a565b8215610deb5781546001810180845583919 08281838015829011610e2057600083815260209020610e20918101908301610851565b6001016 10d5f565b816001016000508054806001018281815481835581811511610ea3578183600052602 06000209182019101610ea39190610851565b5050506000928352506020909120018054600160a 060020a03191633179055600154825460029091049011610e54576111b6565b8215610eda57600 5805467fffffffffffffffff19164217905560088054600181018083558281838015829011610f2f57600402 816004028360005260206000209182019101610f2f9190611048565b50505060009283525060209 09120018054600160a060020a03191633179055600180549083015460029091049011610e54576 111b6565b600060048181556005805467fffffffffffff1916905560068054838255818452919291829 06111bf907ff652222313e28459528d920b65115c16c04f3efc82aaedc97be59f3f377c0d3f9081019 0610851565b5050509190906000526020600020906004020160005060048054825463fffffff19166 3fffffff9182161780845582546401000000009081900483160267fffffff00000000199190911617808 4558254604060020a908190049092169091026bfffffff00000000000000001991909116178083558 154606060020a908190048102819004026bffffffffffffffffffff9190911617825560055460018301805 467fffffffffff191667fffffffffff90921691909117905560068054600284018054828255600082815 26020902094959491928392918201918582156110a75760005260206000209182015b828111156 110a7578254825591600101919060010190611025565b505050506004015b80821115610865576 00080825560018201805467ffffffffffff19169055600282018054828255818352602083208391611 0879190810190610851565b5060018201805460008083559182526020909120611040918101906 10851565b506110cd9291505b80821115610865578054600160a060020a0319168155600101611 0af565b50506001818101805491840180548083556000838152602090209293830192909182156 1111b5760005260206000209182015b8281111561111b578254825591600101919060010190611 100565b506111279291506110af565b5050600060048181556005805467ffffffffffffff19169055600 6805483825581845291975091955090935084925061118691507ff652222313e28459528d920b65 115c16c04f3efc82aaedc97be59f3f377c0d3f90810190610851565b5060018201805460008083559 1825260209091206111a691810190610851565b50505050506111b6565b50505050505b5050505 0505050565b50600182018054600080835591825260209091206111b09181019061085156`

```
// DeployReleaseOracle deploys a new Ethereum contract, binding an instance of ReleaseOracle
to it.
func DeployReleaseOracle(auth *bind.TransactOpts, backend bind.ContractBackend, signers
[]common.Address) (common.Address, *types.Transaction, *ReleaseOracle, error) {
parsed, err := abi.JSON(strings.NewReader(ReleaseOracleABI))
if err != nil {
return common.Address{}, nil, nil, err
address, tx, contract, err := bind.DeployContract(auth, parsed,
common.FromHex(ReleaseOracleBin), backend, signers)
if err != nil {
return common.Address{}, nil, nil, err
return address, tx, &ReleaseOracle{ReleaseOracleCaller: ReleaseOracleCaller{contract: contract},
ReleaseOracleTransactor: ReleaseOracleTransactor{contract: contract}}, nil
}
// ReleaseOracle is an auto generated Go binding around an Ethereum contract.
type ReleaseOracle struct {
                       // Read-only binding to the contract
ReleaseOracleCaller
ReleaseOracleTransactor // Write-only binding to the contract
// ReleaseOracleCaller is an auto generated read-only Go binding around an Ethereum contract.
type ReleaseOracleCaller struct {
```

```
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ReleaseOracleTransactor is an auto generated write-only Go binding around an Ethereum
contract.
type ReleaseOracleTransactor struct {
contract *bind.BoundContract // Generic contract wrapper for the low level calls
}
// ReleaseOracleSession is an auto generated Go binding around an Ethereum contract,
// with pre-set call and transact options.
type ReleaseOracleSession struct {
Contract
          *ReleaseOracle // Generic contract binding to set the session for
CallOpts
           bind.CallOpts // Call options to use throughout this session
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// ReleaseOracleCallerSession is an auto generated read-only Go binding around an Ethereum
contract,
// with pre-set call options.
type ReleaseOracleCallerSession struct {
Contract *ReleaseOracleCaller // Generic contract caller binding to set the session for
CallOpts bind.CallOpts // Call options to use throughout this session
}
// ReleaseOracleTransactorSession is an auto generated write-only Go binding around an
Ethereum contract,
// with pre-set transact options.
type ReleaseOracleTransactorSession struct {
Contract *ReleaseOracleTransactor // Generic contract transactor binding to set the session for
TransactOpts bind.TransactOpts // Transaction auth options to use throughout this session
}
// ReleaseOracleRaw is an auto generated low-level Go binding around an Ethereum contract.
type ReleaseOracleRaw struct {
Contract *ReleaseOracle // Generic contract binding to access the raw methods on
}
// ReleaseOracleCallerRaw is an auto generated low-level read-only Go binding around an
Ethereum contract.
type ReleaseOracleCallerRaw struct {
Contract *ReleaseOracleCaller // Generic read-only contract binding to access the raw methods
```

```
on
}
// ReleaseOracleTransactorRaw is an auto generated low-level write-only Go binding around an
Ethereum contract.
type ReleaseOracleTransactorRaw struct {
Contract *ReleaseOracleTransactor // Generic write-only contract binding to access the raw
methods on
// NewReleaseOracle creates a new instance of ReleaseOracle, bound to a specific deployed
contract.
func NewReleaseOracle(address common.Address, backend bind.ContractBackend)
(*ReleaseOracle, error) {
contract, err := bindReleaseOracle(address, backend, backend)
if err != nil {
return nil, err
return &ReleaseOracle{ReleaseOracleCaller: ReleaseOracleCaller{contract: contract},
ReleaseOracleTransactor: ReleaseOracleTransactor{contract: contract}}, nil
}
// NewReleaseOracleCaller creates a new read-only instance of ReleaseOracle, bound to a
specific deployed contract.
func NewReleaseOracleCaller(address common.Address, caller bind.ContractCaller)
(*ReleaseOracleCaller, error) {
contract, err := bindReleaseOracle(address, caller, nil)
if err != nil {
return nil, err
return &ReleaseOracleCaller{contract: contract}, nil
}
// NewReleaseOracleTransactor creates a new write-only instance of ReleaseOracle, bound to a
specific deployed contract.
func NewReleaseOracleTransactor(address common.Address, transactor
bind.ContractTransactor) (*ReleaseOracleTransactor, error) {
contract, err := bindReleaseOracle(address, nil, transactor)
if err != nil {
return nil, err
}
return &ReleaseOracleTransactor{contract: contract}, nil
```

```
// bindReleaseOracle binds a generic wrapper to an already deployed contract.
func bindReleaseOracle(address common.Address, caller bind.ContractCaller, transactor
bind.ContractTransactor) (*bind.BoundContract, error) {
parsed, err := abi.JSON(strings.NewReader(ReleaseOracleABI))
if err != nil {
return nil, err
return bind.NewBoundContract(address, parsed, caller, transactor), nil
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_ReleaseOracle *ReleaseOracleRaw) Call(opts *bind.CallOpts, result interface{}, method
string, params ...interface{}) error {
return _ReleaseOracle.Contract.ReleaseOracleCaller.contract.Call(opts, result, method,
params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_ReleaseOracle *ReleaseOracleRaw) Transfer(opts *bind.TransactOpts)
(*types.Transaction, error) {
return _ReleaseOracle.Contract.ReleaseOracleTransactor.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_ReleaseOracle *ReleaseOracleRaw) Transact(opts *bind.TransactOpts, method string,
params ...interface{}) (*types.Transaction, error) {
return _ReleaseOracle.Contract.ReleaseOracleTransactor.contract.Transact(opts, method,
params...)
}
// Call invokes the (constant) contract method with params as input values and
// sets the output to result. The result type might be a single field for simple
// returns, a slice of interfaces for anonymous returns and a struct for named
// returns.
func (_ReleaseOracle *ReleaseOracleCallerRaw) Call(opts *bind.CallOpts, result interface{},
method string, params ...interface()) error (
```

}

```
return ReleaseOracle.Contract.contract.Call(opts, result, method, params...)
}
// Transfer initiates a plain transaction to move funds to the contract, calling
// its default method if one is available.
func (_ReleaseOracle *ReleaseOracleTransactorRaw) Transfer(opts *bind.TransactOpts)
(*types.Transaction, error) {
return _ReleaseOracle.Contract.contract.Transfer(opts)
}
// Transact invokes the (paid) contract method with params as input values.
func (_ReleaseOracle *ReleaseOracleTransactorRaw) Transact(opts *bind.TransactOpts, method
string, params ...interface{}) (*types.Transaction, error) {
return _ReleaseOracle.Contract.contract.Transact(opts, method, params...)
}
// AuthProposals is a free data retrieval call binding the contract method 0xbf8ecf9c.
//
// Solidity: function authProposals() constant returns(address[])
func (_ReleaseOracle *ReleaseOracleCaller) AuthProposals(opts *bind.CallOpts)
([]common.Address, error) {
var (
ret0 = new([]common.Address)
out := ret0
err := _ReleaseOracle.contract.Call(opts, out, "authProposals")
return *ret0, err
}
// AuthProposals is a free data retrieval call binding the contract method 0xbf8ecf9c.
//
// Solidity: function authProposals() constant returns(address[])
func (_ReleaseOracle *ReleaseOracleSession) AuthProposals() ([]common.Address, error) {
return _ReleaseOracle.Contract.AuthProposals(&_ReleaseOracle.CallOpts)
}
// AuthProposals is a free data retrieval call binding the contract method 0xbf8ecf9c.
//
// Solidity: function authProposals() constant returns(address[])
func (_ReleaseOracle *ReleaseOracleCallerSession) AuthProposals() ([]common.Address, error) {
return _ReleaseOracle.Contract.AuthProposals(&_ReleaseOracle.CallOpts)
}
```

```
// AuthVotes is a free data retrieval call binding the contract method 0x64ed31fe.
// Solidity: function authVotes(user address) constant returns(promote address[], demote
address[])
func (ReleaseOracle *ReleaseOracleCaller) AuthVotes(opts *bind.CallOpts, user
common.Address) (struct {
Promote []common.Address
Demote []common.Address
}, error) {
ret := new(struct {
Promote []common.Address
Demote []common.Address
})
out := ret
err := _ReleaseOracle.contract.Call(opts, out, "authVotes", user)
return *ret, err
}
// AuthVotes is a free data retrieval call binding the contract method 0x64ed31fe.
//
// Solidity: function authVotes(user address) constant returns(promote address[], demote
address[])
func (_ReleaseOracle *ReleaseOracleSession) AuthVotes(user common.Address) (struct {
Promote []common.Address
Demote []common.Address
}, error) {
return _ReleaseOracle.Contract.AuthVotes(&_ReleaseOracle.CallOpts, user)
}
// AuthVotes is a free data retrieval call binding the contract method 0x64ed31fe.
//
// Solidity: function authVotes(user address) constant returns(promote address[], demote
address[])
func (_ReleaseOracle *ReleaseOracleCallerSession) AuthVotes(user common.Address) (struct {
Promote []common.Address
Demote []common.Address
}, error) {
return _ReleaseOracle.Contract.AuthVotes(&_ReleaseOracle.CallOpts, user)
}
```

// CurrentVersion is a free data retrieval call binding the contract method 0x9d888e86.

```
//
// Solidity: function currentVersion() constant returns(major uint32, minor uint32, patch uint32,
commit bytes20, time uint256)
func ( ReleaseOracle *ReleaseOracleCaller) CurrentVersion(opts *bind.CallOpts) (struct {
Major uint32
Minor uint32
Patch uint32
Commit [20]byte
Time *big.Int
}, error) {
ret := new(struct {
Major uint32
Minor uint32
Patch uint32
Commit [20]byte
Time *big.Int
})
out := ret
err := _ReleaseOracle.contract.Call(opts, out, "currentVersion")
return *ret, err
}
// CurrentVersion is a free data retrieval call binding the contract method 0x9d888e86.
//
// Solidity: function currentVersion() constant returns(major uint32, minor uint32, patch uint32,
commit bytes20, time uint256)
func (_ReleaseOracle *ReleaseOracleSession) CurrentVersion() (struct {
Major uint32
Minor uint32
Patch uint32
Commit [20]byte
Time *big.Int
}, error) {
return _ReleaseOracle.Contract.CurrentVersion(&_ReleaseOracle.CallOpts)
}
// CurrentVersion is a free data retrieval call binding the contract method 0x9d888e86.
//
// Solidity: function currentVersion() constant returns(major uint32, minor uint32, patch uint32,
commit bytes20, time uint256)
func (_ReleaseOracle *ReleaseOracleCallerSession) CurrentVersion() (struct {
Major uint32
```

```
Minor uint32
Patch uint32
Commit [20]byte
Time *big.Int
}, error) {
return _ReleaseOracle.Contract.CurrentVersion(&_ReleaseOracle.CallOpts)
}
// ProposedVersion is a free data retrieval call binding the contract method 0x26db7648.
//
// Solidity: function proposed Version() constant returns (major uint32, minor uint32, patch uint32,
commit bytes20, pass address[], fail address[])
func (_ReleaseOracle *ReleaseOracleCaller) ProposedVersion(opts *bind.CallOpts) (struct {
Major uint32
Minor uint32
Patch uint32
Commit [20]byte
Pass []common.Address
Fail []common.Address
}, error) {
ret := new(struct {
Major uint32
Minor uint32
Patch uint32
Commit [20]byte
Pass []common.Address
Fail []common.Address
})
out := ret
err := _ReleaseOracle.contract.Call(opts, out, "proposedVersion")
return *ret, err
}
// ProposedVersion is a free data retrieval call binding the contract method 0x26db7648.
// Solidity: function proposedVersion() constant returns(major uint32, minor uint32, patch uint32,
commit bytes20, pass address[], fail address[])
func (_ReleaseOracle *ReleaseOracleSession) ProposedVersion() (struct {
Major uint32
Minor uint32
Patch uint32
Commit [20]byte
```

```
Pass []common.Address
Fail []common.Address
}, error) {
return ReleaseOracle.Contract.ProposedVersion(& ReleaseOracle.CallOpts)
}
// ProposedVersion is a free data retrieval call binding the contract method 0x26db7648.
// Solidity: function proposedVersion() constant returns(major uint32, minor uint32, patch uint32,
commit bytes20, pass address[], fail address[])
func (_ReleaseOracle *ReleaseOracleCallerSession) ProposedVersion() (struct {
Major uint32
Minor uint32
Patch uint32
Commit [20]byte
Pass []common.Address
Fail []common.Address
}, error) {
return _ReleaseOracle.Contract.ProposedVersion(&_ReleaseOracle.CallOpts)
// Signers is a free data retrieval call binding the contract method 0x46f0975a.
//
// Solidity: function signers() constant returns(address[])
func (_ReleaseOracle *ReleaseOracleCaller) Signers(opts *bind.CallOpts) ([]common.Address,
error) {
var (
ret0 = new([]common.Address)
out := ret0
err := _ReleaseOracle.contract.Call(opts, out, "signers")
return *ret0, err
}
// Signers is a free data retrieval call binding the contract method 0x46f0975a.
//
// Solidity: function signers() constant returns(address[])
func (_ReleaseOracle *ReleaseOracleSession) Signers() ([]common.Address, error) {
return _ReleaseOracle.Contract.Signers(&_ReleaseOracle.CallOpts)
}
// Signers is a free data retrieval call binding the contract method 0x46f0975a.
```

```
//
// Solidity: function signers() constant returns(address[])
func (_ReleaseOracle *ReleaseOracleCallerSession) Signers() ([]common.Address, error) {
return _ReleaseOracle.Contract.Signers(&_ReleaseOracle.CallOpts)
}
// Demote is a paid mutator transaction binding the contract method 0x5c3d005d.
//
// Solidity: function demote(user address) returns()
func (_ReleaseOracle *ReleaseOracleTransactor) Demote(opts *bind.TransactOpts, user
common.Address) (*types.Transaction, error) {
return _ReleaseOracle.contract.Transact(opts, "demote", user)
}
// Demote is a paid mutator transaction binding the contract method 0x5c3d005d.
//
// Solidity: function demote(user address) returns()
func ( ReleaseOracle *ReleaseOracleSession) Demote(user common.Address)
(*types.Transaction, error) {
return _ReleaseOracle.Contract.Demote(&_ReleaseOracle.TransactOpts, user)
}
// Demote is a paid mutator transaction binding the contract method 0x5c3d005d.
//
// Solidity: function demote(user address) returns()
func ( ReleaseOracle *ReleaseOracleTransactorSession) Demote(user common.Address)
(*types.Transaction, error) {
return _ReleaseOracle.Contract.Demote(&_ReleaseOracle.TransactOpts, user)
}
// Nuke is a paid mutator transaction binding the contract method 0xbc8fbbf8.
//
// Solidity: function nuke() returns()
func (_ReleaseOracle *ReleaseOracleTransactor) Nuke(opts *bind.TransactOpts)
(*types.Transaction, error) {
return _ReleaseOracle.contract.Transact(opts, "nuke")
}
// Nuke is a paid mutator transaction binding the contract method 0xbc8fbbf8.
// Solidity: function nuke() returns()
func (_ReleaseOracle *ReleaseOracleSession) Nuke() (*types.Transaction, error) {
```

```
return ReleaseOracle.Contract.Nuke(& ReleaseOracle.TransactOpts)
}
// Nuke is a paid mutator transaction binding the contract method 0xbc8fbbf8.
//
// Solidity: function nuke() returns()
func (_ReleaseOracle *ReleaseOracleTransactorSession) Nuke() (*types.Transaction, error) {
return _ReleaseOracle.Contract.Nuke(&_ReleaseOracle.TransactOpts)
}
// Promote is a paid mutator transaction binding the contract method 0xd0e0813a.
//
// Solidity: function promote(user address) returns()
func (ReleaseOracle *ReleaseOracleTransactor) Promote(opts *bind.TransactOpts, user
common.Address) (*types.Transaction, error) {
return _ReleaseOracle.contract.Transact(opts, "promote", user)
}
// Promote is a paid mutator transaction binding the contract method 0xd0e0813a.
//
// Solidity: function promote(user address) returns()
func (_ReleaseOracle *ReleaseOracleSession) Promote(user common.Address)
(*types.Transaction, error) {
return _ReleaseOracle.Contract.Promote(&_ReleaseOracle.TransactOpts, user)
}
// Promote is a paid mutator transaction binding the contract method 0xd0e0813a.
//
// Solidity: function promote(user address) returns()
func (_ReleaseOracle *ReleaseOracleTransactorSession) Promote(user common.Address)
(*types.Transaction, error) {
return ReleaseOracle.Contract.Promote(& ReleaseOracle.TransactOpts, user)
}
// Release is a paid mutator transaction binding the contract method 0xd67cbec9.
//
// Solidity: function release(major uint32, minor uint32, patch uint32, commit bytes20) returns()
func (_ReleaseOracle *ReleaseOracleTransactor) Release(opts *bind.TransactOpts, major uint32,
minor uint32, patch uint32, commit [20]byte) (*types.Transaction, error) {
return _ReleaseOracle.contract.Transact(opts, "release", major, minor, patch, commit)
}
```

```
// Release is a paid mutator transaction binding the contract method 0xd67cbec9.
//
// Solidity: function release(major uint32, minor uint32, patch uint32, commit bytes20) returns()
func (ReleaseOracle *ReleaseOracleSession) Release(major uint32, minor uint32, patch uint32,
commit [20]byte) (*types.Transaction, error) {
return _ReleaseOracle.Contract.Release(&_ReleaseOracle.TransactOpts, major, minor, patch,
commit)
}
// Release is a paid mutator transaction binding the contract method 0xd67cbec9.
//
// Solidity: function release(major uint32, minor uint32, patch uint32, commit bytes20) returns()
func (_ReleaseOracle *ReleaseOracleTransactorSession) Release(major uint32, minor uint32,
patch uint32, commit [20]byte) (*types.Transaction, error) {
return _ReleaseOracle.Contract.Release(&_ReleaseOracle.TransactOpts, major, minor, patch,
commit)
}
54:F:\git\coin\ethereum\go-ethereum\contracts\release\contract_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package release
import (
"crypto/ecdsa"
"math/big"
"testing"
"github.com/ethereum/go-ethereum/accounts/abi/bind"
"github.com/ethereum/go-ethereum/accounts/abi/bind/backends"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core"
"github.com/ethereum/go-ethereum/crypto"
)
// setupReleaseTest creates a blockchain simulator and deploys a version oracle
// contract for testing.
func setupReleaseTest(t *testing.T, prefund ... *ecdsa.PrivateKey) (*ecdsa.PrivateKey,
*ReleaseOracle, *backends.SimulatedBackend) {
// Generate a new random account and a funded simulator
key, _ := crypto.GenerateKey()
auth := bind.NewKeyedTransactor(key)
```

```
alloc := core.GenesisAlloc{auth.From: {Balance: big.NewInt(10000000000)}}
for _, key := range prefund {
alloc[crypto.PubkeyToAddress(key.PublicKey)] = core.GenesisAccount{Balance:
big.NewInt(10000000000)}
sim := backends.NewSimulatedBackend(alloc)
// Deploy a version oracle contract, commit and return
_, _, oracle, err := DeployReleaseOracle(auth, sim, []common.Address{auth.From})
if err != nil {
t.Fatalf("Failed to deploy version contract: %v", err)
}
sim.Commit()
return key, oracle, sim
}
// Tests that the version contract can be deployed and the creator is assigned
// the sole authorized signer.
func TestContractCreation(t *testing.T) {
key, oracle, _ := setupReleaseTest(t)
owner := crypto.PubkeyToAddress(key.PublicKey)
signers, err := oracle.Signers(nil)
if err != nil {
t.Fatalf("Failed to retrieve list of signers: %v", err)
}
if len(signers) != 1 || signers[0] != owner {
t.Fatalf("Initial signer mismatch: have %v, want %v", signers, owner)
}
}
// Tests that subsequent signers can be promoted, each requiring half plus one
// votes for it to pass through.
func TestSignerPromotion(t *testing.T) {
// Prefund a few accounts to authorize with and create the oracle
keys := make([]*ecdsa.PrivateKey, 5)
for i := 0; i < len(keys); i++ \{
keys[i], _ = crypto.GenerateKey()
}
key, oracle, sim := setupReleaseTest(t, keys...)
```

```
// Gradually promote the keys, until all are authorized
keys = append([]*ecdsa.PrivateKey{key}, keys...)
for i := 1; i < len(keys); i++ {
// Check that no votes are accepted from the not yet authorized user
if , err := oracle.Promote(bind.NewKeyedTransactor(keys[i]), common.Address{}); err != nil {
t.Fatalf("Iter #%d: failed invalid promotion attempt: %v", i, err)
}
sim.Commit()
pend, err := oracle.AuthProposals(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve active proposals: %v", i, err)
if len(pend) != 0 {
t.Fatalf("Iter #%d: proposal count mismatch: have %d, want 0", i, len(pend))
}
// Promote with half - 1 voters and check that the user's not yet authorized
for j := 0; j < i/2; j++ {
if _, err = oracle.Promote(bind.NewKeyedTransactor(keys[j]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid promotion attempt: %v", i, err)
}
sim.Commit()
signers, err := oracle.Signers(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve list of signers: %v", i, err)
if len(signers) != i {
t.Fatalf("Iter #%d: signer count mismatch: have %v, want %v", i, len(signers), i)
}
// Promote with the last one needed to pass the promotion
if _, err = oracle.Promote(bind.NewKeyedTransactor(keys[i/2]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid promotion completion attempt: %v", i, err)
}
sim.Commit()
signers, err = oracle.Signers(nil)
if err != nil {
```

```
t.Fatalf("Iter #%d: failed to retrieve list of signers: %v", i, err)
if len(signers) != i+1 {
t.Fatalf("Iter #%d: signer count mismatch: have %v, want %v", i, len(signers), i+1)
}
}
}
// Tests that subsequent signers can be demoted, each requiring half plus one
// votes for it to pass through.
func TestSignerDemotion(t *testing.T) {
// Prefund a few accounts to authorize with and create the oracle
keys := make([]*ecdsa.PrivateKey, 5)
for i := 0; i < len(keys); i++ {
keys[i], _ = crypto.GenerateKey()
key, oracle, sim := setupReleaseTest(t, keys...)
// Authorize all the keys as valid signers and verify cardinality
keys = append([]*ecdsa.PrivateKey{key}, keys...)
for i := 1; i < len(keys); i++ \{
for j := 0; j <= i/2; j++ \{
if _, err := oracle.Promote(bind.NewKeyedTransactor(keys[j]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid promotion attempt: %v", i, err)
}
}
sim.Commit()
signers, err := oracle.Signers(nil)
if err != nil {
t.Fatalf("Failed to retrieve list of signers: %v", err)
}
if len(signers) != len(keys) {
t.Fatalf("Signer count mismatch: have %v, want %v", len(signers), len(keys))
}
// Gradually demote users until we run out of signers
for i := len(keys) - 1; i >= 0; i -- \{
// Demote with half - 1 voters and check that the user's not yet dropped
for j := 0; j < (i+1)/2; j++ \{
if _, err = oracle.Demote(bind.NewKeyedTransactor(keys[j]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
```

```
t.Fatalf("Iter #%d: failed valid demotion attempt: %v", len(keys)-i, err)
}
}
sim.Commit()
signers, err := oracle.Signers(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve list of signers: %v", len(keys)-i, err)
if len(signers) != i+1 {
t.Fatalf("Iter #%d: signer count mismatch: have %v, want %v", len(keys)-i, len(signers), i+1)
}
// Demote with the last one needed to pass the demotion
if _, err = oracle.Demote(bind.NewKeyedTransactor(keys[(i+1)/2]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid demotion completion attempt: %v", i, err)
}
sim.Commit()
signers, err = oracle.Signers(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve list of signers: %v", len(keys)-i, err)
}
if len(signers) != i {
t.Fatalf("Iter #%d: signer count mismatch: have %v, want %v", len(keys)-i, len(signers), i)
}
// Check that no votes are accepted from the already demoted users
if _, err = oracle.Promote(bind.NewKeyedTransactor(keys[i]), common.Address{}); err != nil {
t.Fatalf("Iter #%d: failed invalid promotion attempt: %v", i, err)
sim.Commit()
pend, err := oracle.AuthProposals(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve active proposals: %v", i, err)
}
if len(pend) != 0 {
t.Fatalf("Iter #%d: proposal count mismatch: have %d, want 0", i, len(pend))
}
}
}
```

```
// Tests that new versions can be released, honouring both voting rights as well
// as the minimum required vote count.
func TestVersionRelease(t *testing.T) {
// Prefund a few accounts to authorize with and create the oracle
keys := make([]*ecdsa.PrivateKey, 5)
for i := 0; i < len(keys); i++ \{
keys[i], _ = crypto.GenerateKey()
}
key, oracle, sim := setupReleaseTest(t, keys...)
// Track the "current release"
var (
verMajor = uint32(0)
verMinor = uint32(0)
verPatch = uint32(0)
verCommit = [20]byte{}
)
// Gradually push releases, always requiring more signers than previously
keys = append([]*ecdsa.PrivateKey{key}, keys...)
for i := 1; i < len(keys); i++ \{
// Check that no votes are accepted from the not yet authorized user
if _, err := oracle.Release(bind.NewKeyedTransactor(keys[i]), 0, 0, 0, [20]byte{0}); err != nil {
t.Fatalf("Iter #%d: failed invalid release attempt: %v", i, err)
sim.Commit()
prop, err := oracle.ProposedVersion(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve active proposal: %v", i, err)
if len(prop.Pass) != 0 {
t.Fatalf("Iter #%d: proposal vote count mismatch: have %d, want 0", i, len(prop.Pass))
}
// Authorize the user to make releases
for j := 0; j <= i/2; j++ \{
if _, err = oracle.Promote(bind.NewKeyedTransactor(keys[j]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid promotion attempt: %v", i, err)
}
}
sim.Commit()
```

```
// Propose release with half voters and check that the release does not yet go through
for j := 0; j < (i+1)/2; j++ {
if _, err = oracle.Release(bind.NewKeyedTransactor(keys[j]), uint32(i), uint32(i+1), uint32(i+2),
[20]byte{byte(i + 3)}); err != nil {
t.Fatalf("Iter #%d: failed valid release attempt: %v", i, err)
}
}
sim.Commit()
ver, err := oracle.CurrentVersion(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve current version: %v", i, err)
if ver.Major != verMajor || ver.Minor != verMinor || ver.Patch != verPatch || ver.Commit !=
verCommit {
t.Fatalf("Iter #%d: version mismatch: have %d.%d.%d-%x, want %d.%d.%d-%x", i, ver.Major,
ver.Minor, ver.Patch, ver.Commit, verMajor, verMinor, verPatch, verCommit)
}
// Pass the release and check that it became the next version
verMajor, verMinor, verPatch, verCommit = uint32(i), uint32(i+1), uint32(i+2), [20]byte{byte(i + 3)}
if _, err = oracle.Release(bind.NewKeyedTransactor(keys[(i+1)/2]), uint32(i), uint32(i+1),
uint32(i+2), [20]byte{byte(i + 3)}); err != nil {
t.Fatalf("Iter #%d: failed valid release completion attempt: %v", i, err)
sim.Commit()
ver, err = oracle.CurrentVersion(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve current version: %v", i, err)
}
if ver.Major != verMajor || ver.Minor != verMinor || ver.Patch != verPatch || ver.Commit !=
verCommit {
t.Fatalf("Iter #%d: version mismatch: have %d.%d.%d-%x, want %d.%d.%d-%x", i, ver.Major,
ver.Minor, ver.Patch, ver.Commit, verMajor, verMinor, verPatch, verCommit)
}
}
}
// Tests that proposed versions can be nuked out of existence.
func TestVersionNuking(t *testing.T) {
// Prefund a few accounts to authorize with and create the oracle
```

```
keys := make([]*ecdsa.PrivateKey, 9)
for i := 0; i < len(keys); i++ \{
keys[i], _ = crypto.GenerateKey()
key, oracle, sim := setupReleaseTest(t, keys...)
// Authorize all the keys as valid signers
keys = append([]*ecdsa.PrivateKey{key}, keys...)
for i := 1; i < len(keys); i++ \{
for j := 0; j <= i/2; j++ \{
if _, err := oracle.Promote(bind.NewKeyedTransactor(keys[j]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid promotion attempt: %v", i, err)
}
sim.Commit()
}
// Propose releases with more and more keys, always retaining enough users to nuke the
proposals
for i := 1; i < (len(keys)+1)/2; i++ \{
// Propose release with an initial set of signers
for j := 0; j < i; j++ {
if _, err := oracle.Release(bind.NewKeyedTransactor(keys[j]), uint32(i), uint32(i+1), uint32(i+2),
[20]byte{byte(i + 3)}); err != nil {
t.Fatalf("Iter #%d: failed valid proposal attempt: %v", i, err)
}
}
sim.Commit()
prop, err := oracle.ProposedVersion(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve active proposal: %v", i, err)
}
if len(prop.Pass) != i {
t.Fatalf("Iter #%d: proposal vote count mismatch: have %d, want %d", i, len(prop.Pass), i)
}
// Nuke the release with half+1 voters
for j := i; j <= i + (len(keys) + 1)/2; j ++ \{
if _, err := oracle.Nuke(bind.NewKeyedTransactor(keys[j])); err != nil {
t.Fatalf("Iter #%d: failed valid nuke attempt: %v", i, err)
}
}
```

```
sim.Commit()
prop, err = oracle.ProposedVersion(nil)
if err != nil {
t.Fatalf("Iter #%d: failed to retrieve active proposal: %v", i, err)
if len(prop.Pass) != 0 || len(prop.Fail) != 0 {
t.Fatalf("Iter #%d: proposal vote count mismatch: have %d/%d pass/fail, want 0/0", i,
len(prop.Pass), len(prop.Fail))
}
}
}
// Tests that demoting a signer will auto-nuke the currently pending release.
func TestVersionAutoNuke(t *testing.T) {
// Prefund a few accounts to authorize with and create the oracle
keys := make([]*ecdsa.PrivateKey, 5)
for i := 0; i < len(keys); i++ {
keys[i], _ = crypto.GenerateKey()
}
key, oracle, sim := setupReleaseTest(t, keys...)
// Authorize all the keys as valid signers
keys = append([]*ecdsa.PrivateKey{key}, keys...)
for i := 1; i < len(keys); i++ {
for j := 0; j <= i/2; j++ \{
if _, err := oracle.Promote(bind.NewKeyedTransactor(keys[j]),
crypto.PubkeyToAddress(keys[i].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid promotion attempt: %v", i, err)
}
}
sim.Commit()
}
// Make a release proposal and check it's existence
if _, err := oracle.Release(bind.NewKeyedTransactor(keys[0]), 1, 2, 3, [20]byte{4}); err != nil {
t.Fatalf("Failed valid proposal attempt: %v", err)
}
sim.Commit()
prop, err := oracle.ProposedVersion(nil)
if err != nil {
t.Fatalf("Failed to retrieve active proposal: %v", err)
```

```
}
if len(prop.Pass) != 1 {
t.Fatalf("Proposal vote count mismatch: have %d, want 1", len(prop.Pass))
// Demote a signer and check release proposal deletion
for i := 0; i <= len(keys)/2; i++ {
if _, err := oracle.Demote(bind.NewKeyedTransactor(keys[i]),
crypto.PubkeyToAddress(keys[len(keys)-1].PublicKey)); err != nil {
t.Fatalf("Iter #%d: failed valid demotion attempt: %v", i, err)
}
sim.Commit()
prop, err = oracle.ProposedVersion(nil)
if err != nil {
t.Fatalf("Failed to retrieve active proposal: %v", err)
}
if len(prop.Pass) != 0 {
t.Fatalf("Proposal vote count mismatch: have %d, want 0", len(prop.Pass))
}
}
55:F:\git\coin\ethereum\go-ethereum\contracts\release\release.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package release contains the node service that tracks client releases.
package release
//go:generate abigen --sol ./contract.sol --pkg release --out ./contract.go
import (
"context"
"fmt"
"strings"
"time"
"github.com/ethereum/go-ethereum/accounts/abi/bind"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/eth"
"github.com/ethereum/go-ethereum/internal/ethapi"
"github.com/ethereum/go-ethereum/les"
"github.com/ethereum/go-ethereum/log"
```

```
"github.com/ethereum/go-ethereum/node"
"github.com/ethereum/go-ethereum/p2p"
"github.com/ethereum/go-ethereum/rpc"
)
// Interval to check for new releases
const releaseRecheckInterval = time.Hour
// Config contains the configurations of the release service.
type Config struct {
Oracle common. Address // Ethereum address of the release oracle
Major uint32
                  // Major version component of the release
Minor uint32
                  // Minor version component of the release
Patch uint32 // Patch version component of the release
Commit [20]byte
                   // Git SHA1 commit hash of the release
}
// ReleaseService is a node service that periodically checks the blockchain for
// newly released versions of the client being run and issues a warning to the
// user about it.
type ReleaseService struct {
config Config
                   // Current version to check releases against
oracle *ReleaseOracle // Native binding to the release oracle contract
quit chan chan error // Quit channel to terminate the version checker
}
// NewReleaseService creates a new service to periodically check for new client
// releases and notify the user of such.
func NewReleaseService(ctx *node.ServiceContext, config Config) (node.Service, error) {
// Retrieve the Ethereum service dependency to access the blockchain
var apiBackend ethapi.Backend
var ethereum *eth.Ethereum
if err := ctx.Service(&ethereum); err == nil {
apiBackend = ethereum.ApiBackend
} else {
var ethereum *les.LightEthereum
if err := ctx.Service(&ethereum); err == nil {
apiBackend = ethereum.ApiBackend
} else {
return nil, err
}
}
```

```
// Construct the release service
contract, err := NewReleaseOracle(config.Oracle, eth.NewContractBackend(apiBackend))
if err != nil {
return nil, err
}
return &ReleaseService{
config: config,
oracle: contract,
quit: make(chan chan error),
}, nil
}
// Protocols returns an empty list of P2P protocols as the release service does
// not have a networking component.
func (r *ReleaseService) Protocols() []p2p.Protocol { return nil }
// APIs returns an empty list of RPC descriptors as the release service does not
// expose any functioanlity to the outside world.
func (r *ReleaseService) APIs() []rpc.API { return nil }
// Start spawns the periodic version checker goroutine
func (r *ReleaseService) Start(server *p2p.Server) error {
go r.checker()
return nil
// Stop terminates all goroutines belonging to the service, blocking until they
// are all terminated.
func (r *ReleaseService) Stop() error {
errc := make(chan error)
r.quit <- errc
return <-errc
}
// checker runs indefinitely in the background, periodically checking for new
// client releases.
func (r *ReleaseService) checker() {
// Set up the timers to periodically check for releases
timer := time.NewTimer(0) // Immediately fire a version check
defer timer.Stop()
for {
```

```
select {
case <-timer.C:
// Rechedule the timer before continuing
timer.Reset(releaseRecheckInterval)
r.checkVersion()
case errc := <-r.quit:
errc <- nil
return
}
}
func (r *ReleaseService) checkVersion() {
// Retrieve the current version, and handle missing contracts gracefully
ctx, cancel := context.WithTimeout(context.Background(), time.Second*5)
opts := &bind.CallOpts{Context: ctx}
defer cancel()
version, err := r.oracle.CurrentVersion(opts)
if err != nil {
if err == bind.ErrNoCode {
log.Debug("Release oracle not found", "contract", r.config.Oracle)
} else {
log.Error("Failed to retrieve current release", "err", err)
return
// Version was successfully retrieved, notify if newer than ours
if version.Major > r.config.Major ||
(version.Major == r.config.Major && version.Minor > r.config.Minor) ||
(version.Major == r.config.Major && version.Minor == r.config.Minor && version.Patch >
r.config.Patch) {
warning := fmt.Sprintf("Client v%d.%d.%d-%x seems older than the latest upstream release
v%d.%d.%d-%x",
r.config.Major, r.config.Minor, r.config.Patch, r.config.Commit[:4], version.Major, version.Minor,
version.Patch, version.Commit[:4])
howtofix := fmt.Sprintf("Please check https://github.com/ethereum/go-ethereum/releases for new
releases")
separator := strings.Repeat("-", len(warning))
log.Warn(separator)
```

```
log.Warn(warning)
log.Warn(howtofix)
log.Warn(separator)
} else {
log.Debug("Client seems up to date with upstream",
"local", fmt.Sprintf("v%d.%d.%d-%x", r.config.Major, r.config.Minor, r.config.Patch,
r.config.Commit[:4]),
"upstream", fmt.Sprintf("v%d.%d.%d-%x", version.Major, version.Minor, version.Patch,
version.Commit[:4]))
}
}
56:F:\git\coin\ethereum\go-ethereum\core\asm\asm.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Provides support for dealing with EVM assembly instructions (e.g., disassembling them).
package asm
import (
"encoding/hex"
"fmt"
"github.com/ethereum/go-ethereum/core/vm"
)
// Iterator for disassembled EVM instructions
type instructionIterator struct {
code []byte
      uint64
рс
      []byte
arg
      vm.OpCode
op
error error
started bool
}
// Create a new instruction iterator.
func NewInstructionIterator(code []byte) *instructionIterator {
it := new(instructionIterator)
it.code = code
return it
}
```

```
// Returns true if there is a next instruction and moves on.
func (it *instructionIterator) Next() bool {
if it.error != nil || uint64(len(it.code)) <= it.pc {
// We previously reached an error or the end.
return false
if it.started {
// Since the iteration has been already started we move to the next instruction.
if it.arg != nil {
it.pc += uint64(len(it.arg))
}
it.pc++
} else {
// We start the iteration from the first instruction.
it.started = true
}
if uint64(len(it.code)) <= it.pc {
// We reached the end.
return false
}
it.op = vm.OpCode(it.code[it.pc])
if it.op.IsPush() {
a := uint64(it.op) - uint64(vm.PUSH1) + 1
u := it.pc + 1 + a
if uint64(len(it.code)) <= it.pc || uint64(len(it.code)) < u {
it.error = fmt.Errorf("incomplete push instruction at %v", it.pc)
return false
it.arg = it.code[it.pc+1 : u]
} else {
it.arg = nil
return true
}
// Returns any error that may have been encountered.
func (it *instructionIterator) Error() error {
return it.error
}
```

```
// Returns the PC of the current instruction.
func (it *instructionIterator) PC() uint64 {
return it.pc
}
// Returns the opcode of the current instruction.
func (it *instructionIterator) Op() vm.OpCode {
return it.op
}
// Returns the argument of the current instruction.
func (it *instructionIterator) Arg() []byte {
return it.arg
}
// Pretty-print all disassembled EVM instructions to stdout.
func PrintDisassembled(code string) error {
script, err := hex.DecodeString(code)
if err != nil {
return err
}
it := NewInstructionIterator(script)
for it.Next() {
if it.Arg() != nil && 0 < len(it.Arg()) {
fmt.Printf("%06v: %v 0x%x\n", it.PC(), it.Op(), it.Arg())
} else {
fmt.Printf("%06v: %v\n", it.PC(), it.Op())
if err := it.Error(); err != nil {
return err
return nil
}
// Return all disassembled EVM instructions in human-readable format.
func Disassemble(script []byte) ([]string, error) {
instrs := make([]string, 0)
it := NewInstructionIterator(script)
```

```
for it.Next() {
if it.Arg() != nil && 0 < len(it.Arg()) {
instrs = append(instrs, fmt.Sprintf("%06v: %v 0x%x\n", it.PC(), it.Op(), it.Arg()))
} else {
instrs = append(instrs, fmt.Sprintf("%06v: %v\n", it.PC(), it.Op()))
}
}
if err := it.Error(); err != nil {
return nil, err
}
return instrs, nil
}
57:F:\git\coin\ethereum\go-ethereum\core\asm\asm_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package asm
import (
"testing"
"encoding/hex"
)
// Tests disassembling the instructions for valid evm code
func TestInstructionIteratorValid(t *testing.T) {
cnt := 0
script, _ := hex.DecodeString("61000000")
it := NewInstructionIterator(script)
for it.Next() {
cnt++
}
if err := it.Error(); err != nil {
t.Errorf("Expected 2, but encountered error %v instead.", err)
}
if cnt != 2 {
t.Errorf("Expected 2, but got %v instead.", cnt)
}
}
```

```
// Tests disassembling the instructions for invalid evm code
func TestInstructionIteratorInvalid(t *testing.T) {
cnt := 0
script, _ := hex.DecodeString("6100")
it := NewInstructionIterator(script)
for it.Next() {
cnt++
}
if it.Error() == nil {
t.Errorf("Expected an error, but got %v instead.", cnt)
}
}
// Tests disassembling the instructions for empty evm code
func TestInstructionIteratorEmpty(t *testing.T) {
cnt := 0
script, _ := hex.DecodeString("")
it := NewInstructionIterator(script)
for it.Next() {
cnt++
}
if err := it.Error(); err != nil {
t.Errorf("Expected 0, but encountered error %v instead.", err)
}
if cnt != 0 {
t.Errorf("Expected 0, but got %v instead.", cnt)
}
}
58:F:\git\coin\ethereum\go-ethereum\core\asm\compiler.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package asm
import (
"errors"
"fmt"
"math/big"
```

```
"os"
"strings"
"github.com/ethereum/go-ethereum/common/math"
"github.com/ethereum/go-ethereum/core/vm"
)
// Compiler contains information about the parsed source
// and holds the tokens for the program.
type Compiler struct {
tokens []token
binary []interface{}
labels map[string]int
pc, pos int
debug bool
}
// newCompiler returns a new allocated compiler.
func NewCompiler(debug bool) *Compiler {
return &Compiler{
labels: make(map[string]int),
debug: debug,
}
}
// Feed feeds tokens in to ch and are interpreted by
// the compiler.
//
// feed is the first pass in the compile stage as it
// collect the used labels in the program and keeps a
// program counter which is used to determine the locations
// of the jump dests. The labels can than be used in the
// second stage to push labels and determine the right
// position.
func (c *Compiler) Feed(ch <-chan token) {
for i := range ch {
switch i.typ {
case number:
num := math.MustParseBig256(i.text).Bytes()
```

```
if len(num) == 0 {
num = []byte{0}
}
c.pc += len(num)
case stringValue:
c.pc += len(i.text) - 2
case element:
c.pc++
case labelDef:
c.labels[i.text] = c.pc
c.pc++
case label:
c.pc += 5
}
c.tokens = append(c.tokens, i)
}
if c.debug {
fmt.Fprintln(os.Stderr, "found", len(c.labels), "labels")
}
// Compile compiles the current tokens and returns a
// binary string that can be interpreted by the EVM
// and an error if it failed.
//
// compile is the second stage in the compile phase
// which compiles the tokens to EVM instructions.
func (c *Compiler) Compile() (string, []error) {
var errors []error
// continue looping over the tokens until
// the stack has been exhausted.
for c.pos < len(c.tokens) {
if err := c.compileLine(); err != nil {
errors = append(errors, err)
}
}
// turn the binary to hex
var bin string
for _, v := range c.binary {
switch v := v.(type) {
```

```
case vm.OpCode:
bin += fmt.Sprintf("%x", []byte{byte(v)})
case []byte:
bin += fmt.Sprintf("%x", v)
}
return bin, errors
}
// next returns the next token and increments the
// posititon.
func (c *Compiler) next() token {
token := c.tokens[c.pos]
c.pos++
return token
}
// compile line compiles a single line instruction e.g.
// "push 1", "jump @labal".
func (c *Compiler) compileLine() error {
n := c.next()
if n.typ != lineStart {
return compileErr(n, n.typ.String(), lineStart.String())
}
lvalue := c.next()
switch Ivalue.typ {
case eof:
return nil
case element:
if err := c.compileElement(Ivalue); err != nil {
return err
}
case labelDef:
c.compileLabel()
case lineEnd:
return nil
default:
return compileErr(Ivalue, Ivalue.text, fmt.Sprintf("%v or %v", labelDef, element))
}
if n := c.next(); n.typ != lineEnd {
```

```
return compileErr(n, n.text, lineEnd.String())
}
return nil
}
// compileNumber compiles the number to bytes
func (c *Compiler) compileNumber(element token) (int, error) {
num := math.MustParseBig256(element.text).Bytes()
if len(num) == 0 {
num = []byte{0}
}
c.pushBin(num)
return len(num), nil
}
// compileElement compiles the element (push & label or both)
// to a binary representation and may error if incorrect statements
// where fed.
func (c *Compiler) compileElement(element token) error {
// check for a jump. jumps must be read and compiled
// from right to left.
if isJump(element.text) {
rvalue := c.next()
switch rvalue.typ {
case number:
// TODO figure out how to return the error properly
c.compileNumber(rvalue)
case stringValue:
// strings are quoted, remove them.
c.pushBin(rvalue.text[1 : len(rvalue.text)-2])
case label:
c.pushBin(vm.PUSH4)
pos := big.NewInt(int64(c.labels[rvalue.text])).Bytes()
pos = append(make([]byte, 4-len(pos)), pos...)
c.pushBin(pos)
default:
return compileErr(rvalue, rvalue.text, "number, string or label")
// push the operation
c.pushBin(toBinary(element.text))
return nil
```

```
} else if isPush(element.text) {
// handle pushes. pushes are read from left to right.
var value []byte
rvalue := c.next()
switch rvalue.typ {
case number:
value = math.MustParseBig256(rvalue.text).Bytes()
if len(value) == 0 {
value = []byte{0}
}
case stringValue:
value = []byte(rvalue.text[1 : len(rvalue.text)-1])
case label:
value = make([]byte, 4)
copy(value, big.NewInt(int64(c.labels[rvalue.text])).Bytes())
default:
return compileErr(rvalue, rvalue.text, "number, string or label")
}
if len(value) > 32 {
return fmt.Errorf("%d type error: unsupported string or number with size > 32", rvalue.lineno)
}
c.pushBin(vm.OpCode(int(vm.PUSH1) - 1 + len(value)))
c.pushBin(value)
} else {
c.pushBin(toBinary(element.text))
}
return nil
}
// compileLabel pushes a jumpdest to the binary slice.
func (c *Compiler) compileLabel() {
c.pushBin(vm.JUMPDEST)
}
// pushBin pushes the value v to the binary stack.
func (c *Compiler) pushBin(v interface{}) {
if c.debug {
fmt.Printf("%d: %v\n", len(c.binary), v)
```

```
}
c.binary = append(c.binary, v)
}
// isPush returns whether the string op is either any of
// push(N).
func isPush(op string) bool {
if op == "push" {
return true
}
return false
}
// isJump returns whether the string op is jump(i)
func isJump(op string) bool {
return op == "jumpi" || op == "jump"
}
// toBinary converts text to a vm.OpCode
func toBinary(text string) vm.OpCode {
if isPush(text) {
text = "push1"
}
return vm.StringToOp(strings.ToUpper(text))
}
type compileError struct {
got string
want string
lineno int
}
func (err compileError) Error() string {
return fmt.Sprintf("%d syntax error: unexpected %v, expected %v", err.lineno, err.got, err.want)
}
var (
errExpBol
                  = errors.New("expected beginning of line")
errExpElementOrLabel = errors.New("expected beginning of line")
)
```

```
func compileErr(c token, got, want string) error {
return compileError{
got: got,
want: want,
lineno: c.lineno,
}
59:F:\git\coin\ethereum\go-ethereum\core\asm\lexer.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package asm
import (
"fmt"
"os"
"strings"
"unicode"
"unicode/utf8"
)
// stateFn is used through the lifetime of the
// lexer to parse the different values at the
// current state.
type stateFn func(*lexer) stateFn
// token is emitted when the lexer has discovered
// a new parsable token. These are delivered over
// the tokens channels of the lexer
type token struct {
typ tokenType
lineno int
text string
// tokenType are the different types the lexer
// is able to parse and return.
type tokenType int
const (
eof
             tokenType = iota // end of file
lineStart
                          // emitted when a line starts
```

```
lineEnd
                        // emitted when a line ends
invalidStatement
                            // any invalid statement
element
                         // any element during element parsing
label
                       // label is emitted when a labal is found
labelDef
                        // label definition is emitted when a new label is found
number
                         // number is emitted when a number is found
stringValue
                         // stringValue is emitted when a string has been found
Numbers
                = "1234567890"
                                                            // characters representing any decimal
number
HexadecimalNumbers = Numbers + "aAbBcCdDeEfF"
                                                                          // characters
representing any hexadecimal
Alpha
              = "abcdefghijklmnopqrstuwvxyzABCDEFGHIJKLMNOPQRSTUWVXYZ" //
characters representing alphanumeric
)
// String implements stringer
func (it tokenType) String() string {
if int(it) > len(stringtokenTypes) {
return "invalid"
return stringtokenTypes[it]
}
var stringtokenTypes = []string{
            "EOF",
eof:
invalidStatement: "invalid statement",
element:
               "element".
lineEnd:
              "end of line".
             "new line".
lineStart:
            "label",
label:
labelDef:
              "label definition",
number:
               "number",
stringValue:
               "string",
}
// lexer is the basic construct for parsing
// source code and turning them in to tokens.
// Tokens are interpreted by the compiler.
type lexer struct {
input string // input contains the source code of the program
```

```
state stateFn // the current state function
lineno
              int // current line number in the source file
start, pos, width int // positions for lexing and returning value
debug bool // flag for triggering debug output
}
// lex lexes the program by name with the given source. It returns a
// channel on which the tokens are delivered.
func Lex(name string, source []byte, debug bool) <-chan token {
ch := make(chan token)
I := &lexer{
input: string(source),
tokens: ch,
state: lexLine,
debug: debug,
go func() {
I.emit(lineStart)
for I.state != nil {
l.state = l.state(l)
I.emit(eof)
close(l.tokens)
}()
return ch
// next returns the next rune in the program's source.
func (I *lexer) next() (rune rune) {
if I.pos >= len(I.input) {
I.width = 0
return 0
}
rune, I.width = utf8.DecodeRuneInString(I.input[I.pos:])
l.pos += l.width
return rune
}
```

tokens chan token // tokens is used to deliver tokens to the listener

```
// backup backsup the last parsed element (multi-character)
func (I *lexer) backup() {
I.pos -= I.width
}
// peek returns the next rune but does not advance the seeker
func (I *lexer) peek() rune {
r := l.next()
I.backup()
return r
}
// ignore advances the seeker and ignores the value
func (I *lexer) ignore() {
I.start = I.pos
}
// Accepts checks whether the given input matches the next rune
func (I *lexer) accept(valid string) bool {
if strings.IndexRune(valid, I.next()) >= 0 {
return true
}
I.backup()
return false
}
// acceptRun will continue to advance the seeker until valid
// can no longer be met.
func (I *lexer) acceptRun(valid string) {
for strings.IndexRune(valid, I.next()) >= 0 {
}
I.backup()
}
// acceptRunUntil is the inverse of acceptRun and will continue
// to advance the seeker until the rune has been found.
func (I *lexer) acceptRunUntil(until rune) bool {
// Continues running until a rune is found
for i := l.next(); strings.IndexRune(string(until), i) == -1; i = l.next() {
if i == 0 {
```

```
return false
}
}
return true
// blob returns the current value
func (I *lexer) blob() string {
return l.input[l.start:l.pos]
}
// Emits a new token on to token channel for processing
func (I *lexer) emit(t tokenType) {
token := token{t, l.lineno, l.blob()}
if I.debug {
fmt.Fprintf(os.Stderr, "%04d: (%-20v) %s\n", token.lineno, token.typ, token.text)
}
I.tokens <- token
I.start = I.pos
}
// lexLine is state function for lexing lines
func lexLine(I *lexer) stateFn {
for {
switch r := l.next(); {
case r == '\n':
l.emit(lineEnd)
l.ignore()
I.lineno++
l.emit(lineStart)
case r == ';' && I.peek() == ';':
return lexComment
case isSpace(r):
l.ignore()
case isAlphaNumeric(r) || r == '_':
return lexElement
case isNumber(r):
return lexNumber
```

```
case r == '@':
l.ignore()
return lexLabel
case r == "":
return lexInsideString
default:
return nil
}
}
}
// lexComment parses the current position until the end
// of the line and discards the text.
func lexComment(I *lexer) stateFn {
I.acceptRunUntil('\n')
l.ignore()
return lexLine
}
// lexLabel parses the current label, emits and returns
// the lex text state function to advance the parsing
// process.
func lexLabel(I *lexer) stateFn {
I.acceptRun(Alpha + "_")
I.emit(label)
return lexLine
}
// lexInsideString lexes the inside of a string until
// until the state function finds the closing quote.
// It returns the lex text state function.
func lexInsideString(I *lexer) stateFn {
if I.acceptRunUntil("") {
l.emit(stringValue)
}
return lexLine
}
```

```
func lexNumber(I *lexer) stateFn {
acceptance := Numbers
if I.accept("0") && I.accept("xX") {
acceptance = HexadecimalNumbers
}
I.acceptRun(acceptance)
I.emit(number)
return lexLine
}
func lexElement(I *lexer) stateFn {
I.acceptRun(Alpha + "_" + Numbers)
if l.peek() == ':' {
l.emit(labelDef)
l.accept(":")
l.ignore()
} else {
I.emit(element)
return lexLine
func isAlphaNumeric(t rune) bool {
return unicode.lsLetter(t)
}
func isSpace(t rune) bool {
return unicode.IsSpace(t)
}
func isNumber(t rune) bool {
return unicode.IsNumber(t)
}
60:F:\git\coin\ethereum\go-ethereum\core\asm\lex_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package asm
```

```
import "testing"
func lexAll(src string) []token {
ch := Lex("test.asm", []byte(src), false)
var tokens []token
for i := range ch {
tokens = append(tokens, i)
}
return tokens
}
func TestComment(t *testing.T) {
tokens := lexAll(";; this is a comment")
if len(tokens) != 2 { // {new line, EOF}}
t.Error("expected no tokens")
}
}
61:F:\git\coin\ethereum\go-ethereum\core\bench_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"crypto/ecdsa"
"io/ioutil"
"math/big"
"os"
"testing"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/math"
"github.com/ethereum/go-ethereum/consensus/ethash"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/params"
)
```

```
func BenchmarkInsertChain_empty_memdb(b *testing.B) {
benchlnsertChain(b, false, nil)
func BenchmarkInsertChain_empty_diskdb(b *testing.B) {
benchInsertChain(b, true, nil)
func BenchmarkInsertChain_valueTx_memdb(b *testing.B) {
benchInsertChain(b, false, genValueTx(0))
}
func BenchmarkInsertChain_valueTx_diskdb(b *testing.B) {
benchInsertChain(b, true, genValueTx(0))
}
func BenchmarkInsertChain_valueTx_100kB_memdb(b *testing.B) {
benchInsertChain(b, false, genValueTx(100*1024))
func BenchmarkInsertChain_valueTx_100kB_diskdb(b *testing.B) {
benchlnsertChain(b, true, genValueTx(100*1024))
func BenchmarkInsertChain_uncles_memdb(b *testing.B) {
benchInsertChain(b, false, genUncles)
}
func BenchmarkInsertChain_uncles_diskdb(b *testing.B) {
benchlnsertChain(b, true, genUncles)
}
func BenchmarkInsertChain_ring200_memdb(b *testing.B) {
benchInsertChain(b, false, genTxRing(200))
}
func BenchmarkInsertChain_ring200_diskdb(b *testing.B) {
benchInsertChain(b, true, genTxRing(200))
func BenchmarkInsertChain ring1000 memdb(b *testing.B) {
benchlnsertChain(b, false, genTxRing(1000))
func BenchmarkInsertChain_ring1000_diskdb(b *testing.B) {
benchInsertChain(b, true, genTxRing(1000))
}
var (
// This is the content of the genesis block used by the benchmarks.
benchRootKey, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
```

```
291")
benchRootAddr = crypto.PubkeyToAddress(benchRootKey.PublicKey)
benchRootFunds = math.BigPow(2, 100)
)
// genValueTx returns a block generator that includes a single
// value-transfer transaction with n bytes of extra data in each
// block.
func genValueTx(nbytes int) func(int, *BlockGen) {
return func(i int, gen *BlockGen) {
toaddr := common.Address{}
data := make([]byte, nbytes)
gas := IntrinsicGas(data, false, false)
tx, _ := types.SignTx(types.NewTransaction(gen.TxNonce(benchRootAddr), toaddr, big.NewInt(1),
gas, nil, data), types.HomesteadSigner{}, benchRootKey)
gen.AddTx(tx)
}
}
var (
ringKeys = make([]*ecdsa.PrivateKey, 1000)
ringAddrs = make([]common.Address, len(ringKeys))
bigTxGas = new(big.Int).SetUint64(params.TxGas)
)
func init() {
ringKeys[0] = benchRootKey
ringAddrs[0] = benchRootAddr
for i := 1; i < len(ringKeys); i++ {
ringKeys[i], _ = crypto.GenerateKey()
ringAddrs[i] = crypto.PubkeyToAddress(ringKeys[i].PublicKey)
}
}
// genTxRing returns a block generator that sends ether in a ring
// among n accounts. This is creates n entries in the state database
// and fills the blocks with many small transactions.
func genTxRing(naccounts int) func(int, *BlockGen) {
from := 0
return func(i int, gen *BlockGen) {
gas := CalcGasLimit(gen.PrevBlock(i - 1))
for {
```

```
gas.Sub(gas, bigTxGas)
if gas.Cmp(bigTxGas) < 0 {
break
to := (from + 1) % naccounts
tx := types.NewTransaction(
gen.TxNonce(ringAddrs[from]),
ringAddrs[to],
benchRootFunds,
bigTxGas,
nil,
nil,
)
tx, _ = types.SignTx(tx, types.HomesteadSigner{}, ringKeys[from])
gen.AddTx(tx)
from = to
}
}
}
// genUncles generates blocks with two uncle headers.
func genUncles(i int, gen *BlockGen) {
if i >= 6 {
b2 := gen.PrevBlock(i - 6).Header()
b2.Extra = []byte("foo")
gen.AddUncle(b2)
b3 := gen.PrevBlock(i - 6).Header()
b3.Extra = []byte("bar")
gen.AddUncle(b3)
}
}
func benchInsertChain(b *testing.B, disk bool, gen func(int, *BlockGen)) {
// Create the database in memory or in a temporary directory.
var db ethdb.Database
if !disk {
db, _ = ethdb.NewMemDatabase()
} else {
dir, \, err := ioutil.TempDir("", \, "eth-core-bench")
if err != nil {
b.Fatalf("cannot create temporary directory: %v", err)
}
```

```
defer os.RemoveAll(dir)
db, err = ethdb.NewLDBDatabase(dir, 128, 128)
if err != nil {
b.Fatalf("cannot create temporary database: %v", err)
}
defer db.Close()
}
// Generate a chain of b.N blocks using the supplied block
// generator function.
gspec := Genesis{
Config: params.TestChainConfig,
Alloc: GenesisAlloc{benchRootAddr: {Balance: benchRootFunds}},
genesis := gspec.MustCommit(db)
chain, _ := GenerateChain(gspec.Config, genesis, db, b.N, gen)
// Time the insertion of the new chain.
// State and blocks are stored in the same DB.
evmux := new(event.TypeMux)
chainman, _ := NewBlockChain(db, gspec.Config, ethash.NewFaker(), evmux, vm.Config{})
defer chainman.Stop()
b.ReportAllocs()
b.ResetTimer()
if i, err := chainman.InsertChain(chain); err != nil {
b.Fatalf("insert error (block %d): %v\n", i, err)
}
}
func BenchmarkChainRead_header_10k(b *testing.B) {
benchReadChain(b, false, 10000)
}
func BenchmarkChainRead_full_10k(b *testing.B) {
benchReadChain(b, true, 10000)
func BenchmarkChainRead_header_100k(b *testing.B) {
benchReadChain(b, false, 100000)
}
func BenchmarkChainRead_full_100k(b *testing.B) {
benchReadChain(b, true, 100000)
}
func BenchmarkChainRead_header_500k(b *testing.B) {
```

```
benchReadChain(b, false, 500000)
}
func BenchmarkChainRead_full_500k(b *testing.B) {
benchReadChain(b, true, 500000)
}
func BenchmarkChainWrite_header_10k(b *testing.B) {
benchWriteChain(b, false, 10000)
}
func BenchmarkChainWrite_full_10k(b *testing.B) {
benchWriteChain(b, true, 10000)
func BenchmarkChainWrite_header_100k(b *testing.B) {
benchWriteChain(b, false, 100000)
func BenchmarkChainWrite_full_100k(b *testing.B) {
benchWriteChain(b, true, 100000)
}
func BenchmarkChainWrite header 500k(b *testing.B) {
benchWriteChain(b, false, 500000)
}
func BenchmarkChainWrite_full_500k(b *testing.B) {
benchWriteChain(b, true, 500000)
}
// makeChainForBench writes a given number of headers or empty blocks/receipts
// into a database.
func makeChainForBench(db ethdb.Database, full bool, count uint64) {
var hash common.Hash
for n := uint64(0); n < count; n++ {
header := &types.Header{
Coinbase: common.Address{},
Number:
           big.NewInt(int64(n)),
ParentHash: hash,
Difficulty: big.NewInt(1),
UncleHash: types.EmptyUncleHash,
TxHash:
           types.EmptyRootHash,
ReceiptHash: types.EmptyRootHash,
}
hash = header.Hash()
WriteHeader(db, header)
WriteCanonicalHash(db, hash, n)
WriteTd(db, hash, n, big.NewInt(int64(n+1)))
```

```
if full || n == 0 
block := types.NewBlockWithHeader(header)
WriteBody(db, hash, n, block.Body())
WriteBlockReceipts(db, hash, n, nil)
}
}
}
func benchWriteChain(b *testing.B, full bool, count uint64) {
for i := 0; i < b.N; i++ \{
dir, err := ioutil.TempDir("", "eth-chain-bench")
if err != nil {
b.Fatalf("cannot create temporary directory: %v", err)
db, err := ethdb.NewLDBDatabase(dir, 128, 1024)
if err != nil {
b.Fatalf("error opening database at %v: %v", dir, err)
}
makeChainForBench(db, full, count)
db.Close()
os.RemoveAll(dir)
}
}
func benchReadChain(b *testing.B, full bool, count uint64) {
dir, err := ioutil.TempDir("", "eth-chain-bench")
if err != nil {
b.Fatalf("cannot create temporary directory: %v", err)
defer os.RemoveAll(dir)
db, err := ethdb.NewLDBDatabase(dir, 128, 1024)
if err != nil {
b.Fatalf("error opening database at %v: %v", dir, err)
makeChainForBench(db, full, count)
db.Close()
b.ReportAllocs()
b.ResetTimer()
for i := 0; i < b.N; i++ \{
```

```
db, err := ethdb.NewLDBDatabase(dir, 128, 1024)
if err != nil {
b.Fatalf("error opening database at %v: %v", dir, err)
chain, err := NewBlockChain(db, params.TestChainConfig, ethash.NewFaker(),
new(event.TypeMux), vm.Config{})
if err != nil {
b.Fatalf("error creating chain: %v", err)
}
for n := uint64(0); n < count; n++ \{
header := chain.GetHeaderByNumber(n)
if full {
hash := header.Hash()
GetBody(db, hash, n)
GetBlockReceipts(db, hash, n)
}
}
db.Close()
}
}
62:F:\git\coin\ethereum\go-ethereum\core\blockchain.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package core implements the Ethereum consensus protocol.
package core
import (
"errors"
"fmt"
"io"
"math/big"
mrand "math/rand"
"runtime"
"sync"
"sync/atomic"
"time"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/mclock"
```

```
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/metrics"
"github.com/ethereum/go-ethereum/params"
"github.com/ethereum/go-ethereum/rlp"
"github.com/ethereum/go-ethereum/trie"
"github.com/hashicorp/golang-lru"
)
var (
blockInsertTimer = metrics.NewTimer("chain/inserts")
ErrNoGenesis = errors.New("Genesis not found in chain")
)
const (
bodyCacheLimit
                   = 256
blockCacheLimit
                   = 256
maxFutureBlocks = 256
maxTimeFutureBlocks = 30
badBlockLimit
                  = 10
// BlockChainVersion ensures that an incompatible database forces a resync from scratch.
BlockChainVersion = 3
)
// BlockChain represents the canonical chain given a database with a genesis
// block. The Blockchain manages chain imports, reverts, chain reorganisations.
//
// Importing blocks in to the block chain happens according to the set of rules
// defined by the two stage Validator. Processing of blocks is done using the
// Processor which processes the included transaction. The validation of the state
// is done in the second part of the Validator. Failing results in aborting of
// the import.
//
// The BlockChain also helps in returning blocks from **any** chain included
```

```
// in the database as well as blocks that represents the canonical chain. It's
// important to note that GetBlock can return any block and does not need to be
// included in the canonical one where as GetBlockByNumber always represents the
// canonical chain.
type BlockChain struct {
config *params.ChainConfig // chain & network configuration
        *HeaderChain
hc
           ethdb.Database
chainDb
eventMux *event.TypeMux
genesisBlock *types.Block
mu
      sync.RWMutex // global mutex for locking chain operations
chainmu sync.RWMutex // blockchain insertion lock
procmu sync.RWMutex // block processor lock
checkpoint
              int
                       // checkpoint counts towards the new checkpoint
currentBlock
               *types.Block // Current head of the block chain
currentFastBlock *types.Block // Current head of the fast-sync chain (may be above the block
chain!)
stateCache state.Database // State database to reuse between imports (contains state cache)
bodyCache *Iru.Cache // Cache for the most recent block bodies
bodyRLPCache *Iru.Cache // Cache for the most recent block bodies in RLP encoded format
blockCache *Iru.Cache // Cache for the most recent entire blocks
futureBlocks *Iru.Cache // future blocks are blocks added for later processing
quit chan struct{} // blockchain quit channel
                 // running must be called atomically
running int32
// procInterrupt must be atomically called
procInterrupt int32
                       // interrupt signaler for block processing
          sync.WaitGroup // chain processing wait group for shutting down
wg
engine consensus. Engine
processor Processor // block processor interface
validator Validator // block and state validator interface
vmConfig vm.Config
badBlocks *Iru.Cache // Bad block cache
}
```

// NewBlockChain returns a fully initialised block chain using information

```
// available in the database. It initialises the default Ethereum Validator and
// Processor.
func NewBlockChain(chainDb ethdb.Database, config *params.ChainConfig, engine
consensus. Engine, mux *event. TypeMux, vmConfig vm. Config) (*BlockChain, error) {
bodyCache, _ := Iru.New(bodyCacheLimit)
bodyRLPCache, _ := Iru.New(bodyCacheLimit)
blockCache, _ := Iru.New(blockCacheLimit)
futureBlocks, _ := Iru.New(maxFutureBlocks)
badBlocks, _ := Iru.New(badBlockLimit)
bc := &BlockChain{
config:
          config,
chainDb:
           chainDb,
stateCache: state.NewDatabase(chainDb),
eventMux:
            mux.
         make(chan struct{}),
quit:
bodyCache: bodyCache,
bodyRLPCache: bodyRLPCache,
blockCache: blockCache,
futureBlocks: futureBlocks.
engine:
          engine,
vmConfig: vmConfig,
badBlocks: badBlocks.
bc.SetValidator(NewBlockValidator(config, bc, engine))
bc.SetProcessor(NewStateProcessor(config, bc, engine))
var err error
bc.hc, err = NewHeaderChain(chainDb, config, engine, bc.getProcInterrupt)
if err != nil {
return nil. err
}
bc.genesisBlock = bc.GetBlockByNumber(0)
if bc.genesisBlock == nil {
return nil, ErrNoGenesis
}
if err := bc.loadLastState(); err != nil {
return nil, err
// Check the current state of the block hashes and make sure that we do not have any of the bad
blocks in our chain
for hash := range BadHashes {
```

```
if header := bc.GetHeaderByHash(hash); header != nil {
// get the canonical block corresponding to the offending header's number
headerByNumber := bc.GetHeaderByNumber(header.Number.Uint64())
// make sure the headerByNumber (if present) is in our current canonical chain
if headerByNumber != nil && headerByNumber.Hash() == header.Hash() {
log.Error("Found bad hash, rewinding chain", "number", header.Number, "hash",
header.ParentHash)
bc.SetHead(header.Number.Uint64() - 1)
log.Error("Chain rewind was successful, resuming normal operation")
}
}
// Take ownership of this particular state
go bc.update()
return bc, nil
}
func (bc *BlockChain) getProcInterrupt() bool {
return atomic.LoadInt32(&bc.procInterrupt) == 1
}
// loadLastState loads the last known chain state from the database. This method
// assumes that the chain manager mutex is held.
func (bc *BlockChain) loadLastState() error {
// Restore the last known head block
head := GetHeadBlockHash(bc.chainDb)
if head == (common.Hash{}) {
// Corrupt or empty database, init from scratch
log.Warn("Empty database, resetting chain")
return bc.Reset()
}
// Make sure the entire head block is available
currentBlock := bc.GetBlockByHash(head)
if currentBlock == nil {
// Corrupt or empty database, init from scratch
log.Warn("Head block missing, resetting chain", "hash", head)
return bc.Reset()
}
// Make sure the state associated with the block is available
if _, err := state.New(currentBlock.Root(), bc.stateCache); err != nil {
// Dangling block without a state associated, init from scratch
log.Warn("Head state missing, resetting chain", "number", currentBlock.Number(), "hash",
```

```
currentBlock.Hash())
return bc.Reset()
}
// Everything seems to be fine, set as the head block
bc.currentBlock = currentBlock
// Restore the last known head header
currentHeader := bc.currentBlock.Header()
if head := GetHeadHeaderHash(bc.chainDb); head != (common.Hash{}) {
if header := bc.GetHeaderByHash(head); header != nil {
currentHeader = header
}
}
bc.hc.SetCurrentHeader(currentHeader)
// Restore the last known head fast block
bc.currentFastBlock = bc.currentBlock
if head := GetHeadFastBlockHash(bc.chainDb); head != (common.Hash{}) {
if block := bc.GetBlockByHash(head); block != nil {
bc.currentFastBlock = block
}
// Issue a status log for the user
headerTd := bc.GetTd(currentHeader.Hash(), currentHeader.Number.Uint64())
blockTd := bc.GetTd(bc.currentBlock.Hash(), bc.currentBlock.NumberU64())
fastTd := bc.GetTd(bc.currentFastBlock.Hash(), bc.currentFastBlock.NumberU64())
log.Info("Loaded most recent local header", "number", currentHeader.Number, "hash",
currentHeader.Hash(), "td", headerTd)
log.Info("Loaded most recent local full block", "number", bc.currentBlock.Number(), "hash",
bc.currentBlock.Hash(), "td", blockTd)
log.Info("Loaded most recent local fast block", "number", bc.currentFastBlock.Number(), "hash",
bc.currentFastBlock.Hash(), "td", fastTd)
return nil
}
// SetHead rewinds the local chain to a new head. In the case of headers, everything
// above the new head will be deleted and the new one set. In the case of blocks
// though, the head may be further rewound if block bodies are missing (non-archive
// nodes after a fast sync).
```

```
func (bc *BlockChain) SetHead(head uint64) error {
log.Warn("Rewinding blockchain", "target", head)
bc.mu.Lock()
defer bc.mu.Unlock()
// Rewind the header chain, deleting all block bodies until then
delFn := func(hash common.Hash, num uint64) {
DeleteBody(bc.chainDb, hash, num)
}
bc.hc.SetHead(head, delFn)
currentHeader := bc.hc.CurrentHeader()
// Clear out any stale content from the caches
bc.bodyCache.Purge()
bc.bodyRLPCache.Purge()
bc.blockCache.Purge()
bc.futureBlocks.Purge()
// Rewind the block chain, ensuring we don't end up with a stateless head block
if bc.currentBlock != nil && currentHeader.Number.Uint64() < bc.currentBlock.NumberU64() {
bc.currentBlock = bc.GetBlock(currentHeader.Hash(), currentHeader.Number.Uint64())
}
if bc.currentBlock != nil {
if _, err := state.New(bc.currentBlock.Root(), bc.stateCache); err != nil {
// Rewound state missing, rolled back to before pivot, reset to genesis
bc.currentBlock = nil
}
// Rewind the fast block in a simpleton way to the target head
if bc.currentFastBlock != nil && currentHeader.Number.Uint64() <
bc.currentFastBlock.NumberU64() {
bc.currentFastBlock = bc.GetBlock(currentHeader.Hash(), currentHeader.Number.Uint64())
// If either blocks reached nil, reset to the genesis state
if bc.currentBlock == nil {
bc.currentBlock = bc.genesisBlock
}
if bc.currentFastBlock == nil {
bc.currentFastBlock = bc.genesisBlock
if err := WriteHeadBlockHash(bc.chainDb, bc.currentBlock.Hash()); err != nil {
```

```
log.Crit("Failed to reset head full block", "err", err)
}
if err := WriteHeadFastBlockHash(bc.chainDb, bc.currentFastBlock.Hash()); err != nil {
log.Crit("Failed to reset head fast block", "err", err)
}
return bc.loadLastState()
}
// FastSyncCommitHead sets the current head block to the one defined by the hash
// irrelevant what the chain contents were prior.
func (bc *BlockChain) FastSyncCommitHead(hash common.Hash) error {
// Make sure that both the block as well at its state trie exists
block := bc.GetBlockByHash(hash)
if block == nil {
return fmt.Errorf("non existent block [%x...]", hash[:4])
}
if _, err := trie.NewSecure(block.Root(), bc.chainDb, 0); err != nil {
return err
// If all checks out, manually set the head block
bc.mu.Lock()
bc.currentBlock = block
bc.mu.Unlock()
log.Info("Committed new head block", "number", block.Number(), "hash", hash)
return nil
}
// GasLimit returns the gas limit of the current HEAD block.
func (bc *BlockChain) GasLimit() *big.Int {
bc.mu.RLock()
defer bc.mu.RUnlock()
return bc.currentBlock.GasLimit()
}
// LastBlockHash return the hash of the HEAD block.
func (bc *BlockChain) LastBlockHash() common.Hash {
bc.mu.RLock()
defer bc.mu.RUnlock()
return bc.currentBlock.Hash()
```

```
}
// CurrentBlock retrieves the current head block of the canonical chain. The
// block is retrieved from the blockchain's internal cache.
func (bc *BlockChain) CurrentBlock() *types.Block {
bc.mu.RLock()
defer bc.mu.RUnlock()
return bc.currentBlock
}
// CurrentFastBlock retrieves the current fast-sync head block of the canonical
// chain. The block is retrieved from the blockchain's internal cache.
func (bc *BlockChain) CurrentFastBlock() *types.Block {
bc.mu.RLock()
defer bc.mu.RUnlock()
return bc.currentFastBlock
}
// Status returns status information about the current chain such as the HEAD Td,
// the HEAD hash and the hash of the genesis block.
func (bc *BlockChain) Status() (td *big.Int, currentBlock common.Hash, genesisBlock
common.Hash) {
bc.mu.RLock()
defer bc.mu.RUnlock()
return bc.GetTd(bc.currentBlock.Hash(), bc.currentBlock.NumberU64()), bc.currentBlock.Hash(),
bc.genesisBlock.Hash()
}
// SetProcessor sets the processor required for making state modifications.
func (bc *BlockChain) SetProcessor(processor Processor) {
bc.procmu.Lock()
defer bc.procmu.Unlock()
bc.processor = processor
}
// SetValidator sets the validator which is used to validate incoming blocks.
func (bc *BlockChain) SetValidator(validator Validator) {
bc.procmu.Lock()
defer bc.procmu.Unlock()
```

```
bc.validator = validator
}
// Validator returns the current validator.
func (bc *BlockChain) Validator() Validator {
bc.procmu.RLock()
defer bc.procmu.RUnlock()
return bc.validator
// Processor returns the current processor.
func (bc *BlockChain) Processor() Processor {
bc.procmu.RLock()
defer bc.procmu.RUnlock()
return bc.processor
}
// State returns a new mutable state based on the current HEAD block.
func (bc *BlockChain) State() (*state.StateDB, error) {
return bc.StateAt(bc.CurrentBlock().Root())
}
// StateAt returns a new mutable state based on a particular point in time.
func (bc *BlockChain) StateAt(root common.Hash) (*state.StateDB, error) {
return state.New(root, bc.stateCache)
}
// Reset purges the entire blockchain, restoring it to its genesis state.
func (bc *BlockChain) Reset() error {
return bc.ResetWithGenesisBlock(bc.genesisBlock)
}
// ResetWithGenesisBlock purges the entire blockchain, restoring it to the
// specified genesis state.
func (bc *BlockChain) ResetWithGenesisBlock(genesis *types.Block) error {
// Dump the entire block chain and purge the caches
if err := bc.SetHead(0); err != nil {
return err
bc.mu.Lock()
defer bc.mu.Unlock()
```

```
// Prepare the genesis block and reinitialise the chain
if err := bc.hc.WriteTd(genesis.Hash(), genesis.NumberU64(), genesis.Difficulty()); err != nil {
log.Crit("Failed to write genesis block TD", "err", err)
if err := WriteBlock(bc.chainDb, genesis); err != nil {
log.Crit("Failed to write genesis block", "err", err)
}
bc.genesisBlock = genesis
bc.insert(bc.genesisBlock)
bc.currentBlock = bc.genesisBlock
bc.hc.SetGenesis(bc.genesisBlock.Header())
bc.hc.SetCurrentHeader(bc.genesisBlock.Header())
bc.currentFastBlock = bc.genesisBlock
return nil
}
// Export writes the active chain to the given writer.
func (bc *BlockChain) Export(w io.Writer) error {
return bc.ExportN(w, uint64(0), bc.currentBlock.NumberU64())
}
// ExportN writes a subset of the active chain to the given writer.
func (bc *BlockChain) ExportN(w io.Writer, first uint64, last uint64) error {
bc.mu.RLock()
defer bc.mu.RUnlock()
if first > last {
return fmt.Errorf("export failed: first (%d) is greater than last (%d)", first, last)
log.Info("Exporting batch of blocks", "count", last-first+1)
for nr := first; nr <= last; nr++ {
block := bc.GetBlockByNumber(nr)
if block == nil {
return fmt.Errorf("export failed on #%d: not found", nr)
}
if err := block.EncodeRLP(w); err != nil {
return err
}
}
```

```
return nil
}
// insert injects a new head block into the current block chain. This method
// assumes that the block is indeed a true head. It will also reset the head
// header and the head fast sync block to this very same block if they are older
// or if they are on a different side chain.
//
// Note, this function assumes that the `mu` mutex is held!
func (bc *BlockChain) insert(block *types.Block) {
// If the block is on a side chain or an unknown one, force other heads onto it too
updateHeads := GetCanonicalHash(bc.chainDb, block.NumberU64()) != block.Hash()
// Add the block to the canonical chain number scheme and mark as the head
if err := WriteCanonicalHash(bc.chainDb, block.Hash(), block.NumberU64()); err != nil {
log.Crit("Failed to insert block number", "err", err)
}
if err := WriteHeadBlockHash(bc.chainDb, block.Hash()); err != nil {
log.Crit("Failed to insert head block hash", "err", err)
bc.currentBlock = block
// If the block is better than out head or is on a different chain, force update heads
if updateHeads {
bc.hc.SetCurrentHeader(block.Header())
if err := WriteHeadFastBlockHash(bc.chainDb, block.Hash()); err != nil {
log.Crit("Failed to insert head fast block hash", "err", err)
bc.currentFastBlock = block
}
}
// Genesis retrieves the chain's genesis block.
func (bc *BlockChain) Genesis() *types.Block {
return bc.genesisBlock
}
// GetBody retrieves a block body (transactions and uncles) from the database by
// hash, caching it if found.
func (bc *BlockChain) GetBody(hash common.Hash) *types.Body {
```

```
// Short circuit if the body's already in the cache, retrieve otherwise
if cached, ok := bc.bodyCache.Get(hash); ok {
body := cached.(*types.Body)
return body
}
body := GetBody(bc.chainDb, hash, bc.hc.GetBlockNumber(hash))
if body == nil {
return nil
// Cache the found body for next time and return
bc.bodyCache.Add(hash, body)
return body
}
// GetBodyRLP retrieves a block body in RLP encoding from the database by hash,
// caching it if found.
func (bc *BlockChain) GetBodyRLP(hash common.Hash) rlp.RawValue {
// Short circuit if the body's already in the cache, retrieve otherwise
if cached, ok := bc.bodyRLPCache.Get(hash); ok {
return cached.(rlp.RawValue)
}
body := GetBodyRLP(bc.chainDb, hash, bc.hc.GetBlockNumber(hash))
if len(body) == 0 {
return nil
// Cache the found body for next time and return
bc.bodyRLPCache.Add(hash, body)
return body
}
// HasBlock checks if a block is fully present in the database or not, caching
// it if present.
func (bc *BlockChain) HasBlock(hash common.Hash) bool {
return bc.GetBlockByHash(hash) != nil
}
// HasBlockAndState checks if a block and associated state trie is fully present
// in the database or not, caching it if present.
func (bc *BlockChain) HasBlockAndState(hash common.Hash) bool {
// Check first that the block itself is known
block := bc.GetBlockByHash(hash)
if block == nil {
```

```
return false
// Ensure the associated state is also present
_, err := bc.stateCache.OpenTrie(block.Root())
return err == nil
// GetBlock retrieves a block from the database by hash and number,
// caching it if found.
func (bc *BlockChain) GetBlock(hash common.Hash, number uint64) *types.Block {
// Short circuit if the block's already in the cache, retrieve otherwise
if block, ok := bc.blockCache.Get(hash); ok {
return block.(*types.Block)
block := GetBlock(bc.chainDb, hash, number)
if block == nil {
return nil
}
// Cache the found block for next time and return
bc.blockCache.Add(block.Hash(), block)
return block
}
// GetBlockByHash retrieves a block from the database by hash, caching it if found.
func (bc *BlockChain) GetBlockByHash(hash common.Hash) *types.Block {
return bc.GetBlock(hash, bc.hc.GetBlockNumber(hash))
}
// GetBlockByNumber retrieves a block from the database by number, caching it
// (associated with its hash) if found.
func (bc *BlockChain) GetBlockByNumber(number uint64) *types.Block {
hash := GetCanonicalHash(bc.chainDb, number)
if hash == (common.Hash{}) {
return nil
return bc.GetBlock(hash, number)
}
// GetBlocksFromHash returns the block corresponding to hash and up to n-1 ancestors.
// [deprecated by eth/62]
func (bc *BlockChain) GetBlocksFromHash(hash common.Hash, n int) (blocks []*types.Block) {
number := bc.hc.GetBlockNumber(hash)
```

```
for i := 0; i < n; i++ {
block := bc.GetBlock(hash, number)
if block == nil {
break
}
blocks = append(blocks, block)
hash = block.ParentHash()
number--
return
}
// GetUnclesInChain retrieves all the uncles from a given block backwards until
// a specific distance is reached.
func (bc *BlockChain) GetUnclesInChain(block *types.Block, length int) []*types.Header {
uncles := []*types.Header{}
for i := 0; block != nil && i < length; i++ {
uncles = append(uncles, block.Uncles()...)
block = bc.GetBlock(block.ParentHash(), block.NumberU64()-1)
}
return uncles
}
// Stop stops the blockchain service. If any imports are currently in progress
// it will abort them using the procInterrupt.
func (bc *BlockChain) Stop() {
if !atomic.CompareAndSwapInt32(&bc.running, 0, 1) {
return
close(bc.quit)
atomic.StoreInt32(&bc.procInterrupt, 1)
bc.wg.Wait()
log.Info("Blockchain manager stopped")
}
func (bc *BlockChain) procFutureBlocks() {
blocks := make([]*types.Block, 0, bc.futureBlocks.Len())
for _, hash := range bc.futureBlocks.Keys() {
if block, exist := bc.futureBlocks.Peek(hash); exist {
blocks = append(blocks, block.(*types.Block))
}
```

```
}
if len(blocks) > 0 {
types.BlockBy(types.Number).Sort(blocks)
// Insert one by one as chain insertion needs contiguous ancestry between blocks
for i := range blocks {
bc.InsertChain(blocks[i:i+1])
}
}
}
// WriteStatus status of write
type WriteStatus byte
const (
NonStatTy WriteStatus = iota
CanonStatTy
SideStatTy
// Rollback is designed to remove a chain of links from the database that aren't
// certain enough to be valid.
func (bc *BlockChain) Rollback(chain []common.Hash) {
bc.mu.Lock()
defer bc.mu.Unlock()
for i := len(chain) - 1; i >= 0; i -- \{
hash := chain[i]
currentHeader := bc.hc.CurrentHeader()
if currentHeader.Hash() == hash {
bc.hc.SetCurrentHeader(bc.GetHeader(currentHeader.ParentHash,
currentHeader.Number.Uint64()-1))
if bc.currentFastBlock.Hash() == hash {
bc.currentFastBlock = bc.GetBlock(bc.currentFastBlock.ParentHash(),
bc.currentFastBlock.NumberU64()-1)
WriteHeadFastBlockHash(bc.chainDb, bc.currentFastBlock.Hash())
if bc.currentBlock.Hash() == hash {
bc.currentBlock = bc.GetBlock(bc.currentBlock.ParentHash(), bc.currentBlock.NumberU64()-1)
WriteHeadBlockHash(bc.chainDb, bc.currentBlock.Hash())
```

```
}
}
}
// SetReceiptsData computes all the non-consensus fields of the receipts
func SetReceiptsData(config *params.ChainConfig, block *types.Block, receipts types.Receipts) {
signer := types.MakeSigner(config, block.Number())
transactions, logIndex := block.Transactions(), uint(0)
for j := 0; j < len(receipts); j++ {
// The transaction hash can be retrieved from the transaction itself
receipts[j].TxHash = transactions[j].Hash()
// The contract address can be derived from the transaction itself
if transactions[j].To() == nil {
// Deriving the signer is expensive, only do if it's actually needed
from, := types.Sender(signer, transactions[j])
receipts[j].ContractAddress = crypto.CreateAddress(from, transactions[j].Nonce())
}
// The used gas can be calculated based on previous receipts
if j == 0 {
receipts[j].GasUsed = new(big.Int).Set(receipts[j].CumulativeGasUsed)
} else {
receipts[j].GasUsed = new(big.Int).Sub(receipts[j].CumulativeGasUsed, receipts[j-
1].CumulativeGasUsed)
}
// The derived log fields can simply be set from the block and transaction
for k := 0; k < len(receipts[j].Logs); k++ {
receipts[j].Logs[k].BlockNumber = block.NumberU64()
receipts[j].Logs[k].BlockHash = block.Hash()
receipts[j].Logs[k].TxHash = receipts[j].TxHash
receipts[j].Logs[k].TxIndex = uint(j)
receipts[j].Logs[k].Index = logIndex
logIndex++
}
}
}
// InsertReceiptChain attempts to complete an already existing header chain with
// transaction and receipt data.
// XXX should this be moved to the test?
```

```
func (bc *BlockChain) InsertReceiptChain(blockChain types.Blocks, receiptChain []types.Receipts)
(int, error) {
// Do a sanity check that the provided chain is actually ordered and linked
for i := 1; i < len(blockChain); i++ {
if blockChain[i].NumberU64() != blockChain[i-1].NumberU64()+1 || blockChain[i].ParentHash() !=
blockChain[i-1].Hash() {
// Chain broke ancestry, log a messge (programming error) and skip insertion
log.Error("Non contiguous receipt insert", "number", blockChain[i].Number(), "hash",
blockChain[i].Hash(), "parent", blockChain[i].ParentHash(),
"prevnumber", blockChain[i-1].Number(), "prevhash", blockChain[i-1].Hash())
return 0, fmt.Errorf("non contiguous insert: item %d is #%d [%x...], item %d is #%d [%x...] (parent
[%x...])", i-1, blockChain[i-1].NumberU64(),
blockChain[i-1].Hash().Bytes()[:4], i, blockChain[i].NumberU64(), blockChain[i].Hash().Bytes()[:4],
blockChain[i].ParentHash().Bytes()[:4])
}
}
// Pre-checks passed, start the block body and receipt imports
bc.wg.Add(1)
defer bc.wg.Done()
// Collect some import statistics to report on
stats := struct{ processed, ignored int32 }{}
start := time.Now()
// Create the block importing task queue and worker functions
tasks := make(chan int, len(blockChain))
for i := 0; i < len(blockChain) && i < len(receiptChain); i++ {
tasks <- i
}
close(tasks)
errs, failed := make([]error, len(tasks)), int32(0)
process := func(worker int) {
for index := range tasks {
block, receipts := blockChain[index], receiptChain[index]
// Short circuit insertion if shutting down or processing failed
if atomic.LoadInt32(&bc.procInterrupt) == 1 {
return
}
if atomic.LoadInt32(&failed) > 0 {
```

```
return
}
// Short circuit if the owner header is unknown
if !bc.HasHeader(block.Hash()) {
errs[index] = fmt.Errorf("containing header #%d [%x...] unknown", block.Number(),
block.Hash().Bytes()[:4])
atomic.AddInt32(&failed, 1)
return
}
// Skip if the entire data is already known
if bc.HasBlock(block.Hash()) {
atomic.AddInt32(&stats.ignored, 1)
continue
}
// Compute all the non-consensus fields of the receipts
SetReceiptsData(bc.config, block, receipts)
// Write all the data out into the database
if err := WriteBody(bc.chainDb, block.Hash(), block.NumberU64(), block.Body()); err != nil {
errs[index] = fmt.Errorf("failed to write block body: %v", err)
atomic.AddInt32(&failed, 1)
log.Crit("Failed to write block body", "err", err)
return
}
if err := WriteBlockReceipts(bc.chainDb, block.Hash(), block.NumberU64(), receipts); err != nil {
errs[index] = fmt.Errorf("failed to write block receipts: %v", err)
atomic.AddInt32(&failed, 1)
log.Crit("Failed to write block receipts", "err", err)
return
if err := WriteMipmapBloom(bc.chainDb, block.NumberU64(), receipts); err != nil {
errs[index] = fmt.Errorf("failed to write log blooms: %v", err)
atomic.AddInt32(&failed, 1)
log.Crit("Failed to write log blooms", "err", err)
return
if err := WriteTransactions(bc.chainDb, block); err != nil {
errs[index] = fmt.Errorf("failed to write individual transactions: %v", err)
atomic.AddInt32(&failed, 1)
log.Crit("Failed to write individual transactions", "err", err)
return
}
if err := WriteReceipts(bc.chainDb, receipts); err != nil {
```

```
errs[index] = fmt.Errorf("failed to write individual receipts: %v", err)
atomic.AddInt32(&failed, 1)
log.Crit("Failed to write individual receipts", "err", err)
return
}
atomic.AddInt32(&stats.processed, 1)
}
}
// Start as many worker threads as goroutines allowed
pending := new(sync.WaitGroup)
for i := 0; i < runtime.GOMAXPROCS(0); i++ {
pending.Add(1)
go func(id int) {
defer pending.Done()
process(id)
}(i)
pending.Wait()
// If anything failed, report
if failed > 0 {
for i, err := range errs {
if err != nil {
return i, err
}
if atomic.LoadInt32(&bc.procInterrupt) == 1 {
log.Debug("Premature abort during receipts processing")
return 0, nil
}
// Update the head fast sync block if better
bc.mu.Lock()
head := blockChain[len(errs)-1]
if td := bc.GetTd(head.Hash(), head.NumberU64()); td != nil { // Rewind may have occurred, skip in
that case
if bc.GetTd(bc.currentFastBlock.Hash(), bc.currentFastBlock.NumberU64()).Cmp(td) < 0 {
if err := WriteHeadFastBlockHash(bc.chainDb, head.Hash()); err != nil {
log.Crit("Failed to update head fast block hash", "err", err)
}
bc.currentFastBlock = head
```

```
}
}
bc.mu.Unlock()
// Report some public statistics so the user has a clue what's going on
last := blockChain[len(blockChain)-1]
log.Info("Imported new block receipts", "count", stats.processed, "elapsed",
common.PrettyDuration(time.Since(start)),
"number", last.Number(), "hash", last.Hash(), "ignored", stats.ignored)
return 0, nil
}
// WriteBlock writes the block to the chain.
func (bc *BlockChain) WriteBlock(block *types.Block) (status WriteStatus, err error) {
bc.wg.Add(1)
defer bc.wg.Done()
// Calculate the total difficulty of the block
ptd := bc.GetTd(block.ParentHash(), block.NumberU64()-1)
if ptd == nil {
return NonStatTy, consensus.ErrUnknownAncestor
}
// Make sure no inconsistent state is leaked during insertion
bc.mu.Lock()
defer bc.mu.Unlock()
localTd := bc.GetTd(bc.currentBlock.Hash(), bc.currentBlock.NumberU64())
externTd := new(big.Int).Add(block.Difficulty(), ptd)
// Irrelevant of the canonical status, write the block itself to the database
if err := bc.hc.WriteTd(block.Hash(), block.NumberU64(), externTd); err != nil {
log.Crit("Failed to write block total difficulty", "err", err)
if err := WriteBlock(bc.chainDb, block); err != nil {
log.Crit("Failed to write block contents", "err", err)
}
// If the total difficulty is higher than our known, add it to the canonical chain
// Second clause in the if statement reduces the vulnerability to selfish mining.
// Please refer to http://www.cs.cornell.edu/~ie53/publications/btcProcFC.pdf
if externTd.Cmp(localTd) > 0 || (externTd.Cmp(localTd) == 0 && mrand.Float64() < 0.5) {
```

```
// Reorganise the chain if the parent is not the head block
if block.ParentHash() != bc.currentBlock.Hash() {
if err := bc.reorg(bc.currentBlock, block); err != nil {
return NonStatTy, err
}
bc.insert(block) // Insert the block as the new head of the chain
status = CanonStatTy
} else {
status = SideStatTy
}
bc.futureBlocks.Remove(block.Hash())
return
}
// InsertChain will attempt to insert the given chain in to the canonical chain or, otherwise, create a
fork. If an error is returned
// it will return the index number of the failing block as well an error describing what went wrong
(for possible errors see core/errors.go).
func (bc *BlockChain) InsertChain(chain types.Blocks) (int, error) {
// Do a sanity check that the provided chain is actually ordered and linked
for i := 1; i < len(chain); i++ {
if chain[i].NumberU64() != chain[i-1].NumberU64()+1 || chain[i].ParentHash() != chain[i-1].Hash() {
// Chain broke ancestry, log a messge (programming error) and skip insertion
log.Error("Non contiguous block insert", "number", chain[i].Number(), "hash", chain[i].Hash(),
"parent", chain[i].ParentHash(), "prevnumber", chain[i-1].Number(), "prevhash", chain[i-1].Hash())
return 0, fmt.Errorf("non contiguous insert: item %d is #%d [%x...], item %d is #%d [%x...] (parent
[%x...])", i-1, chain[i-1].NumberU64(),
chain[i-1].Hash().Bytes()[:4], i, chain[i].NumberU64(), chain[i].Hash().Bytes()[:4],
chain[i].ParentHash().Bytes()[:4])
}
}
// Pre-checks passed, start the full block imports
bc.wg.Add(1)
defer bc.wg.Done()
bc.chainmu.Lock()
defer bc.chainmu.Unlock()
```

```
// A queued approach to delivering events. This is generally
// faster than direct delivery and requires much less mutex
// acquiring.
var (
stats
          = insertStats{startTime: mclock.Now()}
            = make([]interface{}, 0, len(chain))
events
coalescedLogs []*types.Log
)
// Start the parallel header verifier
headers := make([]*types.Header, len(chain))
seals := make([]bool, len(chain))
for i, block := range chain {
headers[i] = block.Header()
seals[i] = true
}
abort, results := bc.engine.VerifyHeaders(bc, headers, seals)
defer close(abort)
// Iterate over the blocks and insert when the verifier permits
for i, block := range chain {
// If the chain is terminating, stop processing blocks
if atomic.LoadInt32(&bc.procInterrupt) == 1 {
log.Debug("Premature abort during blocks processing")
break
// If the header is a banned one, straight out abort
if BadHashes[block.Hash()] {
bc.reportBlock(block, nil, ErrBlacklistedHash)
return i, ErrBlacklistedHash
// Wait for the block's verification to complete
bstart := time.Now()
err := <-results
if err == nil {
err = bc.Validator().ValidateBody(block)
}
if err != nil {
if err == ErrKnownBlock {
stats.ignored++
continue
```

```
}
if err == consensus.ErrFutureBlock {
// Allow up to MaxFuture second in the future blocks. If this limit
// is exceeded the chain is discarded and processed at a later time
// if given.
max := big.NewInt(time.Now().Unix() + maxTimeFutureBlocks)
if block.Time().Cmp(max) > 0 {
return i, fmt.Errorf("future block: %v > %v", block.Time(), max)
}
bc.futureBlocks.Add(block.Hash(), block)
stats.queued++
continue
}
if err == consensus.ErrUnknownAncestor && bc.futureBlocks.Contains(block.ParentHash()) {
bc.futureBlocks.Add(block.Hash(), block)
stats.queued++
continue
}
bc.reportBlock(block, nil, err)
return i, err
// Create a new statedb using the parent block and report an
// error if it fails.
var parent *types.Block
if i == 0 {
parent = bc.GetBlock(block.ParentHash(), block.NumberU64()-1)
} else {
parent = chain[i-1]
state, err := state.New(parent.Root(), bc.stateCache)
if err != nil {
return i, err
}
// Process block using the parent state as reference point.
receipts, logs, usedGas, err := bc.processor.Process(block, state, bc.vmConfig)
if err != nil {
bc.reportBlock(block, receipts, err)
return i, err
}
```

```
// Validate the state using the default validator
err = bc.Validator().ValidateState(block, parent, state, receipts, usedGas)
if err != nil {
bc.reportBlock(block, receipts, err)
return i, err
// Write state changes to database
if _, err = state.CommitTo(bc.chainDb, bc.config.lsEIP158(block.Number())); err != nil {
return i, err
}
// coalesce logs for later processing
coalescedLogs = append(coalescedLogs, logs...)
if err = WriteBlockReceipts(bc.chainDb, block.Hash(), block.NumberU64(), receipts); err != nil {
return i, err
}
// write the block to the chain and get the status
status, err := bc.WriteBlock(block)
if err != nil {
return i, err
}
switch status {
case CanonStatTy:
log.Debug("Inserted new block", "number", block.Number(), "hash", block.Hash(), "uncles",
len(block.Uncles()),
"txs", len(block.Transactions()), "gas", block.GasUsed(), "elapsed",
common.PrettyDuration(time.Since(bstart)))
blockInsertTimer.UpdateSince(bstart)
events = append(events, ChainEvent{block, block.Hash(), logs})
// This puts transactions in a extra db for rpc
if err := WriteTransactions(bc.chainDb, block); err != nil {
return i, err
}
// store the receipts
if err := WriteReceipts(bc.chainDb, receipts); err != nil {
return i, err
}
```

```
// Write map map bloom filters
if err := WriteMipmapBloom(bc.chainDb, block.NumberU64(), receipts); err != nil {
return i, err
}
// Write hash preimages
if err := WritePreimages(bc.chainDb, block.NumberU64(), state.Preimages()); err != nil {
return i, err
}
case SideStatTy:
log.Debug("Inserted forked block", "number", block.Number(), "hash", block.Hash(), "diff",
block.Difficulty(), "elapsed",
common.PrettyDuration(time.Since(bstart)), "txs", len(block.Transactions()), "gas",
block.GasUsed(), "uncles", len(block.Uncles()))
blockInsertTimer.UpdateSince(bstart)
events = append(events, ChainSideEvent{block})
}
stats.processed++
stats.usedGas += usedGas.Uint64()
stats.report(chain, i)
}
go bc.postChainEvents(events, coalescedLogs)
return 0, nil
}
// insertStats tracks and reports on block insertion.
type insertStats struct {
queued, processed, ignored int
usedGas
                     uint64
lastIndex
                    int
startTime
                    mclock.AbsTime
}
// statsReportLimit is the time limit during import after which we always print
// out progress. This avoids the user wondering what's going on.
const statsReportLimit = 8 * time.Second
// report prints statistics if some number of blocks have been processed
// or more than a few seconds have passed since the last message.
func (st *insertStats) report(chain []*types.Block, index int) {
// Fetch the timings for the batch
```

```
var (
       = mclock.Now()
now
elapsed = time.Duration(now) - time.Duration(st.startTime)
// If we're at the last block of the batch or report period reached, log
if index == len(chain)-1 || elapsed >= statsReportLimit {
var (
end = chain[index]
txs = countTransactions(chain[st.lastIndex : index+1])
)
context := []interface{}{
"blocks", st.processed, "txs", txs, "mgas", float64(st.usedGas) / 1000000,
"elapsed", common.PrettyDuration(elapsed), "mgasps", float64(st.usedGas) * 1000 /
float64(elapsed),
"number", end.Number(), "hash", end.Hash(),
if st.queued > 0 {
context = append(context, []interface{}{"queued", st.queued}...)
if st.ignored > 0 {
context = append(context, []interface{}{"ignored", st.ignored}...)
}
log.Info("Imported new chain segment", context...)
*st = insertStats{startTime: now, lastIndex: index + 1}
}
}
func countTransactions(chain []*types.Block) (c int) {
for _, b := range chain {
c += len(b.Transactions())
}
return c
}
// reorgs takes two blocks, an old chain and a new chain and will reconstruct the blocks and inserts
them
// to be part of the new canonical chain and accumulates potential missing transactions and post
an
// event about them
func (bc *BlockChain) reorg(oldBlock, newBlock *types.Block) error {
var (
```

```
newChain types.Blocks
oldChain types.Blocks
commonBlock *types.Block
deletedTxs types.Transactions
deletedLogs []*types.Log
// collectLogs collects the logs that were generated during the
// processing of the block that corresponds with the given hash.
// These logs are later announced as deleted.
collectLogs = func(h common.Hash) {
// Coalesce logs and set 'Removed'.
receipts := GetBlockReceipts(bc.chainDb, h, bc.hc.GetBlockNumber(h))
for _, receipt := range receipts {
for _, log := range receipt.Logs {
del := *log
del.Removed = true
deletedLogs = append(deletedLogs, &del)
}
}
}
)
// first reduce whoever is higher bound
if oldBlock.NumberU64() > newBlock.NumberU64() {
// reduce old chain
for; oldBlock!= nil && oldBlock.NumberU64()!= newBlock.NumberU64(); oldBlock =
bc.GetBlock(oldBlock.ParentHash(), oldBlock.NumberU64()-1) {
oldChain = append(oldChain, oldBlock)
deletedTxs = append(deletedTxs, oldBlock.Transactions()...)
collectLogs(oldBlock.Hash())
}
} else {
// reduce new chain and append new chain blocks for inserting later on
for; newBlock!= nil && newBlock.NumberU64()!= oldBlock.NumberU64(); newBlock =
bc.GetBlock(newBlock.ParentHash(), newBlock.NumberU64()-1) {
newChain = append(newChain, newBlock)
}
}
if oldBlock == nil {
return fmt.Errorf("Invalid old chain")
}
if newBlock == nil {
```

```
return fmt.Errorf("Invalid new chain")
}
for {
if oldBlock.Hash() == newBlock.Hash() {
commonBlock = oldBlock
break
}
oldChain = append(oldChain, oldBlock)
newChain = append(newChain, newBlock)
deletedTxs = append(deletedTxs, oldBlock.Transactions()...)
collectLogs(oldBlock.Hash())
oldBlock, newBlock = bc.GetBlock(oldBlock.ParentHash(), oldBlock.NumberU64()-1),
bc.GetBlock(newBlock.ParentHash(), newBlock.NumberU64()-1)
if oldBlock == nil {
return fmt.Errorf("Invalid old chain")
if newBlock == nil {
return fmt.Errorf("Invalid new chain")
}
}
// Ensure the user sees large reorgs
if len(oldChain) > 0 && len(newChain) > 0 {
logFn := log.Debug
if len(oldChain) > 63 {
logFn = log.Warn
logFn("Chain split detected", "number", commonBlock.Number(), "hash", commonBlock.Hash(),
"drop", len(oldChain), "dropfrom", oldChain[0].Hash(), "add", len(newChain), "addfrom",
newChain[0].Hash())
} else {
log.Error("Impossible reorg, please file an issue", "oldnum", oldBlock.Number(), "oldhash",
oldBlock.Hash(), "newnum", newBlock.Number(), "newhash", newBlock.Hash())
}
var addedTxs types.Transactions
// insert blocks. Order does not matter. Last block will be written in ImportChain itself which creates
the new head properly
for _, block := range newChain {
// insert the block in the canonical way, re-writing history
bc.insert(block)
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```
// write canonical receipts and transactions
if err := WriteTransactions(bc.chainDb, block); err != nil {
return err
receipts := GetBlockReceipts(bc.chainDb, block.Hash(), block.NumberU64())
// write receipts
if err := WriteReceipts(bc.chainDb, receipts); err != nil {
return err
// Write map map bloom filters
if err := WriteMipmapBloom(bc.chainDb, block.NumberU64(), receipts); err != nil {
return err
}
addedTxs = append(addedTxs, block.Transactions()...)
}
// calculate the difference between deleted and added transactions
diff := types.TxDifference(deletedTxs, addedTxs)
// When transactions get deleted from the database that means the
// receipts that were created in the fork must also be deleted
for _, tx := range diff {
DeleteReceipt(bc.chainDb, tx.Hash())
DeleteTransaction(bc.chainDb, tx.Hash())
// Must be posted in a goroutine because of the transaction pool trying
// to acquire the chain manager lock
if len(diff) > 0 {
go bc.eventMux.Post(RemovedTransactionEvent{diff})
if len(deletedLogs) > 0 {
go bc.eventMux.Post(RemovedLogsEvent{deletedLogs})
}
if len(oldChain) > 0 {
go func() {
for _, block := range oldChain {
bc.eventMux.Post(ChainSideEvent{Block: block})
}
}()
}
```

```
// postChainEvents iterates over the events generated by a chain insertion and
// posts them into the event mux.
func (bc *BlockChain) postChainEvents(events []interface{}, logs []*types.Log) {
// post event logs for further processing
bc.eventMux.Post(logs)
for _, event := range events {
if event, ok := event.(ChainEvent); ok {
// We need some control over the mining operation. Acquiring locks and waiting
// for the miner to create new block takes too long and in most cases isn't
// even necessary.
if bc.LastBlockHash() == event.Hash {
bc.eventMux.Post(ChainHeadEvent{event.Block})
}
// Fire the insertion events individually too
bc.eventMux.Post(event)
}
func (bc *BlockChain) update() {
futureTimer := time.Tick(5 * time.Second)
for {
select {
case <-futureTimer:
bc.procFutureBlocks()
case <-bc.quit:
return
}
// BadBlockArgs represents the entries in the list returned when bad blocks are queried.
type BadBlockArgs struct {
Hash common.Hash `json:"hash"`
Header *types.Header `json:"header"`
}
// BadBlocks returns a list of the last 'bad blocks' that the client has seen on the network
func (bc *BlockChain) BadBlocks() ([]BadBlockArgs, error) {
headers := make([]BadBlockArgs, 0, bc.badBlocks.Len())
```

}

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for _, hash := range bc.badBlocks.Keys() {
if hdr, exist := bc.badBlocks.Peek(hash); exist {
header := hdr.(*types.Header)
headers = append(headers, BadBlockArgs{header.Hash(), header})
}
return headers, nil
}
// addBadBlock adds a bad block to the bad-block LRU cache
func (bc *BlockChain) addBadBlock(block *types.Block) {
bc.badBlocks.Add(block.Header().Hash(), block.Header())
}
// reportBlock logs a bad block error.
func (bc *BlockChain) reportBlock(block *types.Block, receipts types.Receipts, err error) {
bc.addBadBlock(block)
var receiptString string
for _, receipt := range receipts {
receiptString += fmt.Sprintf("\t%v\n", receipt)
}
log.Error(fmt.Sprintf()
######### BAD BLOCK ########
Chain config: %v
Number: %v
Hash: 0x%x
%v
Error: %v
`, bc.config, block.Number(), block.Hash(), receiptString, err))
}
// InsertHeaderChain attempts to insert the given header chain in to the local
// chain, possibly creating a reorg. If an error is returned, it will return the
// index number of the failing header as well an error describing what went wrong.
//
// The verify parameter can be used to fine tune whether nonce verification
// should be done or not. The reason behind the optional check is because some
// of the header retrieval mechanisms already need to verify nonces, as well as
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// because nonces can be verified sparsely, not needing to check each.
func (bc *BlockChain) InsertHeaderChain(chain []*types.Header, checkFreq int) (int, error) {
start := time.Now()
if i, err := bc.hc.ValidateHeaderChain(chain, checkFreg); err != nil {
return i, err
}
// Make sure only one thread manipulates the chain at once
bc.chainmu.Lock()
defer bc.chainmu.Unlock()
bc.wg.Add(1)
defer bc.wg.Done()
whFunc := func(header *types.Header) error {
bc.mu.Lock()
defer bc.mu.Unlock()
_, err := bc.hc.WriteHeader(header)
return err
}
return bc.hc.InsertHeaderChain(chain, whFunc, start)
}
// writeHeader writes a header into the local chain, given that its parent is
// already known. If the total difficulty of the newly inserted header becomes
// greater than the current known TD, the canonical chain is re-routed.
//
// Note: This method is not concurrent-safe with inserting blocks simultaneously
// into the chain, as side effects caused by reorganisations cannot be emulated
// without the real blocks. Hence, writing headers directly should only be done
// in two scenarios: pure-header mode of operation (light clients), or properly
// separated header/block phases (non-archive clients).
func (bc *BlockChain) writeHeader(header *types.Header) error {
bc.wg.Add(1)
defer bc.wg.Done()
bc.mu.Lock()
defer bc.mu.Unlock()
_, err := bc.hc.WriteHeader(header)
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return err
}
// CurrentHeader retrieves the current head header of the canonical chain. The
// header is retrieved from the HeaderChain's internal cache.
func (bc *BlockChain) CurrentHeader() *types.Header {
bc.mu.RLock()
defer bc.mu.RUnlock()
return bc.hc.CurrentHeader()
}
// GetTd retrieves a block's total difficulty in the canonical chain from the
// database by hash and number, caching it if found.
func (bc *BlockChain) GetTd(hash common.Hash, number uint64) *big.Int {
return bc.hc.GetTd(hash, number)
}
// GetTdByHash retrieves a block's total difficulty in the canonical chain from the
// database by hash, caching it if found.
func (bc *BlockChain) GetTdByHash(hash common.Hash) *big.Int {
return bc.hc.GetTdByHash(hash)
}
// GetHeader retrieves a block header from the database by hash and number,
// caching it if found.
func (bc *BlockChain) GetHeader(hash common.Hash, number uint64) *types.Header {
return bc.hc.GetHeader(hash, number)
}
// GetHeaderByHash retrieves a block header from the database by hash, caching it if
// found.
func (bc *BlockChain) GetHeaderByHash(hash common.Hash) *types.Header {
return bc.hc.GetHeaderByHash(hash)
}
// HasHeader checks if a block header is present in the database or not, caching
// it if present.
func (bc *BlockChain) HasHeader(hash common.Hash) bool {
return bc.hc.HasHeader(hash)
}
```

```
// GetBlockHashesFromHash retrieves a number of block hashes starting at a given
// hash, fetching towards the genesis block.
func (bc *BlockChain) GetBlockHashesFromHash(hash common.Hash, max uint64)
[]common.Hash {
return bc.hc.GetBlockHashesFromHash(hash, max)
}
// GetHeaderByNumber retrieves a block header from the database by number,
// caching it (associated with its hash) if found.
func (bc *BlockChain) GetHeaderByNumber(number uint64) *types.Header {
return bc.hc.GetHeaderByNumber(number)
}
// Config retrieves the blockchain's chain configuration.
func (bc *BlockChain) Config() *params.ChainConfig { return bc.config }
// Engine retrieves the blockchain's consensus engine.
func (bc *BlockChain) Engine() consensus. Engine { return bc.engine }
63:F:\git\coin\ethereum\go-ethereum\core\blockchain_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"fmt"
"math/big"
"math/rand"
"testing"
"time"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/consensus/ethash"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/params"
)
```

```
// newTestBlockChain creates a blockchain without validation.
func newTestBlockChain(fake bool) *BlockChain {
db, _ := ethdb.NewMemDatabase()
gspec := &Genesis{
Config:
          params.TestChainConfig,
Difficulty: big.NewInt(1),
}
gspec.MustCommit(db)
engine := ethash.NewFullFaker()
if !fake {
engine = ethash.NewTester()
}
blockchain, err := NewBlockChain(db, gspec.Config, engine, new(event.TypeMux), vm.Config{})
if err != nil {
panic(err)
}
blockchain.SetValidator(bproc{})
return blockchain
// Test fork of length N starting from block i
func testFork(t *testing.T, blockchain *BlockChain, i, n int, full bool, comparator func(td1, td2
*big.Int)) {
// Copy old chain up to #i into a new db
db, blockchain2, err := newCanonical(i, full)
if err != nil {
t.Fatal("could not make new canonical in testFork", err)
}
// Assert the chains have the same header/block at #i
var hash1, hash2 common.Hash
if full {
hash1 = blockchain.GetBlockByNumber(uint64(i)).Hash()
hash2 = blockchain2.GetBlockByNumber(uint64(i)).Hash()
} else {
hash1 = blockchain.GetHeaderByNumber(uint64(i)).Hash()
hash2 = blockchain2.GetHeaderByNumber(uint64(i)).Hash()
}
if hash1 != hash2 {
t.Errorf("chain content mismatch at %d: have hash %v, want hash %v", i, hash2, hash1)
// Extend the newly created chain
var (
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blockChainB []*types.Block
headerChainB []*types.Header
)
if full {
blockChainB = makeBlockChain(blockchain2.CurrentBlock(), n, db, forkSeed)
if , err := blockchain2.InsertChain(blockChainB); err != nil {
t.Fatalf("failed to insert forking chain: %v", err)
}
} else {
headerChainB = makeHeaderChain(blockchain2.CurrentHeader(), n, db, forkSeed)
if _, err := blockchain2.InsertHeaderChain(headerChainB, 1); err != nil {
t.Fatalf("failed to insert forking chain: %v", err)
}
}
// Sanity check that the forked chain can be imported into the original
var tdPre, tdPost *big.Int
if full {
tdPre = blockchain.GetTdByHash(blockchain.CurrentBlock().Hash())
if err := testBlockChainImport(blockChainB, blockchain); err != nil {
t.Fatalf("failed to import forked block chain: %v", err)
}
tdPost = blockchain.GetTdByHash(blockChainB[len(blockChainB)-1].Hash())
} else {
tdPre = blockchain.GetTdByHash(blockchain.CurrentHeader().Hash())
if err := testHeaderChainImport(headerChainB, blockchain); err != nil {
t.Fatalf("failed to import forked header chain: %v", err)
}
tdPost = blockchain.GetTdByHash(headerChainB[len(headerChainB)-1].Hash())
// Compare the total difficulties of the chains
comparator(tdPre, tdPost)
}
func printChain(bc *BlockChain) {
for i := bc.CurrentBlock().Number().Uint64(); i > 0; i-- {
b := bc.GetBlockByNumber(uint64(i))
fmt.Printf("\t%x %v\n", b.Hash(), b.Difficulty())
}
}
```

// testBlockChainImport tries to process a chain of blocks, writing them into

```
// the database if successful.
func testBlockChainImport(chain types.Blocks, blockchain *BlockChain) error {
for _, block := range chain {
// Try and process the block
err := blockchain.engine.VerifyHeader(blockchain, block.Header(), true)
if err == nil {
err = blockchain.validator.ValidateBody(block)
if err != nil {
if err == ErrKnownBlock {
continue
}
return err
statedb, err := state.New(blockchain.GetBlockByHash(block.ParentHash()).Root(),
blockchain.stateCache)
if err != nil {
return err
receipts, _, usedGas, err := blockchain.Processor().Process(block, statedb, vm.Config{})
if err != nil {
blockchain.reportBlock(block, receipts, err)
return err
err = blockchain.validator.ValidateState(block, blockchain.GetBlockByHash(block.ParentHash()),
statedb, receipts, usedGas)
if err != nil {
blockchain.reportBlock(block, receipts, err)
return err
}
blockchain.mu.Lock()
WriteTd(blockchain.chainDb, block.Hash(), block.NumberU64(), new(big.Int).Add(block.Difficulty(),
blockchain.GetTdByHash(block.ParentHash())))
WriteBlock(blockchain.chainDb, block)
statedb.CommitTo(blockchain.chainDb, false)
blockchain.mu.Unlock()
}
return nil
// testHeaderChainImport tries to process a chain of header, writing them into
// the database if successful.
```

```
func testHeaderChainImport(chain []*types.Header, blockchain *BlockChain) error {
for _, header := range chain {
// Try and validate the header
if err := blockchain.engine.VerifyHeader(blockchain, header, false); err != nil {
return err
// Manually insert the header into the database, but don't reorganise (allows subsequent testing)
blockchain.mu.Lock()
WriteTd(blockchain.chainDb, header.Hash(), header.Number.Uint64(),
new(big.Int).Add(header.Difficulty, blockchain.GetTdByHash(header.ParentHash)))
WriteHeader(blockchain.chainDb, header)
blockchain.mu.Unlock()
}
return nil
func insertChain(done chan bool, blockchain *BlockChain, chain types.Blocks, t *testing.T) {
, err := blockchain.InsertChain(chain)
if err != nil {
fmt.Println(err)
t.FailNow()
}
done <- true
}
func TestLastBlock(t *testing.T) {
bchain := newTestBlockChain(false)
block := makeBlockChain(bchain.CurrentBlock(), 1, bchain.chainDb, 0)[0]
bchain.insert(block)
if block.Hash() != GetHeadBlockHash(bchain.chainDb) {
t.Errorf("Write/Get HeadBlockHash failed")
}
}
// Tests that given a starting canonical chain of a given size, it can be extended
// with various length chains.
func TestExtendCanonicalHeaders(t *testing.T) { testExtendCanonical(t, false) }
func TestExtendCanonicalBlocks(t *testing.T) { testExtendCanonical(t, true) }
func testExtendCanonical(t *testing.T, full bool) {
length := 5
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// Make first chain starting from genesis
_, processor, err := newCanonical(length, full)
if err != nil {
t.Fatalf("failed to make new canonical chain: %v", err)
}
// Define the difficulty comparator
better := func(td1, td2 *big.Int) {
if td2.Cmp(td1) \le 0 {
t.Errorf("total difficulty mismatch: have %v, expected more than %v", td2, td1)
}
// Start fork from current height
testFork(t, processor, length, 1, full, better)
testFork(t, processor, length, 2, full, better)
testFork(t, processor, length, 5, full, better)
testFork(t, processor, length, 10, full, better)
}
// Tests that given a starting canonical chain of a given size, creating shorter
// forks do not take canonical ownership.
func TestShorterForkHeaders(t *testing.T) { testShorterFork(t, false) }
func TestShorterForkBlocks(t *testing.T) { testShorterFork(t, true) }
func testShorterFork(t *testing.T, full bool) {
length := 10
// Make first chain starting from genesis
_, processor, err := newCanonical(length, full)
if err != nil {
t.Fatalf("failed to make new canonical chain: %v", err)
}
// Define the difficulty comparator
worse := func(td1, td2 *big.Int) {
if td2.Cmp(td1) >= 0 {
t.Errorf("total difficulty mismatch: have %v, expected less than %v", td2, td1)
}
}
// Sum of numbers must be less than `length` for this to be a shorter fork
testFork(t, processor, 0, 3, full, worse)
testFork(t, processor, 0, 7, full, worse)
testFork(t, processor, 1, 1, full, worse)
testFork(t, processor, 1, 7, full, worse)
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```
testFork(t, processor, 5, 3, full, worse)
testFork(t, processor, 5, 4, full, worse)
}
// Tests that given a starting canonical chain of a given size, creating longer
// forks do take canonical ownership.
func TestLongerForkHeaders(t *testing.T) { testLongerFork(t, false) }
func TestLongerForkBlocks(t *testing.T) { testLongerFork(t, true) }
func testLongerFork(t *testing.T, full bool) {
length := 10
// Make first chain starting from genesis
_, processor, err := newCanonical(length, full)
if err != nil {
t.Fatalf("failed to make new canonical chain: %v", err)
}
// Define the difficulty comparator
better := func(td1, td2 *big.Int) {
if td2.Cmp(td1) \le 0 {
t.Errorf("total difficulty mismatch: have %v, expected more than %v", td2, td1)
}
}
// Sum of numbers must be greater than `length` for this to be a longer fork
testFork(t, processor, 0, 11, full, better)
testFork(t, processor, 0, 15, full, better)
testFork(t, processor, 1, 10, full, better)
testFork(t, processor, 1, 12, full, better)
testFork(t, processor, 5, 6, full, better)
testFork(t, processor, 5, 8, full, better)
}
// Tests that given a starting canonical chain of a given size, creating equal
// forks do take canonical ownership.
func TestEqualForkHeaders(t *testing.T) { testEqualFork(t, false) }
func TestEqualForkBlocks(t *testing.T) { testEqualFork(t, true) }
func testEqualFork(t *testing.T, full bool) {
length := 10
// Make first chain starting from genesis
_, processor, err := newCanonical(length, full)
```

```
if err != nil {
t.Fatalf("failed to make new canonical chain: %v", err)
}
// Define the difficulty comparator
equal := func(td1, td2 *big.Int) {
if td2.Cmp(td1) != 0 {
t.Errorf("total difficulty mismatch: have %v, want %v", td2, td1)
}
}
// Sum of numbers must be equal to `length` for this to be an equal fork
testFork(t, processor, 0, 10, full, equal)
testFork(t, processor, 1, 9, full, equal)
testFork(t, processor, 2, 8, full, equal)
testFork(t, processor, 5, 5, full, equal)
testFork(t, processor, 6, 4, full, equal)
testFork(t, processor, 9, 1, full, equal)
}
// Tests that chains missing links do not get accepted by the processor.
func TestBrokenHeaderChain(t *testing.T) { testBrokenChain(t, false) }
func TestBrokenBlockChain(t *testing.T) { testBrokenChain(t, true) }
func testBrokenChain(t *testing.T, full bool) {
// Make chain starting from genesis
db, blockchain, err := newCanonical(10, full)
if err != nil {
t.Fatalf("failed to make new canonical chain: %v", err)
}
// Create a forked chain, and try to insert with a missing link
if full {
chain := makeBlockChain(blockchain.CurrentBlock(), 5, db, forkSeed)[1:]
if err := testBlockChainImport(chain, blockchain); err == nil {
t.Errorf("broken block chain not reported")
} else {
chain := makeHeaderChain(blockchain.CurrentHeader(), 5, db, forkSeed)[1:]
if err := testHeaderChainImport(chain, blockchain); err == nil {
t.Errorf("broken header chain not reported")
}
}
}
```

```
type bproc struct{}
func (bproc) ValidateBody(*types.Block) error { return nil }
func (bproc) ValidateState(block, parent *types.Block, state *state.StateDB, receipts
types.Receipts, usedGas *big.Int) error {
return nil
func (bproc) Process(block *types.Block, statedb *state.StateDB, cfg vm.Config) (types.Receipts,
[]*types.Log, *big.Int, error) {
return nil, nil, new(big.Int), nil
}
func makeHeaderChainWithDiff(genesis *types.Block, d []int, seed byte) []*types.Header {
blocks := makeBlockChainWithDiff(genesis, d, seed)
headers := make([]*types.Header, len(blocks))
for i, block := range blocks {
headers[i] = block.Header()
}
return headers
}
func makeBlockChainWithDiff(genesis *types.Block, d []int, seed byte) []*types.Block {
var chain []*types.Block
for i, difficulty := range d {
header := &types.Header{
Coinbase: common.Address{seed},
Number:
            big.NewInt(int64(i + 1)),
Difficulty: big.NewInt(int64(difficulty)),
UncleHash: types.EmptyUncleHash,
TxHash:
            types.EmptyRootHash,
ReceiptHash: types.EmptyRootHash,
Time:
          big.NewInt(int64(i) + 1),
}
if i == 0 {
header.ParentHash = genesis.Hash()
} else {
header.ParentHash = chain[i-1].Hash()
}
block := types.NewBlockWithHeader(header)
chain = append(chain, block)
}
return chain
```

```
}
// Tests that reorganising a long difficult chain after a short easy one
// overwrites the canonical numbers and links in the database.
func TestReorgLongHeaders(t *testing.T) { testReorgLong(t, false) }
func TestReorgLongBlocks(t *testing.T) { testReorgLong(t, true) }
func testReorgLong(t *testing.T, full bool) {
testReorg(t, []int{1, 2, 4}, []int{1, 2, 3, 4}, 10, full)
}
// Tests that reorganising a short difficult chain after a long easy one
// overwrites the canonical numbers and links in the database.
func TestReorgShortHeaders(t *testing.T) { testReorgShort(t, false) }
func TestReorgShortBlocks(t *testing.T) { testReorgShort(t, true) }
func testReorgShort(t *testing.T, full bool) {
testReorg(t, []int{1, 2, 3, 4}, []int{1, 10}, 11, full)
}
func testReorg(t *testing.T, first, second []int, td int64, full bool) {
bc := newTestBlockChain(true)
// Insert an easy and a difficult chain afterwards
if full {
bc.InsertChain(makeBlockChainWithDiff(bc.genesisBlock, first, 11))
bc.InsertChain(makeBlockChainWithDiff(bc.genesisBlock, second, 22))
} else {
bc.InsertHeaderChain(makeHeaderChainWithDiff(bc.genesisBlock, first, 11), 1)
bc.InsertHeaderChain(makeHeaderChainWithDiff(bc.genesisBlock, second, 22), 1)
}
// Check that the chain is valid number and link wise
if full {
prev := bc.CurrentBlock()
for block := bc.GetBlockByNumber(bc.CurrentBlock().NumberU64() - 1); block.NumberU64() != 0;
prev, block = block, bc.GetBlockByNumber(block.NumberU64()-1) {
if prev.ParentHash() != block.Hash() {
t.Errorf("parent block hash mismatch: have %x, want %x", prev.ParentHash(), block.Hash())
}
}
} else {
prev := bc.CurrentHeader()
```

```
for header := bc.GetHeaderByNumber(bc.CurrentHeader().Number.Uint64() - 1);
header.Number.Uint64() != 0; prev, header = header,
bc.GetHeaderByNumber(header.Number.Uint64()-1) {
if prev.ParentHash != header.Hash() {
t.Errorf("parent header hash mismatch: have %x, want %x", prev.ParentHash, header.Hash())
}
}
}
// Make sure the chain total difficulty is the correct one
want := new(big.Int).Add(bc.genesisBlock.Difficulty(), big.NewInt(td))
if full {
if have := bc.GetTdByHash(bc.CurrentBlock().Hash()); have.Cmp(want) != 0 {
t.Errorf("total difficulty mismatch: have %v, want %v", have, want)
} else {
if have := bc.GetTdByHash(bc.CurrentHeader().Hash()); have.Cmp(want) != 0 {
t.Errorf("total difficulty mismatch: have %v, want %v", have, want)
}
}
}
// Tests that the insertion functions detect banned hashes.
func TestBadHeaderHashes(t *testing.T) { testBadHashes(t, false) }
func TestBadBlockHashes(t *testing.T) { testBadHashes(t, true) }
func testBadHashes(t *testing.T, full bool) {
bc := newTestBlockChain(true)
// Create a chain, ban a hash and try to import
var err error
if full {
blocks := makeBlockChainWithDiff(bc.genesisBlock, []int{1, 2, 4}, 10)
BadHashes[blocks[2].Header().Hash()] = true
_, err = bc.InsertChain(blocks)
} else {
headers := makeHeaderChainWithDiff(bc.genesisBlock, []int{1, 2, 4}, 10)
BadHashes[headers[2].Hash()] = true
_, err = bc.InsertHeaderChain(headers, 1)
if err != ErrBlacklistedHash {
t.Errorf("error mismatch: have: %v, want: %v", err, ErrBlacklistedHash)
}
```

```
}
// Tests that bad hashes are detected on boot, and the chain rolled back to a
// good state prior to the bad hash.
func TestReorgBadHeaderHashes(t *testing.T) { testReorgBadHashes(t, false) }
func TestReorgBadBlockHashes(t *testing.T) { testReorgBadHashes(t, true) }
func testReorgBadHashes(t *testing.T, full bool) {
bc := newTestBlockChain(true)
// Create a chain, import and ban afterwards
headers := makeHeaderChainWithDiff(bc.genesisBlock, []int{1, 2, 3, 4}, 10)
blocks := makeBlockChainWithDiff(bc.genesisBlock, []int{1, 2, 3, 4}, 10)
if full {
if _, err := bc.InsertChain(blocks); err != nil {
t.Fatalf("failed to import blocks: %v", err)
}
if bc.CurrentBlock().Hash() != blocks[3].Hash() {
t.Errorf("last block hash mismatch: have: %x, want %x", bc.CurrentBlock().Hash(),
blocks[3].Header().Hash())
}
BadHashes[blocks[3].Header().Hash()] = true
defer func() { delete(BadHashes, blocks[3].Header().Hash()) }()
} else {
if _, err := bc.InsertHeaderChain(headers, 1); err != nil {
t.Fatalf("failed to import headers: %v", err)
}
if bc.CurrentHeader().Hash() != headers[3].Hash() {
t.Errorf("last header hash mismatch: have: %x, want %x", bc.CurrentHeader().Hash(),
headers[3].Hash())
}
BadHashes[headers[3].Hash()] = true
defer func() { delete(BadHashes, headers[3].Hash()) }()
}
// Create a new BlockChain and check that it rolled back the state.
ncm, err := NewBlockChain(bc.chainDb, bc.config, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
if err != nil {
t.Fatalf("failed to create new chain manager: %v", err)
}
```

```
if full {
if ncm.CurrentBlock().Hash() != blocks[2].Header().Hash() {
t.Errorf("last block hash mismatch: have: %x, want %x", ncm.CurrentBlock().Hash(),
blocks[2].Header().Hash())
}
if blocks[2].Header().GasLimit.Cmp(ncm.GasLimit()) != 0 {
t.Errorf("last_block gasLimit mismatch: have: %x, want %x", ncm.GasLimit(),
blocks[2].Header().GasLimit)
} else {
if ncm.CurrentHeader().Hash() != headers[2].Hash() {
t.Errorf("last header hash mismatch: have: %x, want %x", ncm.CurrentHeader().Hash(),
headers[2].Hash())
}
}
}
// Tests chain insertions in the face of one entity containing an invalid nonce.
func TestHeadersInsertNonceError(t *testing.T) { testInsertNonceError(t, false) }
func TestBlocksInsertNonceError(t *testing.T) { testInsertNonceError(t, true) }
func testInsertNonceError(t *testing.T, full bool) {
for i := 1; i < 25 && !t.Failed(); i++ {
// Create a pristine chain and database
db, blockchain, err := newCanonical(0, full)
if err != nil {
t.Fatalf("failed to create pristine chain: %v", err)
}
// Create and insert a chain with a failing nonce
var (
failAt int
failRes int
failNum uint64
if full {
blocks := makeBlockChain(blockchain.CurrentBlock(), i, db, 0)
failAt = rand.Int() % len(blocks)
failNum = blocks[failAt].NumberU64()
blockchain.engine = ethash.NewFakeFailer(failNum)
failRes, err = blockchain.InsertChain(blocks)
```

```
} else {
headers := makeHeaderChain(blockchain.CurrentHeader(), i, db, 0)
failAt = rand.Int() % len(headers)
failNum = headers[failAt].Number.Uint64()
blockchain.engine = ethash.NewFakeFailer(failNum)
blockchain.hc.engine = blockchain.engine
failRes, err = blockchain.InsertHeaderChain(headers, 1)
}
// Check that the returned error indicates the failure.
if failRes != failAt {
t.Errorf("test %d: failure index mismatch: have %d, want %d", i, failRes, failAt)
// Check that all no blocks after the failing block have been inserted.
for j := 0; j < i-failAt; j++ {
if full {
if block := blockchain.GetBlockByNumber(failNum + uint64(j)); block != nil {
t.Errorf("test %d: invalid block in chain: %v", i, block)
}
} else {
if header := blockchain.GetHeaderByNumber(failNum + uint64(j)); header != nil {
t.Errorf("test %d: invalid header in chain: %v", i, header)
}
}
}
}
// Tests that fast importing a block chain produces the same chain data as the
// classical full block processing.
func TestFastVsFullChains(t *testing.T) {
// Configure and generate a sample block chain
var (
gendb, _ = ethdb.NewMemDatabase()
key, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
address = crypto.PubkeyToAddress(key.PublicKey)
funds = big.NewInt(1000000000)
gspec = &Genesis{
Config: params.TestChainConfig,
```

```
Alloc: GenesisAlloc{address: {Balance: funds}},
}
genesis = gspec.MustCommit(gendb)
signer = types.NewEIP155Signer(gspec.Config.ChainId)
)
blocks, receipts := GenerateChain(gspec.Config, genesis, gendb, 1024, func(i int, block
*BlockGen) {
block.SetCoinbase(common.Address{0x00})
// If the block number is multiple of 3, send a few bonus transactions to the miner
if i\%3 == 2 {
for j := 0; j < i\%4+1; j++ {
tx, err := types.SignTx(types.NewTransaction(block.TxNonce(address), common.Address{0x00},
big.NewInt(1000), bigTxGas, nil, nil), signer, key)
if err != nil {
panic(err)
block.AddTx(tx)
}
// If the block number is a multiple of 5, add a few bonus uncles to the block
if i%5 == 5 {
block.AddUncle(&types.Header{ParentHash: block.PrevBlock(i - 1).Hash(), Number:
big.NewInt(int64(i - 1))})
}
})
// Import the chain as an archive node for the comparison baseline
archiveDb, _ := ethdb.NewMemDatabase()
gspec.MustCommit(archiveDb)
archive, _ := NewBlockChain(archiveDb, gspec.Config, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
if n, err := archive.InsertChain(blocks); err != nil {
t.Fatalf("failed to process block %d: %v", n, err)
}
// Fast import the chain as a non-archive node to test
fastDb, _ := ethdb.NewMemDatabase()
gspec.MustCommit(fastDb)
fast, _ := NewBlockChain(fastDb, gspec.Config, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
```

```
headers := make([]*types.Header, len(blocks))
for i, block := range blocks {
headers[i] = block.Header()
if n, err := fast.InsertHeaderChain(headers, 1); err != nil {
t.Fatalf("failed to insert header %d: %v", n, err)
}
if n, err := fast.InsertReceiptChain(blocks, receipts); err != nil {
t.Fatalf("failed to insert receipt %d: %v", n, err)
}
// Iterate over all chain data components, and cross reference
for i := 0; i < len(blocks); i++ \{
num, hash := blocks[i].NumberU64(), blocks[i].Hash()
if ftd, atd := fast.GetTdByHash(hash), archive.GetTdByHash(hash); ftd.Cmp(atd) != 0 {
t.Errorf("block #%d [%x]: td mismatch: have %v, want %v", num, hash, ftd, atd)
}
if fheader, aheader := fast.GetHeaderByHash(hash), archive.GetHeaderByHash(hash);
fheader.Hash() != aheader.Hash() {
t.Errorf("block #%d [%x]: header mismatch: have %v, want %v", num, hash, fheader, aheader)
}
if fblock, ablock := fast.GetBlockByHash(hash), archive.GetBlockByHash(hash); fblock.Hash() !=
ablock.Hash() {
t.Errorf("block #%d [%x]: block mismatch: have %v, want %v", num, hash, fblock, ablock)
} else if types.DeriveSha(fblock.Transactions()) != types.DeriveSha(ablock.Transactions()) {
t.Errorf("block #%d [%x]: transactions mismatch: have %v, want %v", num, hash,
fblock.Transactions(), ablock.Transactions())
} else if types.CalcUncleHash(fblock.Uncles()) != types.CalcUncleHash(ablock.Uncles()) {
t.Errorf("block #%d [%x]: uncles mismatch: have %v, want %v", num, hash, fblock.Uncles(),
ablock.Uncles())
}
if freceipts, areceipts := GetBlockReceipts(fastDb, hash, GetBlockNumber(fastDb, hash)),
GetBlockReceipts(archiveDb, hash, GetBlockNumber(archiveDb, hash));
types.DeriveSha(freceipts) != types.DeriveSha(areceipts) {
t.Errorf("block #%d [%x]: receipts mismatch: have %v, want %v", num, hash, freceipts, areceipts)
}
// Check that the canonical chains are the same between the databases
for i := 0; i < len(blocks)+1; i++ {
if fhash, ahash := GetCanonicalHash(fastDb, uint64(i)), GetCanonicalHash(archiveDb, uint64(i));
fhash != ahash {
t.Errorf("block #%d: canonical hash mismatch: have %v, want %v", i, fhash, ahash)
```

```
}
}
}
// Tests that various import methods move the chain head pointers to the correct
// positions.
func TestLightVsFastVsFullChainHeads(t *testing.T) {
// Configure and generate a sample block chain
var (
gendb, _ = ethdb.NewMemDatabase()
key, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
address = crypto.PubkeyToAddress(key.PublicKey)
funds = big.NewInt(1000000000)
gspec = &Genesis{Config: params.TestChainConfig, Alloc: GenesisAlloc{address: {Balance:
funds}}}
genesis = gspec.MustCommit(gendb)
height := uint64(1024)
blocks, receipts := GenerateChain(gspec.Config, genesis, gendb, int(height), nil)
// Configure a subchain to roll back
remove := []common.Hash{}
for _, block := range blocks[height/2:] {
remove = append(remove, block.Hash())
}
// Create a small assertion method to check the three heads
assert := func(t *testing.T, kind string, chain *BlockChain, header uint64, fast uint64, block uint64)
if num := chain.CurrentBlock().NumberU64(); num != block {
t.Errorf("%s head block mismatch: have #%v, want #%v", kind, num, block)
}
if num := chain.CurrentFastBlock().NumberU64(); num != fast {
t.Errorf("%s head fast-block mismatch: have #%v, want #%v", kind, num, fast)
}
if num := chain.CurrentHeader().Number.Uint64(); num != header {
t.Errorf("%s head header mismatch: have #%v, want #%v", kind, num, header)
}
}
// Import the chain as an archive node and ensure all pointers are updated
archiveDb, _ := ethdb.NewMemDatabase()
```

```
gspec.MustCommit(archiveDb)
archive, _ := NewBlockChain(archiveDb, gspec.Config, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
if n, err := archive.InsertChain(blocks); err != nil {
t.Fatalf("failed to process block %d: %v", n, err)
}
assert(t, "archive", archive, height, height, height)
archive.Rollback(remove)
assert(t, "archive", archive, height/2, height/2, height/2)
// Import the chain as a non-archive node and ensure all pointers are updated
fastDb, _ := ethdb.NewMemDatabase()
gspec.MustCommit(fastDb)
fast, := NewBlockChain(fastDb, gspec.Config, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
headers := make([]*types.Header, len(blocks))
for i, block := range blocks {
headers[i] = block.Header()
}
if n, err := fast.InsertHeaderChain(headers, 1); err != nil {
t.Fatalf("failed to insert header %d: %v", n, err)
if n, err := fast.InsertReceiptChain(blocks, receipts); err != nil {
t.Fatalf("failed to insert receipt %d: %v", n, err)
}
assert(t, "fast", fast, height, height, 0)
fast.Rollback(remove)
assert(t, "fast", fast, height/2, height/2, 0)
// Import the chain as a light node and ensure all pointers are updated
lightDb, _ := ethdb.NewMemDatabase()
gspec.MustCommit(lightDb)
light, _ := NewBlockChain(lightDb, gspec.Config, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
if n, err := light.InsertHeaderChain(headers, 1); err != nil {
t.Fatalf("failed to insert header %d: %v", n, err)
}
assert(t, "light", light, height, 0, 0)
light.Rollback(remove)
```

```
assert(t, "light", light, height/2, 0, 0)
}
// Tests that chain reorganisations handle transaction removals and reinsertions.
func TestChainTxReorgs(t *testing.T) {
var (
key1, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
key2, _ =
crypto.HexToECDSA("8a1f9a8f95be41cd7ccb6168179afb4504aefe388d1e14474d32c45c72ce7b
7a")
key3, =
crypto.HexToECDSA("49a7b37aa6f6645917e7b807e9d1c00d4fa71f18343b0d4122a4d2df64dd6f
ee")
addr1 = crypto.PubkeyToAddress(key1.PublicKey)
addr2 = crypto.PubkeyToAddress(key2.PublicKey)
addr3 = crypto.PubkeyToAddress(key3.PublicKey)
db, _ = ethdb.NewMemDatabase()
gspec = &Genesis{
Config: params.TestChainConfig,
GasLimit: 3141592,
Alloc: GenesisAlloc{
addr1: {Balance: big.NewInt(1000000)},
addr2: {Balance: big.NewInt(1000000)},
addr3: {Balance: big.NewInt(1000000)},
},
}
genesis = gspec.MustCommit(db)
signer = types.NewEIP155Signer(gspec.Config.ChainId)
)
// Create two transactions shared between the chains:
// - postponed: transaction included at a later block in the forked chain
// - swapped: transaction included at the same block number in the forked chain
postponed, _ := types.SignTx(types.NewTransaction(0, addr1, big.NewInt(1000), bigTxGas, nil,
nil), signer, key1)
swapped, _ := types.SignTx(types.NewTransaction(1, addr1, big.NewInt(1000), bigTxGas, nil, nil),
signer, key1)
// Create two transactions that will be dropped by the forked chain:
// - pastDrop: transaction dropped retroactively from a past block
```

```
// - freshDrop: transaction dropped exactly at the block where the reorg is detected
var pastDrop, freshDrop *types.Transaction
// Create three transactions that will be added in the forked chain:
// - pastAdd: transaction added before the reorganization is detected
// - freshAdd: transaction added at the exact block the reorg is detected
// - futureAdd: transaction added after the reorg has already finished
var pastAdd, freshAdd, futureAdd *types.Transaction
chain, _ := GenerateChain(gspec.Config, genesis, db, 3, func(i int, gen *BlockGen) {
switch i {
case 0:
pastDrop, _ = types.SignTx(types.NewTransaction(gen.TxNonce(addr2), addr2, big.NewInt(1000),
bigTxGas, nil, nil), signer, key2)
gen.AddTx(pastDrop) // This transaction will be dropped in the fork from below the split point
gen.AddTx(postponed) // This transaction will be postponed till block #3 in the fork
case 2:
freshDrop, _ = types.SignTx(types.NewTransaction(gen.TxNonce(addr2), addr2,
big.NewInt(1000), bigTxGas, nil, nil), signer, key2)
gen.AddTx(freshDrop) // This transaction will be dropped in the fork from exactly at the split point
gen.AddTx(swapped) // This transaction will be swapped out at the exact height
gen.OffsetTime(9) // Lower the block difficulty to simulate a weaker chain
}
})
// Import the chain. This runs all block validation rules.
evmux := &event.TypeMux{}
blockchain, _ := NewBlockChain(db, gspec.Config, ethash.NewFaker(), evmux, vm.Config{})
if i, err := blockchain.InsertChain(chain); err != nil {
t.Fatalf("failed to insert original chain[%d]: %v", i, err)
}
// overwrite the old chain
chain, _ = GenerateChain(gspec.Config, genesis, db, 5, func(i int, gen *BlockGen) {
switch i {
case 0:
pastAdd, _ = types.SignTx(types.NewTransaction(gen.TxNonce(addr3), addr3, big.NewInt(1000),
bigTxGas, nil, nil), signer, key3)
gen.AddTx(pastAdd) // This transaction needs to be injected during reorg
```

```
case 2:
gen.AddTx(postponed) // This transaction was postponed from block #1 in the original chain
gen.AddTx(swapped) // This transaction was swapped from the exact current spot in the original
chain
freshAdd, _ = types.SignTx(types.NewTransaction(gen.TxNonce(addr3), addr3, big.NewInt(1000),
bigTxGas, nil, nil), signer, key3)
gen.AddTx(freshAdd) // This transaction will be added exactly at reorg time
case 3:
futureAdd, _ = types.SignTx(types.NewTransaction(gen.TxNonce(addr3), addr3,
big.NewInt(1000), bigTxGas, nil, nil), signer, key3)
gen.AddTx(futureAdd) // This transaction will be added after a full reorg
}
})
if _, err := blockchain.InsertChain(chain); err != nil {
t.Fatalf("failed to insert forked chain: %v", err)
}
// removed tx
for i, tx := range (types.Transactions{pastDrop, freshDrop}) {
if txn, _, _, := GetTransaction(db, tx.Hash()); txn != nil {
t.Errorf("drop %d: tx %v found while shouldn't have been", i, txn)
if GetReceipt(db, tx.Hash()) != nil {
t.Errorf("drop %d: receipt found while shouldn't have been", i)
}
// added tx
for i, tx := range (types.Transactions{pastAdd, freshAdd, futureAdd}) {
if txn, , := GetTransaction(db, tx.Hash()); txn == nil {
t.Errorf("add %d: expected tx to be found", i)
if GetReceipt(db, tx.Hash()) == nil {
t.Errorf("add %d: expected receipt to be found", i)
}
}
// shared tx
for i, tx := range (types.Transactions{postponed, swapped}) {
if txn, _, _, _ := GetTransaction(db, tx.Hash()); txn == nil {
```

t.Errorf("share %d: expected tx to be found", i)

```
}
if GetReceipt(db, tx.Hash()) == nil {
t.Errorf("share %d: expected receipt to be found", i)
}
}
}
func TestLogReorgs(t *testing.T) {
var (
key1, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
addr1 = crypto.PubkeyToAddress(key1.PublicKey)
db, _ = ethdb.NewMemDatabase()
// this code generates a log
code =
common.Hex2Bytes("60606040525b7f24ec1d3ff24c2f6ff210738839dbc339cd45a5294d85c79361
016243157aae7b60405180905060405180910390a15b600a8060416000396000f3606060405260
08565b00")
gspec = &Genesis{Config: params.TestChainConfig, Alloc: GenesisAlloc{addr1: {Balance:
big.NewInt(10000000000000)}}}
genesis = gspec.MustCommit(db)
signer = types.NewEIP155Signer(gspec.Config.ChainId)
)
var evmux event. Type Mux
blockchain, _ := NewBlockChain(db, gspec.Config, ethash.NewFaker(), &evmux, vm.Config{})
subs := evmux.Subscribe(RemovedLogsEvent{})
chain, _ := GenerateChain(params.TestChainConfig, genesis, db, 2, func(i int, gen *BlockGen) {
if i == 1 {
tx, err := types.SignTx(types.NewContractCreation(gen.TxNonce(addr1), new(big.Int),
big.NewInt(1000000), new(big.Int), code), signer, key1)
if err != nil {
t.Fatalf("failed to create tx: %v", err)
}
gen.AddTx(tx)
}
})
if _, err := blockchain.InsertChain(chain); err != nil {
t.Fatalf("failed to insert chain: %v", err)
```

```
}
chain, _ = GenerateChain(params.TestChainConfig, genesis, db, 3, func(i int, gen *BlockGen) {})
if _, err := blockchain.InsertChain(chain); err != nil {
t.Fatalf("failed to insert forked chain: %v", err)
}
ev := <-subs.Chan()
if len(ev.Data.(RemovedLogsEvent).Logs) == 0 {
t.Error("expected logs")
}
}
func TestReorgSideEvent(t *testing.T) {
var (
db, _ = ethdb.NewMemDatabase()
key1, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
addr1 = crypto.PubkeyToAddress(key1.PublicKey)
gspec = &Genesis{
Config: params.TestChainConfig,
Alloc: GenesisAlloc{addr1: {Balance: big.NewInt(1000000000000)}},
genesis = gspec.MustCommit(db)
signer = types.NewEIP155Signer(gspec.Config.ChainId)
)
evmux := &event.TypeMux{}
blockchain, _ := NewBlockChain(db, gspec.Config, ethash.NewFaker(), evmux, vm.Config{})
chain, _ := GenerateChain(gspec.Config, genesis, db, 3, func(i int, gen *BlockGen) {})
if _, err := blockchain.InsertChain(chain); err != nil {
t.Fatalf("failed to insert chain: %v", err)
}
replacementBlocks, _ := GenerateChain(gspec.Config, genesis, db, 4, func(i int, gen *BlockGen) {
tx, err := types.SignTx(types.NewContractCreation(gen.TxNonce(addr1), new(big.Int),
big.NewInt(1000000), new(big.Int), nil), signer, key1)
if i == 2 {
gen.OffsetTime(-1)
}
```

```
if err != nil {
t.Fatalf("failed to create tx: %v", err)
}
gen.AddTx(tx)
})
subs := evmux.Subscribe(ChainSideEvent{})
if _, err := blockchain.InsertChain(replacementBlocks); err != nil {
t.Fatalf("failed to insert chain: %v", err)
}
// first two block of the secondary chain are for a brief moment considered
// side chains because up to that point the first one is considered the
// heavier chain.
expectedSideHashes := map[common.Hash]bool{
replacementBlocks[0].Hash(): true,
replacementBlocks[1].Hash(): true,
chain[0].Hash():
                        true,
chain[1].Hash():
                        true,
chain[2].Hash():
                        true,
}
i := 0
const timeoutDura = 10 * time.Second
timeout := time.NewTimer(timeoutDura)
done:
for {
select {
case ev := <-subs.Chan():
block := ev.Data.(ChainSideEvent).Block
if _, ok := expectedSideHashes[block.Hash()]; !ok {
t.Errorf("%d: didn't expect %x to be in side chain", i, block.Hash())
}
i++
if i == len(expectedSideHashes) {
timeout.Stop()
break done
timeout.Reset(timeoutDura)
```

```
case <-timeout.C:
t.Fatal("Timeout. Possibly not all blocks were triggered for sideevent")
}
}
// make sure no more events are fired
select {
case e := <-subs.Chan():
t.Errorf("unexpected event fired: %v", e)
case <-time.After(250 * time.Millisecond):
}
}
// Tests if the canonical block can be fetched from the database during chain insertion.
func TestCanonicalBlockRetrieval(t *testing.T) {
bc := newTestBlockChain(false)
chain, _ := GenerateChain(bc.config, bc.genesisBlock, bc.chainDb, 10, func(i int, gen *BlockGen)
{})
for i := range chain {
go func(block *types.Block) {
// try to retrieve a block by its canonical hash and see if the block data can be retrieved.
for {
ch := GetCanonicalHash(bc.chainDb, block.NumberU64())
if ch == (common.Hash{}) {
continue // busy wait for canonical hash to be written
}
if ch != block.Hash() {
t.Fatalf("unknown canonical hash, want %s, got %s", block.Hash().Hex(), ch.Hex())
}
fb := GetBlock(bc.chainDb, ch, block.NumberU64())
if fb == nil \{
t.Fatalf("unable to retrieve block %d for canonical hash: %s", block.NumberU64(), ch.Hex())
if fb.Hash() != block.Hash() {
t.Fatalf("invalid block hash for block %d, want %s, got %s", block.NumberU64(),
block.Hash().Hex(), fb.Hash().Hex())
return
}
}(chain[i])
```

```
bc.InsertChain(types.Blocks{chain[i]})
}
}
func TestEIP155Transition(t *testing.T) {
// Configure and generate a sample block chain
var (
db, _
        = ethdb.NewMemDatabase()
key, _
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
address = crypto.PubkeyToAddress(key.PublicKey)
        = big.NewInt(1000000000)
deleteAddr = common.Address{1}
         = &Genesis{
gspec
Config: &params.ChainConfig{ChainId: big.NewInt(1), EIP155Block: big.NewInt(2),
HomesteadBlock: new(big.Int)},
Alloc: GenesisAlloc{address: {Balance: funds}, deleteAddr: {Balance: new(big.Int)}},
}
genesis = gspec.MustCommit(db)
mux
      event.TypeMux
)
blockchain, _ := NewBlockChain(db, gspec.Config, ethash.NewFaker(), &mux, vm.Config{})
blocks, _ := GenerateChain(gspec.Config, genesis, db, 4, func(i int, block *BlockGen) {
var (
tx
     *types.Transaction
err
basicTx = func(signer types.Signer) (*types.Transaction, error) {
return types.SignTx(types.NewTransaction(block.TxNonce(address), common.Address{},
new(big.Int), big.NewInt(21000), new(big.Int), nil), signer, key)
}
switch i {
case 0:
tx, err = basicTx(types.HomesteadSigner{})
if err != nil {
t.Fatal(err)
}
block.AddTx(tx)
case 2:
```

```
tx, err = basicTx(types.HomesteadSigner{})
if err != nil {
t.Fatal(err)
block.AddTx(tx)
tx, err = basicTx(types.NewEIP155Signer(gspec.Config.ChainId))
if err != nil {
t.Fatal(err)
}
block.AddTx(tx)
case 3:
tx, err = basicTx(types.HomesteadSigner{})
if err != nil {
t.Fatal(err)
}
block.AddTx(tx)
tx, err = basicTx(types.NewEIP155Signer(gspec.Config.ChainId))
if err != nil {
t.Fatal(err)
}
block.AddTx(tx)
})
if _, err := blockchain.InsertChain(blocks); err != nil {
t.Fatal(err)
block := blockchain.GetBlockByNumber(1)
if block.Transactions()[0].Protected() {
t.Error("Expected block[0].txs[0] to not be replay protected")
}
block = blockchain.GetBlockByNumber(3)
if block.Transactions()[0].Protected() {
t.Error("Expected block[3].txs[0] to not be replay protected")
}
if !block.Transactions()[1].Protected() {
t.Error("Expected block[3].txs[1] to be replay protected")
}
if _, err := blockchain.InsertChain(blocks[4:]); err != nil {
```

```
t.Fatal(err)
}
// generate an invalid chain id transaction
config := &params.ChainConfig{ChainId: big.NewInt(2), EIP155Block: big.NewInt(2),
HomesteadBlock: new(big.Int)}
blocks, _ = GenerateChain(config, blocks[len(blocks)-1], db, 4, func(i int, block *BlockGen) {
var (
tx
     *types.Transaction
     error
err
basicTx = func(signer types.Signer) (*types.Transaction, error) {
return types.SignTx(types.NewTransaction(block.TxNonce(address), common.Address{},
new(big.Int), big.NewInt(21000), new(big.Int), nil), signer, key)
}
)
switch i {
case 0:
tx, err = basicTx(types.NewEIP155Signer(big.NewInt(2)))
if err != nil {
t.Fatal(err)
}
block.AddTx(tx)
}
})
_, err := blockchain.InsertChain(blocks)
if err != types.ErrInvalidChainId {
t.Error("expected error:", types.ErrInvalidChainId)
}
}
func TestEIP161AccountRemoval(t *testing.T) {
// Configure and generate a sample block chain
var (
db, _ = ethdb.NewMemDatabase()
key, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
address = crypto.PubkeyToAddress(key.PublicKey)
funds = big.NewInt(1000000000)
theAddr = common.Address{1}
gspec = &Genesis{
Config: &params.ChainConfig{
```

```
ChainId:
             big.NewInt(1),
HomesteadBlock: new(big.Int),
EIP155Block: new(big.Int),
EIP158Block: big.NewInt(2),
},
Alloc: GenesisAlloc{address: {Balance: funds}},
}
genesis
            = gspec.MustCommit(db)
mux
           event.TypeMux
blockchain, _ = NewBlockChain(db, gspec.Config, ethash.NewFaker(), &mux, vm.Config{})
)
blocks, _ := GenerateChain(gspec.Config, genesis, db, 3, func(i int, block *BlockGen) {
var (
    *types.Transaction
tx
err error
signer = types.NewEIP155Signer(gspec.Config.ChainId)
)
switch i {
case 0:
tx, err = types.SignTx(types.NewTransaction(block.TxNonce(address), theAddr, new(big.Int),
big.NewInt(21000), new(big.Int), nil), signer, key)
case 1:
tx, err = types.SignTx(types.NewTransaction(block.TxNonce(address), theAddr, new(big.Int),
big.NewInt(21000), new(big.Int), nil), signer, key)
case 2:
tx, err = types.SignTx(types.NewTransaction(block.TxNonce(address), theAddr, new(big.Int),
big.NewInt(21000), new(big.Int), nil), signer, key)
}
if err != nil {
t.Fatal(err)
}
block.AddTx(tx)
})
// account must exist pre eip 161
if _, err := blockchain.InsertChain(types.Blocks{blocks[0]}); err != nil {
t.Fatal(err)
}
if st, _ := blockchain.State(); !st.Exist(theAddr) {
t.Error("expected account to exist")
}
```

// account needs to be deleted post eip 161

```
if , err := blockchain.InsertChain(types.Blocks{blocks[1]}); err != nil {
t.Fatal(err)
}
if st, := blockchain.State(); st.Exist(theAddr) {
t.Error("account should not exist")
}
// account musn't be created post eip 161
if _, err := blockchain.InsertChain(types.Blocks{blocks[2]}); err != nil {
t.Fatal(err)
if st, _ := blockchain.State(); st.Exist(theAddr) {
t.Error("account should not exist")
}
64:F:\git\coin\ethereum\go-ethereum\core\blocks.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import "github.com/ethereum/go-ethereum/common"
// BadHashes represent a set of manually tracked bad hashes (usually hard forks)
var BadHashes = map[common.Hash]bool{
common.HexToHash("05bef30ef572270f654746da22639a7a0c97dd97a7050b9e252391996aaeb
689"): true,
common.HexToHash("7d05d08cbc596a2e5e4f13b80a743e53e09221b5323c3a61946b20873e585
83f"): true,
}
65:F:\git\coin\ethereum\go-ethereum\core\block_validator.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"fmt"
"math/big"
"github.com/ethereum/go-ethereum/common/math"
"github.com/ethereum/go-ethereum/consensus"
```

```
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/params"
)
// BlockValidator is responsible for validating block headers, uncles and
// processed state.
//
// BlockValidator implements Validator.
type BlockValidator struct {
config *params.ChainConfig // Chain configuration options
bc
     *BlockChain
                       // Canonical block chain
engine consensus. Engine // Consensus engine used for validating
}
// NewBlockValidator returns a new block validator which is safe for re-use
func NewBlockValidator(config *params.ChainConfig, blockchain *BlockChain, engine
consensus.Engine) *BlockValidator {
validator := &BlockValidator{
config: config,
engine: engine,
      blockchain,
bc:
}
return validator
// ValidateBody validates the given block's uncles and verifies the the block
// header's transaction and uncle roots. The headers are assumed to be already
// validated at this point.
func (v *BlockValidator) ValidateBody(block *types.Block) error {
// Check whether the block's known, and if not, that it's linkable
if v.bc.HasBlockAndState(block.Hash()) {
return ErrKnownBlock
if !v.bc.HasBlockAndState(block.ParentHash()) {
return consensus. ErrUnknown Ancestor
}
// Header validity is known at this point, check the uncles and transactions
header := block.Header()
if err := v.engine.VerifyUncles(v.bc, block); err != nil {
return err
}
```

```
if hash := types.CalcUncleHash(block.Uncles()); hash != header.UncleHash {
return fmt.Errorf("uncle root hash mismatch: have %x, want %x", hash, header.UncleHash)
}
if hash := types.DeriveSha(block.Transactions()); hash != header.TxHash {
return fmt.Errorf("transaction root hash mismatch: have %x, want %x", hash, header.TxHash)
return nil
}
// ValidateState validates the various changes that happen after a state
// transition, such as amount of used gas, the receipt roots and the state root
// itself. ValidateState returns a database batch if the validation was a success
// otherwise nil and an error is returned.
func (v *BlockValidator) ValidateState(block, parent *types.Block, statedb *state.StateDB, receipts
types.Receipts, usedGas *big.Int) error {
header := block.Header()
if block.GasUsed().Cmp(usedGas) != 0 {
return fmt.Errorf("invalid gas used (remote: %v local: %v)", block.GasUsed(), usedGas)
// Validate the received block's bloom with the one derived from the generated receipts.
// For valid blocks this should always validate to true.
rbloom := types.CreateBloom(receipts)
if rbloom != header.Bloom {
return fmt.Errorf("invalid bloom (remote: %x local: %x)", header.Bloom, rbloom)
// Tre receipt Trie's root (R = (Tr [[H1, R1], ... [Hn, R1]]))
receiptSha := types.DeriveSha(receipts)
if receiptSha != header.ReceiptHash {
return fmt.Errorf("invalid receipt root hash (remote: %x local: %x)", header.ReceiptHash,
receiptSha)
// Validate the state root against the received state root and throw
// an error if they don't match.
if root := statedb.IntermediateRoot(v.config.IsEIP158(header.Number)); header.Root != root {
return fmt.Errorf("invalid merkle root (remote: %x local: %x)", header.Root, root)
}
return nil
}
// CalcGasLimit computes the gas limit of the next block after parent.
// The result may be modified by the caller.
// This is miner strategy, not consensus protocol.
```

```
func CalcGasLimit(parent *types.Block) *big.Int {
// contrib = (parentGasUsed * 3 / 2) / 1024
contrib := new(big.Int).Mul(parent.GasUsed(), big.NewInt(3))
contrib = contrib.Div(contrib, big.NewInt(2))
contrib = contrib.Div(contrib, params.GasLimitBoundDivisor)
// decay = parentGasLimit / 1024 -1
decay := new(big.Int).Div(parent.GasLimit(), params.GasLimitBoundDivisor)
decay.Sub(decay, big.NewInt(1))
/*
strategy: gasLimit of block-to-mine is set based on parent's
gasUsed value. if parentGasUsed > parentGasLimit * (2/3) then we
increase it, otherwise lower it (or leave it unchanged if it's right
at that usage) the amount increased/decreased depends on how far away
from parentGasLimit * (2/3) parentGasUsed is.
*/
gl := new(big.Int).Sub(parent.GasLimit(), decay)
gl = gl.Add(gl, contrib)
gl.Set(math.BigMax(gl, params.MinGasLimit))
// however, if we're now below the target (TargetGasLimit) we increase the
// limit as much as we can (parentGasLimit / 1024 -1)
if gl.Cmp(params.TargetGasLimit) < 0 {
gl.Add(parent.GasLimit(), decay)
gl.Set(math.BigMin(gl, params.TargetGasLimit))
}
return gl
}
66:F:\git\coin\ethereum\go-ethereum\core\block_validator_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"runtime"
"testing"
"time"
"github.com/ethereum/go-ethereum/consensus/ethash"
"github.com/ethereum/go-ethereum/core/types"
```

```
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/params"
)
// Tests that simple header verification works, for both good and bad blocks.
func TestHeaderVerification(t *testing.T) {
// Create a simple chain to verify
var (
testdb, _ = ethdb.NewMemDatabase()
         = &Genesis{Config: params.TestChainConfig}
genesis = gspec.MustCommit(testdb)
blocks, _ = GenerateChain(params.TestChainConfig, genesis, testdb, 8, nil)
)
headers := make([]*types.Header, len(blocks))
for i, block := range blocks {
headers[i] = block.Header()
// Run the header checker for blocks one-by-one, checking for both valid and invalid nonces
chain, _ := NewBlockChain(testdb, params.TestChainConfig, ethash.NewFaker(),
new(event.TypeMux), vm.Config{})
for i := 0; i < len(blocks); i++ {
for j, valid := range []bool{true, false} {
var results <-chan error
if valid {
engine := ethash.NewFaker()
_, results = engine.VerifyHeaders(chain, []*types.Header{headers[i]}, []bool{true})
} else {
engine := ethash.NewFakeFailer(headers[i].Number.Uint64())
_, results = engine.VerifyHeaders(chain, []*types.Header{headers[i]}, []bool{true})
// Wait for the verification result
select {
case result := <-results:
if (result == nil) != valid {
t.Errorf("test %d.%d: validity mismatch: have %v, want %v", i, j, result, valid)
}
case <-time.After(time.Second):
t.Fatalf("test %d.%d: verification timeout", i, j)
```

```
}
// Make sure no more data is returned
select {
case result := <-results:
t.Fatalf("test %d.%d: unexpected result returned: %v", i, j, result)
case <-time.After(25 * time.Millisecond):
}
}
chain.InsertChain(blocks[i:i+1])
}
}
// Tests that concurrent header verification works, for both good and bad blocks.
func TestHeaderConcurrentVerification2(t *testing.T) { testHeaderConcurrentVerification(t, 2) }
func TestHeaderConcurrentVerification8(t *testing.T) { testHeaderConcurrentVerification(t, 8) }
func TestHeaderConcurrentVerification32(t *testing.T) { testHeaderConcurrentVerification(t, 32) }
func testHeaderConcurrentVerification(t *testing.T, threads int) {
// Create a simple chain to verify
var (
testdb, _ = ethdb.NewMemDatabase()
         = &Genesis{Config: params.TestChainConfig}
genesis = gspec.MustCommit(testdb)
blocks, _ = GenerateChain(params.TestChainConfig, genesis, testdb, 8, nil)
headers := make([]*types.Header, len(blocks))
seals := make([]bool, len(blocks))
for i, block := range blocks {
headers[i] = block.Header()
seals[i] = true
}
// Set the number of threads to verify on
old := runtime.GOMAXPROCS(threads)
defer runtime.GOMAXPROCS(old)
// Run the header checker for the entire block chain at once both for a valid and
// also an invalid chain (enough if one arbitrary block is invalid).
for i, valid := range []bool{true, false} {
var results <-chan error
if valid {
```

```
chain, _ := NewBlockChain(testdb, params.TestChainConfig, ethash.NewFaker(),
new(event.TypeMux), vm.Config{})
_, results = chain.engine.VerifyHeaders(chain, headers, seals)
} else {
chain, _ := NewBlockChain(testdb, params.TestChainConfig,
ethash.NewFakeFailer(uint64(len(headers)-1)), new(event.TypeMux), vm.Config{})
_, results = chain.engine.VerifyHeaders(chain, headers, seals)
}
// Wait for all the verification results
checks := make(map[int]error)
for j := 0; j < len(blocks); j++ {
select {
case result := <-results:
checks[j] = result
case <-time.After(time.Second):
t.Fatalf("test %d.%d: verification timeout", i, j)
}
}
// Check nonce check validity
for j := 0; j < len(blocks); j++ {
want := valid || (j < len(blocks)-2) // We chose the last-but-one nonce in the chain to fail
if (checks[j] == nil) != want {
t.Errorf("test %d.%d: validity mismatch: have %v, want %v", i, j, checks[j], want)
if !want {
// A few blocks after the first error may pass verification due to concurrent
// workers. We don't care about those in this test, just that the correct block
// errors out.
break
}
// Make sure no more data is returned
select {
case result := <-results:
t.Fatalf("test %d: unexpected result returned: %v", i, result)
case <-time.After(25 * time.Millisecond):
}
}
}
```

// Tests that aborting a header validation indeed prevents further checks from being

```
// run, as well as checks that no left-over goroutines are leaked.
func TestHeaderConcurrentAbortion2(t *testing.T) { testHeaderConcurrentAbortion(t, 2) }
func TestHeaderConcurrentAbortion8(t *testing.T) { testHeaderConcurrentAbortion(t, 8) }
func TestHeaderConcurrentAbortion32(t *testing.T) { testHeaderConcurrentAbortion(t, 32) }
func testHeaderConcurrentAbortion(t *testing.T, threads int) {
// Create a simple chain to verify
var (
testdb, _ = ethdb.NewMemDatabase()
gspec = &Genesis{Config: params.TestChainConfig}
genesis = gspec.MustCommit(testdb)
blocks, _ = GenerateChain(params.TestChainConfig, genesis, testdb, 1024, nil)
headers := make([]*types.Header, len(blocks))
seals := make([]bool, len(blocks))
for i, block := range blocks {
headers[i] = block.Header()
seals[i] = true
}
// Set the number of threads to verify on
old := runtime.GOMAXPROCS(threads)
defer runtime.GOMAXPROCS(old)
// Start the verifications and immediately abort
chain, _ := NewBlockChain(testdb, params.TestChainConfig,
ethash.NewFakeDelayer(time.Millisecond), new(event.TypeMux), vm.Config{})
abort, results := chain.engine.VerifyHeaders(chain, headers, seals)
close(abort)
// Deplete the results channel
verified := 0
for depleted := false; !depleted; {
select {
case result := <-results:
if result != nil {
t.Errorf("header %d: validation failed: %v", verified, result)
}
verified++
case <-time.After(50 * time.Millisecond):
depleted = true
}
```

```
}
// Check that abortion was honored by not processing too many POWs
if verified > 2*threads {
t.Errorf("verification count too large: have %d, want below %d", verified, 2*threads)
}
}
67:F:\git\coin\ethereum\go-ethereum\core\chain_makers.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"fmt"
"math/big"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/consensus/ethash"
"github.com/ethereum/go-ethereum/consensus/misc"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/params"
)
// So we can deterministically seed different blockchains
var (
canonicalSeed = 1
forkSeed
          = 2
)
// BlockGen creates blocks for testing.
// See GenerateChain for a detailed explanation.
type BlockGen struct {
    int
parent *types.Block
chain []*types.Block
header *types.Header
statedb *state.StateDB
```

```
gasPool *GasPool
      []*types.Transaction
txs
receipts []*types.Receipt
uncles []*types.Header
config *params.ChainConfig
}
// SetCoinbase sets the coinbase of the generated block.
// It can be called at most once.
func (b *BlockGen) SetCoinbase(addr common.Address) {
if b.gasPool != nil {
if len(b.txs) > 0 {
panic("coinbase must be set before adding transactions")
}
panic("coinbase can only be set once")
b.header.Coinbase = addr
b.gasPool = new(GasPool).AddGas(b.header.GasLimit)
}
// SetExtra sets the extra data field of the generated block.
func (b *BlockGen) SetExtra(data []byte) {
b.header.Extra = data
}
// AddTx adds a transaction to the generated block. If no coinbase has
// been set, the block's coinbase is set to the zero address.
//
// AddTx panics if the transaction cannot be executed. In addition to
// the protocol-imposed limitations (gas limit, etc.), there are some
// further limitations on the content of transactions that can be
// added. Notably, contract code relying on the BLOCKHASH instruction
// will panic during execution.
func (b *BlockGen) AddTx(tx *types.Transaction) {
if b.gasPool == nil {
b.SetCoinbase(common.Address{})
}
b.statedb.Prepare(tx.Hash(), common.Hash{}, len(b.txs))
receipt, _, err := ApplyTransaction(b.config, nil, &b.header.Coinbase, b.gasPool, b.statedb,
b.header, tx, b.header.GasUsed, vm.Config{})
if err != nil {
```

```
panic(err)
b.txs = append(b.txs, tx)
b.receipts = append(b.receipts, receipt)
}
// Number returns the block number of the block being generated.
func (b *BlockGen) Number() *big.Int {
return new(big.Int).Set(b.header.Number)
}
// AddUncheckedReceipt forcefully adds a receipts to the block without a
// backing transaction.
//
// AddUncheckedReceipt will cause consensus failures when used during real
// chain processing. This is best used in conjunction with raw block insertion.
func (b *BlockGen) AddUncheckedReceipt(receipt *types.Receipt) {
b.receipts = append(b.receipts, receipt)
}
// TxNonce returns the next valid transaction nonce for the
// account at addr. It panics if the account does not exist.
func (b *BlockGen) TxNonce(addr common.Address) uint64 {
if !b.statedb.Exist(addr) {
panic("account does not exist")
}
return b.statedb.GetNonce(addr)
}
// AddUncle adds an uncle header to the generated block.
func (b *BlockGen) AddUncle(h *types.Header) {
b.uncles = append(b.uncles, h)
}
// PrevBlock returns a previously generated block by number. It panics if
// num is greater or equal to the number of the block being generated.
// For index -1, PrevBlock returns the parent block given to GenerateChain.
func (b *BlockGen) PrevBlock(index int) *types.Block {
if index >= b.i {
panic("block index out of range")
}
if index == -1 {
```

```
return b.parent
return b.chain[index]
}
// OffsetTime modifies the time instance of a block, implicitly changing its
// associated difficulty. It's useful to test scenarios where forking is not
// tied to chain length directly.
func (b *BlockGen) OffsetTime(seconds int64) {
b.header.Time.Add(b.header.Time, new(big.Int).SetInt64(seconds))
if b.header.Time.Cmp(b.parent.Header().Time) <= 0 {
panic("block time out of range")
}
b.header.Difficulty = ethash.CalcDifficulty(b.config, b.header.Time.Uint64(), b.parent.Header())
}
// GenerateChain creates a chain of n blocks. The first block's
// parent will be the provided parent. db is used to store
// intermediate states and should contain the parent's state trie.
//
// The generator function is called with a new block generator for
// every block. Any transactions and uncles added to the generator
// become part of the block. If gen is nil, the blocks will be empty
// and their coinbase will be the zero address.
//
// Blocks created by GenerateChain do not contain valid proof of work
// values. Inserting them into BlockChain requires use of FakePow or
// a similar non-validating proof of work implementation.
func GenerateChain(config *params.ChainConfig, parent *types.Block, db ethdb.Database, n int,
gen func(int, *BlockGen)) ([]*types.Block, []types.Receipts) {
if config == nil {
config = params.TestChainConfig
}
blocks, receipts := make(types.Blocks, n), make([]types.Receipts, n)
genblock := func(i int, h *types.Header, statedb *state.StateDB) (*types.Block, types.Receipts) {
b := &BlockGen{parent: parent, i: i, chain: blocks, header: h, statedb: statedb, config: config}
// Mutate the state and block according to any hard-fork specs
if daoBlock := config.DAOForkBlock; daoBlock != nil {
limit := new(big.Int).Add(daoBlock, params.DAOForkExtraRange)
if h.Number.Cmp(daoBlock) >= 0 && h.Number.Cmp(limit) < 0 {
if config.DAOForkSupport {
h.Extra = common.CopyBytes(params.DAOForkBlockExtra)
```

```
}
}
}
if config.DAOForkSupport && config.DAOForkBlock != nil &&
config.DAOForkBlock.Cmp(h.Number) == 0 {
misc.ApplyDAOHardFork(statedb)
}
// Execute any user modifications to the block and finalize it
if gen != nil {
gen(i, b)
}
ethash.AccumulateRewards(statedb, h, b.uncles)
root, err := statedb.CommitTo(db, config.IsEIP158(h.Number))
if err != nil {
panic(fmt.Sprintf("state write error: %v", err))
}
h.Root = root
return types.NewBlock(h, b.txs, b.uncles, b.receipts), b.receipts
for i := 0; i < n; i++ \{
statedb, err := state.New(parent.Root(), state.NewDatabase(db))
if err != nil {
panic(err)
header := makeHeader(config, parent, statedb)
block, receipt := genblock(i, header, statedb)
blocks[i] = block
receipts[i] = receipt
parent = block
}
return blocks, receipts
}
func makeHeader(config *params.ChainConfig, parent *types.Block, state *state.StateDB)
*types.Header {
var time *big.Int
if parent.Time() == nil {
time = big.NewInt(10)
} else {
time = new(big.Int).Add(parent.Time(), big.NewInt(10)) // block time is fixed at 10 seconds
}
```

```
return &types.Header{
Root:
         state.IntermediateRoot(config.IsEIP158(parent.Number())),
ParentHash: parent.Hash(),
Coinbase: parent.Coinbase(),
Difficulty: ethash.CalcDifficulty(config, time.Uint64(), &types.Header{
           parent.Number(),
Number:
Time:
          new(big.Int).Sub(time, big.NewInt(10)),
Difficulty: parent.Difficulty(),
}),
GasLimit: CalcGasLimit(parent),
GasUsed: new(big.Int),
Number: new(big.Int).Add(parent.Number(), common.Big1),
Time:
        time.
}
}
// newCanonical creates a chain database, and injects a deterministic canonical
// chain. Depending on the full flag, if creates either a full block chain or a
// header only chain.
func newCanonical(n int, full bool) (ethdb.Database, *BlockChain, error) {
// Initialize a fresh chain with only a genesis block
gspec := new(Genesis)
db, _ := ethdb.NewMemDatabase()
genesis := gspec.MustCommit(db)
blockchain, _ := NewBlockChain(db, params.AllProtocolChanges, ethash.NewFaker(),
new(event.TypeMux), vm.Config{})
// Create and inject the requested chain
if n == 0 {
return db, blockchain, nil
}
if full {
// Full block-chain requested
blocks := makeBlockChain(genesis, n, db, canonicalSeed)
_, err := blockchain.InsertChain(blocks)
return db, blockchain, err
}
// Header-only chain requested
headers := makeHeaderChain(genesis.Header(), n, db, canonicalSeed)
_, err := blockchain.InsertHeaderChain(headers, 1)
return db, blockchain, err
}
```

```
// makeHeaderChain creates a deterministic chain of headers rooted at parent.
func makeHeaderChain(parent *types.Header, n int, db ethdb.Database, seed int) []*types.Header
blocks := makeBlockChain(types.NewBlockWithHeader(parent), n, db, seed)
headers := make([]*types.Header, len(blocks))
for i, block := range blocks {
headers[i] = block.Header()
return headers
// makeBlockChain creates a deterministic chain of blocks rooted at parent.
func makeBlockChain(parent *types.Block, n int, db ethdb.Database, seed int) []*types.Block {
blocks, _ := GenerateChain(params.TestChainConfig, parent, db, n, func(i int, b *BlockGen) {
b.SetCoinbase(common.Address{0: byte(seed), 19: byte(i)})
})
return blocks
68:F:\git\coin\ethereum\go-ethereum\core\chain_makers_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"fmt"
"math/big"
"github.com/ethereum/go-ethereum/consensus/ethash"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/params"
)
func ExampleGenerateChain() {
var (
key1, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
```

```
291")
key2, _ =
crypto.HexToECDSA("8a1f9a8f95be41cd7ccb6168179afb4504aefe388d1e14474d32c45c72ce7b
7a")
key3, \underline{\phantom{a}} =
crypto.HexToECDSA("49a7b37aa6f6645917e7b807e9d1c00d4fa71f18343b0d4122a4d2df64dd6f
ee")
addr1 = crypto.PubkeyToAddress(key1.PublicKey)
addr2 = crypto.PubkeyToAddress(key2.PublicKey)
addr3 = crypto.PubkeyToAddress(key3.PublicKey)
db, _ = ethdb.NewMemDatabase()
)
// Ensure that key1 has some funds in the genesis block.
gspec := &Genesis{
Config: &params.ChainConfig{HomesteadBlock: new(big.Int)},
Alloc: GenesisAlloc{addr1: {Balance: big.NewInt(1000000)}},
}
genesis := gspec.MustCommit(db)
// This call generates a chain of 5 blocks. The function runs for
// each block and adds different features to gen based on the
// block index.
signer := types.HomesteadSigner{}
chain, _ := GenerateChain(gspec.Config, genesis, db, 5, func(i int, gen *BlockGen) {
switch i {
case 0:
// In block 1, addr1 sends addr2 some ether.
tx, _ := types.SignTx(types.NewTransaction(gen.TxNonce(addr1), addr2, big.NewInt(10000),
bigTxGas, nil, nil), signer, key1)
gen.AddTx(tx)
case 1:
// In block 2, addr1 sends some more ether to addr2.
// addr2 passes it on to addr3.
tx1, _ := types.SignTx(types.NewTransaction(gen.TxNonce(addr1), addr2, big.NewInt(1000),
bigTxGas, nil, nil), signer, key1)
tx2, _ := types.SignTx(types.NewTransaction(gen.TxNonce(addr2), addr3, big.NewInt(1000),
bigTxGas, nil, nil), signer, key2)
gen.AddTx(tx1)
gen.AddTx(tx2)
case 2:
// Block 3 is empty but was mined by addr3.
```

```
gen.SetCoinbase(addr3)
gen.SetExtra([]byte("yeehaw"))
case 3:
// Block 4 includes blocks 2 and 3 as uncle headers (with modified extra data).
b2 := gen.PrevBlock(1).Header()
b2.Extra = []byte("foo")
gen.AddUncle(b2)
b3 := gen.PrevBlock(2).Header()
b3.Extra = []byte("foo")
gen.AddUncle(b3)
}
})
// Import the chain. This runs all block validation rules.
evmux := &event.TypeMux{}
blockchain, _ := NewBlockChain(db, gspec.Config, ethash.NewFaker(), evmux, vm.Config{})
if i, err := blockchain.InsertChain(chain); err != nil {
fmt.Printf("insert error (block %d): %v\n", chain[i].NumberU64(), err)
return
}
state, _ := blockchain.State()
fmt.Printf("last block: #%d\n", blockchain.CurrentBlock().Number())
fmt.Println("balance of addr1:", state.GetBalance(addr1))
fmt.Println("balance of addr2:", state.GetBalance(addr2))
fmt.Println("balance of addr3:", state.GetBalance(addr3))
// Output:
// last block: #5
// balance of addr1: 989000
// balance of addr2: 10000
// balance of addr3: 19687500000000001000
}
69:F:\git\coin\ethereum\go-ethereum\core\dao.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"bytes"
"fmt"
"math/big"
```

```
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/params"
)
// ValidateDAOHeaderExtraData validates the extra-data field of a block header to
// ensure it conforms to DAO hard-fork rules.
//
// DAO hard-fork extension to the header validity:
// a) if the node is no-fork, do not accept blocks in the [fork, fork+10) range
    with the fork specific extra-data set
// b) if the node is pro-fork, require blocks in the specific range to have the
     unique extra-data set.
func ValidateDAOHeaderExtraData(config *params.ChainConfig, header *types.Header) error {
// Short circuit validation if the node doesn't care about the DAO fork
if config.DAOForkBlock == nil {
return nil
// Make sure the block is within the fork's modified extra-data range
limit := new(big.Int).Add(config.DAOForkBlock, params.DAOForkExtraRange)
if header.Number.Cmp(config.DAOForkBlock) < 0 || header.Number.Cmp(limit) >= 0 {
return nil
// Depending whether we support or oppose the fork, validate the extra-data contents
if config.DAOForkSupport {
if !bytes.Equal(header.Extra, params.DAOForkBlockExtra) {
return fmt.Errorf("DAO pro-fork bad block extra-data: 0x%x", header.Extra)
} else {
if bytes.Equal(header.Extra, params.DAOForkBlockExtra) {
return fmt.Errorf("DAO no-fork bad block extra-data: 0x%x", header.Extra)
}
// All ok, header has the same extra-data we expect
return nil
}
// ApplyDAOHardFork modifies the state database according to the DAO hard-fork
// rules, transferring all balances of a set of DAO accounts to a single refund
// contract.
func ApplyDAOHardFork(statedb *state.StateDB) {
```

```
// Retrieve the contract to refund balances into
if !statedb.Exist(params.DAORefundContract) {
statedb.CreateAccount(params.DAORefundContract)
}
// Move every DAO account and extra-balance account funds into the refund contract
for _, addr := range params.DAODrainList() {
statedb.AddBalance(params.DAORefundContract, statedb.GetBalance(addr))
statedb.SetBalance(addr, new(big.Int))
}
70:F:\git\coin\ethereum\go-ethereum\core\dao_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"math/big"
"testing"
"github.com/ethereum/go-ethereum/consensus/ethash"
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/params"
)
// Tests that DAO-fork enabled clients can properly filter out fork-commencing
// blocks based on their extradata fields.
func TestDAOForkRangeExtradata(t *testing.T) {
forkBlock := big.NewInt(32)
// Generate a common prefix for both pro-forkers and non-forkers
db, _ := ethdb.NewMemDatabase()
gspec := new(Genesis)
genesis := gspec.MustCommit(db)
prefix, _ := GenerateChain(params.TestChainConfig, genesis, db, int(forkBlock.Int64()-1), func(i
int, gen *BlockGen) {})
// Create the concurrent, conflicting two nodes
proDb, _ := ethdb.NewMemDatabase()
```

```
gspec.MustCommit(proDb)
proConf := &params.ChainConfig{HomesteadBlock: big.NewInt(0), DAOForkBlock: forkBlock,
DAOForkSupport: true}
proBc, := NewBlockChain(proDb, proConf, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
conDb, _ := ethdb.NewMemDatabase()
gspec.MustCommit(conDb)
conConf := &params.ChainConfig{HomesteadBlock: big.NewInt(0), DAOForkBlock: forkBlock,
DAOForkSupport: false}
conBc, _ := NewBlockChain(conDb, conConf, ethash.NewFaker(), new(event.TypeMux),
vm.Config{})
if _, err := proBc.InsertChain(prefix); err != nil {
t.Fatalf("pro-fork: failed to import chain prefix: %v", err)
}
if _, err := conBc.InsertChain(prefix); err != nil {
t.Fatalf("con-fork: failed to import chain prefix: %v", err)
// Try to expand both pro-fork and non-fork chains iteratively with other camp's blocks
for i := int64(0); i < params.DAOForkExtraRange.Int64(); i++ {
// Create a pro-fork block, and try to feed into the no-fork chain
db, _ = ethdb.NewMemDatabase()
gspec.MustCommit(db)
bc, _ := NewBlockChain(db, conConf, ethash.NewFaker(), new(event.TypeMux), vm.Config{})
blocks := conBc.GetBlocksFromHash(conBc.CurrentBlock().Hash(),
int(conBc.CurrentBlock().NumberU64()))
for i := 0; i < len(blocks)/2; i++ {
blocks[j], blocks[len(blocks)-1-j] = blocks[len(blocks)-1-j], blocks[j]
}
if , err := bc.InsertChain(blocks); err != nil {
t.Fatalf("failed to import contra-fork chain for expansion: %v", err)
blocks, _ = GenerateChain(proConf, conBc.CurrentBlock(), db, 1, func(i int, gen *BlockGen) {})
if _, err := conBc.InsertChain(blocks); err == nil {
t.Fatalf("contra-fork chain accepted pro-fork block: %v", blocks[0])
}
// Create a proper no-fork block for the contra-forker
blocks, _ = GenerateChain(conConf, conBc.CurrentBlock(), db, 1, func(i int, gen *BlockGen) {})
if _, err := conBc.InsertChain(blocks); err != nil {
t.Fatalf("contra-fork chain didn't accepted no-fork block: %v", err)
```

```
}
// Create a no-fork block, and try to feed into the pro-fork chain
db, _ = ethdb.NewMemDatabase()
gspec.MustCommit(db)
bc, _ = NewBlockChain(db, proConf, ethash.NewFaker(), new(event.TypeMux), vm.Config{})
blocks = proBc.GetBlocksFromHash(proBc.CurrentBlock().Hash(),
int(proBc.CurrentBlock().NumberU64()))
for i := 0; i < \text{len(blocks)/2}; i + + \{
blocks[j], blocks[len(blocks)-1-j] = blocks[len(blocks)-1-j], blocks[j]
}
if _, err := bc.InsertChain(blocks); err != nil {
t.Fatalf("failed to import pro-fork chain for expansion: %v", err)
blocks, _ = GenerateChain(conConf, proBc.CurrentBlock(), db, 1, func(i int, gen *BlockGen) {})
if _, err := proBc.InsertChain(blocks); err == nil {
t.Fatalf("pro-fork chain accepted contra-fork block: %v", blocks[0])
}
// Create a proper pro-fork block for the pro-forker
blocks, _ = GenerateChain(proConf, proBc.CurrentBlock(), db, 1, func(i int, gen *BlockGen) {})
if _, err := proBc.InsertChain(blocks); err != nil {
t.Fatalf("pro-fork chain didn't accepted pro-fork block: %v", err)
}
// Verify that contra-forkers accept pro-fork extra-datas after forking finishes
db, _ = ethdb.NewMemDatabase()
gspec.MustCommit(db)
bc, _ := NewBlockChain(db, conConf, ethash.NewFaker(), new(event.TypeMux), vm.Config{})
blocks := conBc.GetBlocksFromHash(conBc.CurrentBlock().Hash(),
int(conBc.CurrentBlock().NumberU64()))
for j := 0; j < \text{len(blocks)/2}; j++ \{
blocks[j], blocks[len(blocks)-1-j] = blocks[len(blocks)-1-j], blocks[j]
if _, err := bc.InsertChain(blocks); err != nil {
t.Fatalf("failed to import contra-fork chain for expansion: %v", err)
}
blocks, _ = GenerateChain(proConf, conBc.CurrentBlock(), db, 1, func(i int, gen *BlockGen) {})
if _, err := conBc.InsertChain(blocks); err != nil {
t.Fatalf("contra-fork chain didn't accept pro-fork block post-fork: %v", err)
}
// Verify that pro-forkers accept contra-fork extra-datas after forking finishes
```

```
db, = ethdb.NewMemDatabase()
gspec.MustCommit(db)
bc, _ = NewBlockChain(db, proConf, ethash.NewFaker(), new(event.TypeMux), vm.Config{})
blocks = proBc.GetBlocksFromHash(proBc.CurrentBlock().Hash(),
int(proBc.CurrentBlock().NumberU64()))
for j := 0; j < len(blocks)/2; j++ {
blocks[j], blocks[len(blocks)-1-j] = blocks[len(blocks)-1-j], blocks[j]
if _, err := bc.InsertChain(blocks); err != nil {
t.Fatalf("failed to import pro-fork chain for expansion: %v", err)
}
blocks, _ = GenerateChain(conConf, proBc.CurrentBlock(), db, 1, func(i int, gen *BlockGen) {})
if _, err := proBc.InsertChain(blocks); err != nil {
t.Fatalf("pro-fork chain didn't accept contra-fork block post-fork: %v", err)
}
}
71:F:\git\coin\ethereum\go-ethereum\core\database_util.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"bytes"
"encoding/binary"
"encoding/json"
"errors"
"fmt"
"math/big"
"sync"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/metrics"
"github.com/ethereum/go-ethereum/params"
"github.com/ethereum/go-ethereum/rlp"
)
var (
```

```
headHeaderKey = []byte("LastHeader")
headBlockKey = []byte("LastBlock")
headFastKey = []byte("LastFast")
                 = []byte("h") // headerPrefix + num (uint64 big endian) + hash -> header
headerPrefix
tdSuffix
              = []byte("t") // headerPrefix + num (uint64 big endian) + hash + tdSuffix -> td
numSuffix
                = []byte("n") // headerPrefix + num (uint64 big endian) + numSuffix -> hash
blockHashPrefix
                  = []byte("H") // blockHashPrefix + hash -> num (uint64 big endian)
bodyPrefix
                = []byte("b") // bodyPrefix + num (uint64 big endian) + hash -> block body
blockReceiptsPrefix = []byte("r") // blockReceiptsPrefix + num (uint64 big endian) + hash -> block
receipts
preimagePrefix
                  = "secure-key-" // preimagePrefix + hash -> preimage
txMetaSuffix = []byte{0x01}
receiptsPrefix = []byte("receipts-")
mipmapPre = []byte("mipmap-log-bloom-")
MIPMapLevels = []uint64{1000000, 500000, 100000, 50000, 1000}
configPrefix = []byte("ethereum-config-") // config prefix for the db
// used by old (non-sequential keys) db, now only used for conversion
oldBlockPrefix
                   = []byte("block-")
oldHeaderSuffix
                    = []byte("-header")
oldTdSuffix
                  = []byte("-td") // headerPrefix + num (uint64 big endian) + hash + tdSuffix -> td
                   = []byte("-body")
oldBodySuffix
oldBlockNumPrefix
                      = []byte("block-num-")
oldBlockReceiptsPrefix = []byte("receipts-block-")
oldBlockHashPrefix
                     = []byte("block-hash-") // [deprecated by the header/block split, remove
eventually]
ErrChainConfigNotFound = errors.New("ChainConfig not found") // general config not found error
mipmapBloomMu sync.Mutex // protect against race condition when updating mipmap blooms
preimageCounter = metrics.NewCounter("db/preimage/total")
preimageHitCounter = metrics.NewCounter("db/preimage/hits")
)
// encodeBlockNumber encodes a block number as big endian uint64
func encodeBlockNumber(number uint64) []byte {
enc := make([]byte, 8)
```

```
binary.BigEndian.PutUint64(enc, number)
return enc
}
// GetCanonicalHash retrieves a hash assigned to a canonical block number.
func GetCanonicalHash(db ethdb.Database, number uint64) common.Hash {
data, _ := db.Get(append(append(headerPrefix, encodeBlockNumber(number)...), numSuffix...))
if len(data) == 0 {
data, _ = db.Get(append(oldBlockNumPrefix, big.NewInt(int64(number)).Bytes()...))
if len(data) == 0 {
return common.Hash{}
}
}
return common.BytesToHash(data)
}
// missingNumber is returned by GetBlockNumber if no header with the
// given block hash has been stored in the database
// GetBlockNumber returns the block number assigned to a block hash
// if the corresponding header is present in the database
func GetBlockNumber(db ethdb.Database, hash common.Hash) uint64 {
data, _ := db.Get(append(blockHashPrefix, hash.Bytes()...))
if len(data) != 8 {
data, _ := db.Get(append(append(oldBlockPrefix, hash.Bytes()...), oldHeaderSuffix...))
if len(data) == 0 {
return missingNumber
header := new(types.Header)
if err := rlp.Decode(bytes.NewReader(data), header); err != nil {
log.Crit("Failed to decode block header", "err", err)
}
return header.Number.Uint64()
return binary.BigEndian.Uint64(data)
}
// GetHeadHeaderHash retrieves the hash of the current canonical head block's
// header. The difference between this and GetHeadBlockHash is that whereas the
// last block hash is only updated upon a full block import, the last header
// hash is updated already at header import, allowing head tracking for the
```

```
// light synchronization mechanism.
func GetHeadHeaderHash(db ethdb.Database) common.Hash {
data, _ := db.Get(headHeaderKey)
if len(data) == 0 {
return common.Hash{}
return common.BytesToHash(data)
}
// GetHeadBlockHash retrieves the hash of the current canonical head block.
func GetHeadBlockHash(db ethdb.Database) common.Hash {
data, _ := db.Get(headBlockKey)
if len(data) == 0 {
return common.Hash{}
}
return common.BytesToHash(data)
}
// GetHeadFastBlockHash retrieves the hash of the current canonical head block during
// fast synchronization. The difference between this and GetHeadBlockHash is that
// whereas the last block hash is only updated upon a full block import, the last
// fast hash is updated when importing pre-processed blocks.
func GetHeadFastBlockHash(db ethdb.Database) common.Hash {
data, _ := db.Get(headFastKey)
if len(data) == 0 {
return common.Hash{}
}
return common.BytesToHash(data)
}
// GetHeaderRLP retrieves a block header in its raw RLP database encoding, or nil
// if the header's not found.
func GetHeaderRLP(db ethdb.Database, hash common.Hash, number uint64) rlp.RawValue {
data, _ := db.Get(append(append(headerPrefix, encodeBlockNumber(number)...), hash.Bytes()...))
if len(data) == 0 {
data, _ = db.Get(append(append(oldBlockPrefix, hash.Bytes()...), oldHeaderSuffix...))
}
return data
// GetHeader retrieves the block header corresponding to the hash, nil if none
// found.
```

```
func GetHeader(db ethdb.Database, hash common.Hash, number uint64) *types.Header {
data := GetHeaderRLP(db, hash, number)
if len(data) == 0 {
return nil
}
header := new(types.Header)
if err := rlp.Decode(bytes.NewReader(data), header); err != nil {
log.Error("Invalid block header RLP", "hash", hash, "err", err)
return nil
}
return header
}
// GetBodyRLP retrieves the block body (transactions and uncles) in RLP encoding.
func GetBodyRLP(db ethdb.Database, hash common.Hash, number uint64) rlp.RawValue {
data, _ := db.Get(append(append(bodyPrefix, encodeBlockNumber(number)...), hash.Bytes()...))
if len(data) == 0 {
data, = db.Get(append(append(oldBlockPrefix, hash.Bytes()...), oldBodySuffix...))
return data
}
// GetBody retrieves the block body (transactons, uncles) corresponding to the
// hash, nil if none found.
func GetBody(db ethdb.Database, hash common.Hash, number uint64) *types.Body {
data := GetBodyRLP(db, hash, number)
if len(data) == 0 {
return nil
body := new(types.Body)
if err := rlp.Decode(bytes.NewReader(data), body); err != nil {
log.Error("Invalid block body RLP", "hash", hash, "err", err)
return nil
return body
}
// GetTd retrieves a block's total difficulty corresponding to the hash, nil if
// none found.
func GetTd(db ethdb.Database, hash common.Hash, number uint64) *big.Int {
data, _ := db.Get(append(append(headerPrefix, encodeBlockNumber(number)...),
hash[:]...), tdSuffix...))
```

```
if len(data) == 0 {
data, _ = db.Get(append(append(oldBlockPrefix, hash.Bytes()...), oldTdSuffix...))
if len(data) == 0 {
return nil
}
td := new(big.Int)
if err := rlp.Decode(bytes.NewReader(data), td); err != nil {
log.Error("Invalid block total difficulty RLP", "hash", hash, "err", err)
return nil
return td
}
// GetBlock retrieves an entire block corresponding to the hash, assembling it
// back from the stored header and body. If either the header or body could not
// be retrieved nil is returned.
//
// Note, due to concurrent download of header and block body the header and thus
// canonical hash can be stored in the database but the body data not (yet).
func GetBlock(db ethdb.Database, hash common.Hash, number uint64) *types.Block {
// Retrieve the block header and body contents
header := GetHeader(db, hash, number)
if header == nil {
return nil
}
body := GetBody(db, hash, number)
if body == nil {
return nil
// Reassemble the block and return
return types.NewBlockWithHeader(header).WithBody(body.Transactions, body.Uncles)
}
// GetBlockReceipts retrieves the receipts generated by the transactions included
// in a block given by its hash.
func GetBlockReceipts(db ethdb.Database, hash common.Hash, number uint64) types.Receipts {
data, _ := db.Get(append(append(blockReceiptsPrefix, encodeBlockNumber(number)...),
hash[:]...))
if len(data) == 0 {
data, _ = db.Get(append(oldBlockReceiptsPrefix, hash.Bytes()...))
if len(data) == 0 {
```

```
return nil
}
}
storageReceipts := []*types.ReceiptForStorage{}
if err := rlp.DecodeBytes(data, &storageReceipts); err != nil {
log.Error("Invalid receipt array RLP", "hash", hash, "err", err)
return nil
}
receipts := make(types.Receipts, len(storageReceipts))
for i, receipt := range storageReceipts {
receipts[i] = (*types.Receipt)(receipt)
}
return receipts
}
// GetTransaction retrieves a specific transaction from the database, along with
// its added positional metadata.
func GetTransaction(db ethdb.Database, hash common.Hash) (*types.Transaction,
common.Hash, uint64, uint64) {
// Retrieve the transaction itself from the database
data, _ := db.Get(hash.Bytes())
if len(data) == 0 {
return nil, common.Hash{}, 0, 0
var tx types. Transaction
if err := rlp.DecodeBytes(data, &tx); err != nil {
return nil, common.Hash{}, 0, 0
}
// Retrieve the blockchain positional metadata
data, _ = db.Get(append(hash.Bytes(), txMetaSuffix...))
if len(data) == 0 {
return nil, common.Hash{}, 0, 0
}
var meta struct {
BlockHash common.Hash
BlockIndex uint64
Index
         uint64
}
if err := rlp.DecodeBytes(data, &meta); err != nil {
return nil, common.Hash{}, 0, 0
}
return &tx, meta.BlockHash, meta.BlockIndex, meta.Index
```

```
}
// GetReceipt returns a receipt by hash
func GetReceipt(db ethdb.Database, hash common.Hash) *types.Receipt {
data, _ := db.Get(append(receiptsPrefix, hash[:]...))
if len(data) == 0 {
return nil
}
var receipt types.ReceiptForStorage
err := rlp.DecodeBytes(data, &receipt)
if err != nil {
log.Error("Invalid receipt RLP", "hash", hash, "err", err)
return (*types.Receipt)(&receipt)
// WriteCanonicalHash stores the canonical hash for the given block number.
func WriteCanonicalHash(db ethdb.Database, hash common.Hash, number uint64) error {
key := append(append(headerPrefix, encodeBlockNumber(number)...), numSuffix...)
if err := db.Put(key, hash.Bytes()); err != nil {
log.Crit("Failed to store number to hash mapping", "err", err)
}
return nil
}
// WriteHeadHeaderHash stores the head header's hash.
func WriteHeadHeaderHash(db ethdb.Database, hash common.Hash) error {
if err := db.Put(headHeaderKey, hash.Bytes()); err != nil {
log.Crit("Failed to store last header's hash", "err", err)
}
return nil
}
// WriteHeadBlockHash stores the head block's hash.
func WriteHeadBlockHash(db ethdb.Database, hash common.Hash) error {
if err := db.Put(headBlockKey, hash.Bytes()); err != nil {
log.Crit("Failed to store last block's hash", "err", err)
}
return nil
// WriteHeadFastBlockHash stores the fast head block's hash.
```

```
func WriteHeadFastBlockHash(db ethdb.Database, hash common.Hash) error {
if err := db.Put(headFastKey, hash.Bytes()); err != nil {
log.Crit("Failed to store last fast block's hash", "err", err)
}
return nil
// WriteHeader serializes a block header into the database.
func WriteHeader(db ethdb.Database, header *types.Header) error {
data, err := rlp.EncodeToBytes(header)
if err != nil {
return err
}
hash := header.Hash().Bytes()
num := header.Number.Uint64()
encNum := encodeBlockNumber(num)
key := append(blockHashPrefix, hash...)
if err := db.Put(key, encNum); err != nil {
log.Crit("Failed to store hash to number mapping", "err", err)
}
key = append(append(headerPrefix, encNum...), hash...)
if err := db.Put(key, data); err != nil {
log.Crit("Failed to store header", "err", err)
return nil
}
// WriteBody serializes the body of a block into the database.
func WriteBody(db ethdb.Database, hash common.Hash, number uint64, body *types.Body) error
data, err := rlp.EncodeToBytes(body)
if err != nil {
return err
return WriteBodyRLP(db, hash, number, data)
}
// WriteBodyRLP writes a serialized body of a block into the database.
func WriteBodyRLP(db ethdb.Database, hash common.Hash, number uint64, rlp rlp.RawValue)
error {
key := append(append(bodyPrefix, encodeBlockNumber(number)...), hash.Bytes()...)
if err := db.Put(key, rlp); err != nil {
```

```
log.Crit("Failed to store block body", "err", err)
}
return nil
}
// WriteTd serializes the total difficulty of a block into the database.
func WriteTd(db ethdb.Database, hash common.Hash, number uint64, td *big.Int) error {
data, err := rlp.EncodeToBytes(td)
if err != nil {
return err
key := append(append(headerPrefix, encodeBlockNumber(number)...), hash.Bytes()...),
tdSuffix...)
if err := db.Put(key, data); err != nil {
log.Crit("Failed to store block total difficulty", "err", err)
}
return nil
}
// WriteBlock serializes a block into the database, header and body separately.
func WriteBlock(db ethdb.Database, block *types.Block) error {
// Store the body first to retain database consistency
if err := WriteBody(db, block.Hash(), block.NumberU64(), block.Body()); err != nil {
return err
// Store the header too, signaling full block ownership
if err := WriteHeader(db, block.Header()); err != nil {
return err
return nil
}
// WriteBlockReceipts stores all the transaction receipts belonging to a block
// as a single receipt slice. This is used during chain reorganisations for
// rescheduling dropped transactions.
func WriteBlockReceipts(db ethdb.Database, hash common.Hash, number uint64, receipts
types.Receipts) error {
// Convert the receipts into their storage form and serialize them
storageReceipts := make([]*types.ReceiptForStorage, len(receipts))
for i, receipt := range receipts {
storageReceipts[i] = (*types.ReceiptForStorage)(receipt)
}
```

```
bytes, err := rlp.EncodeToBytes(storageReceipts)
if err != nil {
return err
// Store the flattened receipt slice
key := append(append(blockReceiptsPrefix, encodeBlockNumber(number)...), hash.Bytes()...)
if err := db.Put(key, bytes); err != nil {
log.Crit("Failed to store block receipts", "err", err)
}
return nil
// WriteTransactions stores the transactions associated with a specific block
// into the given database. Beside writing the transaction, the function also
// stores a metadata entry along with the transaction, detailing the position
// of this within the blockchain.
func WriteTransactions(db ethdb.Database, block *types.Block) error {
batch := db.NewBatch()
// Iterate over each transaction and encode it with its metadata
for i, tx := range block.Transactions() {
// Encode and queue up the transaction for storage
data, err := rlp.EncodeToBytes(tx)
if err != nil {
return err
if err = batch.Put(tx.Hash().Bytes(), data); err != nil {
return err
// Encode and queue up the transaction metadata for storage
meta := struct {
BlockHash common.Hash
BlockIndex uint64
Index
         uint64
}{
BlockHash: block.Hash(),
BlockIndex: block.NumberU64(),
Index:
          uint64(i),
data, err = rlp.EncodeToBytes(meta)
if err != nil {
return err
```

```
}
if err := batch.Put(append(tx.Hash().Bytes(), txMetaSuffix...), data); err != nil {
return err
}
}
// Write the scheduled data into the database
if err := batch.Write(); err != nil {
log.Crit("Failed to store transactions", "err", err)
}
return nil
}
// WriteReceipt stores a single transaction receipt into the database.
func WriteReceipt(db ethdb.Database, receipt *types.Receipt) error {
storageReceipt := (*types.ReceiptForStorage)(receipt)
data, err := rlp.EncodeToBytes(storageReceipt)
if err != nil {
return err
return db.Put(append(receiptsPrefix, receipt.TxHash.Bytes()...), data)
}
// WriteReceipts stores a batch of transaction receipts into the database.
func WriteReceipts(db ethdb.Database, receipts types.Receipts) error {
batch := db.NewBatch()
// Iterate over all the receipts and queue them for database injection
for _, receipt := range receipts {
storageReceipt := (*types.ReceiptForStorage)(receipt)
data, err := rlp.EncodeToBytes(storageReceipt)
if err != nil {
return err
}
if err := batch.Put(append(receiptsPrefix, receipt.TxHash.Bytes()...), data); err != nil {
return err
}
// Write the scheduled data into the database
if err := batch.Write(); err != nil {
log.Crit("Failed to store receipts", "err", err)
}
return nil
```

```
}
// DeleteCanonicalHash removes the number to hash canonical mapping.
func DeleteCanonicalHash(db ethdb.Database, number uint64) {
db.Delete(append(append(headerPrefix, encodeBlockNumber(number)...), numSuffix...))
}
// DeleteHeader removes all block header data associated with a hash.
func DeleteHeader(db ethdb.Database, hash common.Hash, number uint64) {
db.Delete(append(blockHashPrefix, hash.Bytes()...))
db.Delete(append(append(headerPrefix, encodeBlockNumber(number)...), hash.Bytes()...))
}
// DeleteBody removes all block body data associated with a hash.
func DeleteBody(db ethdb.Database, hash common.Hash, number uint64) {
db.Delete(append(append(bodyPrefix, encodeBlockNumber(number)...), hash.Bytes()...))
}
// DeleteTd removes all block total difficulty data associated with a hash.
func DeleteTd(db ethdb.Database, hash common.Hash, number uint64) {
db.Delete(append(append(headerPrefix, encodeBlockNumber(number)...),
hash.Bytes()...), tdSuffix...))
}
// DeleteBlock removes all block data associated with a hash.
func DeleteBlock(db ethdb.Database, hash common.Hash, number uint64) {
DeleteBlockReceipts(db, hash, number)
DeleteHeader(db, hash, number)
DeleteBody(db, hash, number)
DeleteTd(db, hash, number)
}
// DeleteBlockReceipts removes all receipt data associated with a block hash.
func DeleteBlockReceipts(db ethdb.Database, hash common.Hash, number uint64) {
db.Delete(append(append(blockReceiptsPrefix, encodeBlockNumber(number)...), hash.Bytes()...))
}
// DeleteTransaction removes all transaction data associated with a hash.
func DeleteTransaction(db ethdb.Database, hash common.Hash) {
db.Delete(hash.Bytes())
db.Delete(append(hash.Bytes(), txMetaSuffix...))
}
```

```
// DeleteReceipt removes all receipt data associated with a transaction hash.
func DeleteReceipt(db ethdb.Database, hash common.Hash) {
db.Delete(append(receiptsPrefix, hash.Bytes()...))
}
// returns a formatted MIP mapped key by adding prefix, canonical number and level
// ex. fn(98, 1000) = (prefix || 1000 || 0)
func mipmapKey(num, level uint64) []byte {
lkey := make([]byte, 8)
binary.BigEndian.PutUint64(lkey, level)
key := new(big.Int).SetUint64(num / level * level)
return append(mipmapPre, append(lkey, key.Bytes()...)...)
}
// WriteMipmapBloom writes each address included in the receipts' logs to the
// MIP bloom bin.
func WriteMipmapBloom(db ethdb.Database, number uint64, receipts types.Receipts) error {
mipmapBloomMu.Lock()
defer mipmapBloomMu.Unlock()
batch := db.NewBatch()
for _, level := range MIPMapLevels {
key := mipmapKey(number, level)
bloomDat, _ := db.Get(key)
bloom := types.BytesToBloom(bloomDat)
for _, receipt := range receipts {
for _, log := range receipt.Logs {
bloom.Add(log.Address.Big())
}
batch.Put(key, bloom.Bytes())
if err := batch.Write(); err != nil {
return fmt.Errorf("mipmap write fail for: %d: %v", number, err)
}
return nil
```

// GetMipmapBloom returns a bloom filter using the number and level as input

```
// parameters. For available levels see MIPMapLevels.
func GetMipmapBloom(db ethdb.Database, number, level uint64) types.Bloom {
bloomDat, _ := db.Get(mipmapKey(number, level))
return types.BytesToBloom(bloomDat)
}
// PreimageTable returns a Database instance with the key prefix for preimage entries.
func PreimageTable(db ethdb.Database) ethdb.Database {
return ethdb.NewTable(db, preimagePrefix)
}
// WritePreimages writes the provided set of preimages to the database. `number` is the
// current block number, and is used for debug messages only.
func WritePreimages(db ethdb.Database, number uint64, preimages map[common.Hash][]byte)
error {
table := PreimageTable(db)
batch := table.NewBatch()
hitCount := 0
for hash, preimage := range preimages {
if _, err := table.Get(hash.Bytes()); err != nil {
batch.Put(hash.Bytes(), preimage)
hitCount++
}
}
preimageCounter.Inc(int64(len(preimages)))
preimageHitCounter.Inc(int64(hitCount))
if hitCount > 0 {
if err := batch.Write(); err != nil {
return fmt.Errorf("preimage write fail for block %d: %v", number, err)
}
}
return nil
}
// GetBlockChainVersion reads the version number from db.
func GetBlockChainVersion(db ethdb.Database) int {
var vsn uint
enc, _ := db.Get([]byte("BlockchainVersion"))
rlp.DecodeBytes(enc, &vsn)
return int(vsn)
}
```

```
// WriteBlockChainVersion writes vsn as the version number to db.
func WriteBlockChainVersion(db ethdb.Database, vsn int) {
enc, _ := rlp.EncodeToBytes(uint(vsn))
db.Put([]byte("BlockchainVersion"), enc)
}
// WriteChainConfig writes the chain config settings to the database.
func WriteChainConfig(db ethdb.Database, hash common.Hash, cfg *params.ChainConfig) error {
// short circuit and ignore if nil config. GetChainConfig
// will return a default.
if cfg == nil {
return nil
}
jsonChainConfig, err := json.Marshal(cfg)
if err != nil {
return err
}
return db.Put(append(configPrefix, hash[:]...), jsonChainConfig)
}
// GetChainConfig will fetch the network settings based on the given hash.
func GetChainConfig(db ethdb.Database, hash common.Hash) (*params.ChainConfig, error) {
jsonChainConfig, _ := db.Get(append(configPrefix, hash[:]...))
if len(jsonChainConfig) == 0 {
return nil, ErrChainConfigNotFound
}
var config params. Chain Config
if err := json.Unmarshal(jsonChainConfig, &config); err != nil {
return nil, err
}
return &config, nil
}
// FindCommonAncestor returns the last common ancestor of two block headers
func FindCommonAncestor(db ethdb.Database, a, b *types.Header) *types.Header {
for bn := b.Number.Uint64(); a.Number.Uint64() > bn; {
a = GetHeader(db, a.ParentHash, a.Number.Uint64()-1)
if a == nil \{
```

```
}
}
for an := a.Number.Uint64(); an < b.Number.Uint64(); {
b = GetHeader(db, b.ParentHash, b.Number.Uint64()-1)
if b == nil \{
return nil
}
}
for a.Hash() != b.Hash() {
a = GetHeader(db, a.ParentHash, a.Number.Uint64()-1)
if a == nil \{
return nil
b = GetHeader(db, b.ParentHash, b.Number.Uint64()-1)
if b == nil \{
return nil
}
return a
}
72:F:\git\coin\ethereum\go-ethereum\core\database_util_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"bytes"
"io/ioutil"
"math/big"
"os"
"testing"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/crypto/sha3"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/params"
"github.com/ethereum/go-ethereum/rlp"
)
```

return nil

```
// Tests block header storage and retrieval operations.
func TestHeaderStorage(t *testing.T) {
db, := ethdb.NewMemDatabase()
// Create a test header to move around the database and make sure it's really new
header := &types.Header{Number: big.NewInt(42), Extra: []byte("test header")}
if entry := GetHeader(db, header.Hash(), header.Number.Uint64()); entry != nil {
t.Fatalf("Non existent header returned: %v", entry)
}
// Write and verify the header in the database
if err := WriteHeader(db, header); err != nil {
t.Fatalf("Failed to write header into database: %v", err)
if entry := GetHeader(db, header.Hash(), header.Number.Uint64()); entry == nil {
t.Fatalf("Stored header not found")
} else if entry.Hash() != header.Hash() {
t.Fatalf("Retrieved header mismatch: have %v, want %v", entry, header)
if entry := GetHeaderRLP(db, header.Hash(), header.Number.Uint64()); entry == nil {
t.Fatalf("Stored header RLP not found")
} else {
hasher := sha3.NewKeccak256()
hasher.Write(entry)
if hash := common.BytesToHash(hasher.Sum(nil)); hash != header.Hash() {
t.Fatalf("Retrieved RLP header mismatch: have %v, want %v", entry, header)
}
// Delete the header and verify the execution
DeleteHeader(db, header.Hash(), header.Number.Uint64())
if entry := GetHeader(db, header.Hash(), header.Number.Uint64()); entry != nil {
t.Fatalf("Deleted header returned: %v", entry)
}
// Tests block body storage and retrieval operations.
func TestBodyStorage(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
// Create a test body to move around the database and make sure it's really new
body := &types.Body{Uncles: []*types.Header{{Extra: []byte("test header")}}}
```

```
hasher := sha3.NewKeccak256()
rlp.Encode(hasher, body)
hash := common.BytesToHash(hasher.Sum(nil))
if entry := GetBody(db, hash, 0); entry != nil {
t.Fatalf("Non existent body returned: %v", entry)
}
// Write and verify the body in the database
if err := WriteBody(db, hash, 0, body); err != nil {
t.Fatalf("Failed to write body into database: %v", err)
}
if entry := GetBody(db, hash, 0); entry == nil {
t.Fatalf("Stored body not found")
} else if types.DeriveSha(types.Transactions(entry.Transactions)) !=
types.DeriveSha(types.Transactions(body.Transactions)) || types.CalcUncleHash(entry.Uncles) !=
types.CalcUncleHash(body.Uncles) {
t.Fatalf("Retrieved body mismatch: have %v, want %v", entry, body)
if entry := GetBodyRLP(db, hash, 0); entry == nil {
t.Fatalf("Stored body RLP not found")
} else {
hasher := sha3.NewKeccak256()
hasher.Write(entry)
if calc := common.BytesToHash(hasher.Sum(nil)); calc != hash {
t.Fatalf("Retrieved RLP body mismatch: have %v, want %v", entry, body)
}
// Delete the body and verify the execution
DeleteBody(db, hash, 0)
if entry := GetBody(db, hash, 0); entry != nil {
t.Fatalf("Deleted body returned: %v", entry)
}
// Tests block storage and retrieval operations.
func TestBlockStorage(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
// Create a test block to move around the database and make sure it's really new
block := types.NewBlockWithHeader(&types.Header{
```

```
[]byte("test block"),
Extra:
UncleHash: types.EmptyUncleHash,
TxHash:
            types.EmptyRootHash,
ReceiptHash: types.EmptyRootHash,
})
if entry := GetBlock(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Non existent block returned: %v", entry)
}
if entry := GetHeader(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Non existent header returned: %v", entry)
}
if entry := GetBody(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Non existent body returned: %v", entry)
// Write and verify the block in the database
if err := WriteBlock(db, block); err != nil {
t.Fatalf("Failed to write block into database: %v", err)
}
if entry := GetBlock(db, block.Hash(), block.NumberU64()); entry == nil {
t.Fatalf("Stored block not found")
} else if entry.Hash() != block.Hash() {
t.Fatalf("Retrieved block mismatch: have %v, want %v", entry, block)
}
if entry := GetHeader(db, block.Hash(), block.NumberU64()); entry == nil {
t.Fatalf("Stored header not found")
} else if entry.Hash() != block.Header().Hash() {
t.Fatalf("Retrieved header mismatch: have %v, want %v", entry, block.Header())
}
if entry := GetBody(db, block.Hash(), block.NumberU64()); entry == nil {
t.Fatalf("Stored body not found")
} else if types.DeriveSha(types.Transactions(entry.Transactions)) !=
types.DeriveSha(block.Transactions()) || types.CalcUncleHash(entry.Uncles) !=
types.CalcUncleHash(block.Uncles()) {
t.Fatalf("Retrieved body mismatch: have %v, want %v", entry, block.Body())
}
// Delete the block and verify the execution
DeleteBlock(db, block.Hash(), block.NumberU64())
if entry := GetBlock(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Deleted block returned: %v", entry)
}
if entry := GetHeader(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Deleted header returned: %v", entry)
```

```
}
if entry := GetBody(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Deleted body returned: %v", entry)
}
}
// Tests that partial block contents don't get reassembled into full blocks.
func TestPartialBlockStorage(t *testing.T) {
db, := ethdb.NewMemDatabase()
block := types.NewBlockWithHeader(&types.Header{
          []byte("test block"),
Extra:
UncleHash: types.EmptyUncleHash,
TxHash:
            types.EmptyRootHash,
ReceiptHash: types.EmptyRootHash,
})
// Store a header and check that it's not recognized as a block
if err := WriteHeader(db, block.Header()); err != nil {
t.Fatalf("Failed to write header into database: %v", err)
if entry := GetBlock(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Non existent block returned: %v", entry)
}
DeleteHeader(db, block.Hash(), block.NumberU64())
// Store a body and check that it's not recognized as a block
if err := WriteBody(db, block.Hash(), block.NumberU64(), block.Body()); err != nil {
t.Fatalf("Failed to write body into database: %v", err)
}
if entry := GetBlock(db, block.Hash(), block.NumberU64()); entry != nil {
t.Fatalf("Non existent block returned: %v", entry)
}
DeleteBody(db, block.Hash(), block.NumberU64())
// Store a header and a body separately and check reassembly
if err := WriteHeader(db, block.Header()); err != nil {
t.Fatalf("Failed to write header into database: %v", err)
}
if err := WriteBody(db, block.Hash(), block.NumberU64(), block.Body()); err != nil {
t.Fatalf("Failed to write body into database: %v", err)
if entry := GetBlock(db, block.Hash(), block.NumberU64()); entry == nil {
t.Fatalf("Stored block not found")
```

```
} else if entry.Hash() != block.Hash() {
t.Fatalf("Retrieved block mismatch: have %v, want %v", entry, block)
}
}
// Tests block total difficulty storage and retrieval operations.
func TestTdStorage(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
// Create a test TD to move around the database and make sure it's really new
hash, td := common.Hash{}, big.NewInt(314)
if entry := GetTd(db, hash, 0); entry != nil {
t.Fatalf("Non existent TD returned: %v", entry)
// Write and verify the TD in the database
if err := WriteTd(db, hash, 0, td); err != nil {
t.Fatalf("Failed to write TD into database: %v", err)
}
if entry := GetTd(db, hash, 0); entry == nil {
t.Fatalf("Stored TD not found")
} else if entry.Cmp(td) != 0 {
t.Fatalf("Retrieved TD mismatch: have %v, want %v", entry, td)
}
// Delete the TD and verify the execution
DeleteTd(db, hash, 0)
if entry := GetTd(db, hash, 0); entry != nil {
t.Fatalf("Deleted TD returned: %v", entry)
}
}
// Tests that canonical numbers can be mapped to hashes and retrieved.
func TestCanonicalMappingStorage(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
// Create a test canonical number and assinged hash to move around
hash, number := common.Hash{0: 0xff}, uint64(314)
if entry := GetCanonicalHash(db, number); entry != (common.Hash{}) {
t.Fatalf("Non existent canonical mapping returned: %v", entry)
// Write and verify the TD in the database
if err := WriteCanonicalHash(db, hash, number); err != nil {
t.Fatalf("Failed to write canonical mapping into database: %v", err)
```

```
}
if entry := GetCanonicalHash(db, number); entry == (common.Hash{}) {
t.Fatalf("Stored canonical mapping not found")
} else if entry != hash {
t.Fatalf("Retrieved canonical mapping mismatch: have %v, want %v", entry, hash)
// Delete the TD and verify the execution
DeleteCanonicalHash(db, number)
if entry := GetCanonicalHash(db, number); entry != (common.Hash{}) {
t.Fatalf("Deleted canonical mapping returned: %v", entry)
}
}
// Tests that head headers and head blocks can be assigned, individually.
func TestHeadStorage(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
blockHead := types.NewBlockWithHeader(&types.Header{Extra: []byte("test block header")})
blockFull := types.NewBlockWithHeader(&types.Header{Extra: []byte("test block full")})
blockFast := types.NewBlockWithHeader(&types.Header{Extra: []byte("test block fast")})
// Check that no head entries are in a pristine database
if entry := GetHeadHeaderHash(db); entry != (common.Hash{}) {
t.Fatalf("Non head header entry returned: %v", entry)
}
if entry := GetHeadBlockHash(db); entry != (common.Hash{}) {
t.Fatalf("Non head block entry returned: %v", entry)
}
if entry := GetHeadFastBlockHash(db); entry != (common.Hash{}) {
t.Fatalf("Non fast head block entry returned: %v", entry)
}
// Assign separate entries for the head header and block
if err := WriteHeadHeaderHash(db, blockHead.Hash()); err != nil {
t.Fatalf("Failed to write head header hash: %v", err)
if err := WriteHeadBlockHash(db, blockFull.Hash()); err != nil {
t.Fatalf("Failed to write head block hash: %v", err)
}
if err := WriteHeadFastBlockHash(db, blockFast.Hash()); err != nil {
t.Fatalf("Failed to write fast head block hash: %v", err)
}
// Check that both heads are present, and different (i.e. two heads maintained)
```

```
if entry := GetHeadHeaderHash(db); entry != blockHead.Hash() {
t.Fatalf("Head header hash mismatch: have %v, want %v", entry, blockHead.Hash())
}
if entry := GetHeadBlockHash(db); entry != blockFull.Hash() {
t.Fatalf("Head block hash mismatch: have %v, want %v", entry, blockFull.Hash())
if entry := GetHeadFastBlockHash(db); entry != blockFast.Hash() {
t.Fatalf("Fast head block hash mismatch: have %v, want %v", entry, blockFast.Hash())
}
// Tests that transactions and associated metadata can be stored and retrieved.
func TestTransactionStorage(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
tx1 := types.NewTransaction(1, common.BytesToAddress([]byte{0x11}), big.NewInt(111),
big.NewInt(1111), big.NewInt(11111), []byte{0x11, 0x11, 0x11})
tx2 := types.NewTransaction(2, common.BytesToAddress([]byte{0x22}), big.NewInt(222),
big.NewInt(2222), big.NewInt(22222), []byte{0x22, 0x22, 0x22})
tx3 := types.NewTransaction(3, common.BytesToAddress([]byte{0x33}), big.NewInt(333),
big.NewInt(3333), big.NewInt(33333), []byte{0x33, 0x33, 0x33})
txs := []*types.Transaction{tx1, tx2, tx3}
block := types.NewBlock(&types.Header{Number: big.NewInt(314)}, txs, nil, nil)
// Check that no transactions entries are in a pristine database
for i, tx := range txs {
if txn, _, _, _ := GetTransaction(db, tx.Hash()); txn != nil {
t.Fatalf("tx #%d [%x]: non existent transaction returned: %v", i, tx.Hash(), txn)
}
}
// Insert all the transactions into the database, and verify contents
if err := WriteTransactions(db, block); err != nil {
t.Fatalf("failed to write transactions: %v", err)
for i, tx := range txs {
if txn, hash, number, index := GetTransaction(db, tx.Hash()); txn == nil {
t.Fatalf("tx #%d [%x]: transaction not found", i, tx.Hash())
} else {
if hash != block.Hash() || number != block.NumberU64() || index != uint64(i) {
t.Fatalf("tx #%d [%x]: positional metadata mismatch: have %x/%d/%d, want %x/%v/%v", i,
tx.Hash(), hash, number, index, block.Hash(), block.NumberU64(), i)
```

```
}
if tx.String() != txn.String() {
t.Fatalf("tx #%d [%x]: transaction mismatch: have %v, want %v", i, tx.Hash(), txn, tx)
}
}
// Delete the transactions and check purge
for i, tx := range txs {
DeleteTransaction(db, tx.Hash())
if txn, _, _, _ := GetTransaction(db, tx.Hash()); txn != nil {
t.Fatalf("tx #%d [%x]: deleted transaction returned: %v", i, tx.Hash(), txn)
}
}
}
// Tests that receipts can be stored and retrieved.
func TestReceiptStorage(t *testing.T) {
db, := ethdb.NewMemDatabase()
receipt1 := &types.Receipt{
PostState:
               []byte{0x01},
CumulativeGasUsed: big.NewInt(1),
Logs: []*types.Log{
{Address: common.BytesToAddress([]byte{0x11})},
{Address: common.BytesToAddress([]byte{0x01, 0x11})},
},
TxHash:
              common.BytesToHash([]byte{0x11, 0x11}),
ContractAddress: common.BytesToAddress([]byte{0x01, 0x11, 0x11}),
GasUsed:
               big.NewInt(111111),
}
receipt2 := &types.Receipt{
PostState:
               []byte{0x02},
CumulativeGasUsed: big.NewInt(2),
Logs: []*types.Log{
{Address: common.BytesToAddress([]byte{0x22})},
{Address: common.BytesToAddress([]byte{0x02, 0x22})},
},
TxHash:
              common.BytesToHash([]byte{0x22, 0x22}),
ContractAddress: common.BytesToAddress([]byte{0x02, 0x22, 0x22}),
               big.NewInt(222222),
GasUsed:
}
receipts := []*types.Receipt{receipt1, receipt2}
```

```
// Check that no receipt entries are in a pristine database
for i, receipt := range receipts {
if r := GetReceipt(db, receipt.TxHash); r != nil {
t.Fatalf("receipt #%d [%x]: non existent receipt returned: %v", i, receipt.TxHash, r)
}
// Insert all the receipts into the database, and verify contents
if err := WriteReceipts(db, receipts); err != nil {
t.Fatalf("failed to write receipts: %v", err)
}
for i, receipt := range receipts {
if r := GetReceipt(db, receipt.TxHash); r == nil {
t.Fatalf("receipt #%d [%x]: receipt not found", i, receipt.TxHash)
} else {
rlpHave, _ := rlp.EncodeToBytes(r)
rlpWant, _ := rlp.EncodeToBytes(receipt)
if !bytes.Equal(rlpHave, rlpWant) {
t.Fatalf("receipt #%d [%x]: receipt mismatch: have %v, want %v", i, receipt.TxHash, r, receipt)
}
}
}
// Delete the receipts and check purge
for i, receipt := range receipts {
DeleteReceipt(db, receipt.TxHash)
if r := GetReceipt(db, receipt.TxHash); r != nil {
t.Fatalf("receipt #%d [%x]: deleted receipt returned: %v", i, receipt.TxHash, r)
}
}
// Tests that receipts associated with a single block can be stored and retrieved.
func TestBlockReceiptStorage(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
receipt1 := &types.Receipt{
PostState:
                []byte{0x01},
CumulativeGasUsed: big.NewInt(1),
Logs: []*types.Log{
{Address: common.BytesToAddress([]byte{0x11})},
{Address: common.BytesToAddress([]byte{0x01, 0x11})},
```

```
},
TxHash:
               common.BytesToHash([]byte{0x11, 0x11}),
ContractAddress: common.BytesToAddress([]byte{0x01, 0x11, 0x11}),
GasUsed:
                big.NewInt(111111),
}
receipt2 := &types.Receipt{
PostState:
                []byte{0x02},
CumulativeGasUsed: big.NewInt(2),
Logs: []*types.Log{
{Address: common.BytesToAddress([]byte{0x22})},
{Address: common.BytesToAddress([]byte{0x02, 0x22})},
},
TxHash:
               common.BytesToHash([]byte{0x22, 0x22}),
ContractAddress: common.BytesToAddress([]byte{0x02, 0x22, 0x22}),
GasUsed:
                big.NewInt(222222),
}
receipts := []*types.Receipt{receipt1, receipt2}
// Check that no receipt entries are in a pristine database
hash := common.BytesToHash([]byte{0x03, 0x14})
if rs := GetBlockReceipts(db, hash, 0); len(rs) != 0 {
t.Fatalf("non existent receipts returned: %v", rs)
}
// Insert the receipt slice into the database and check presence
if err := WriteBlockReceipts(db, hash, 0, receipts); err != nil {
t.Fatalf("failed to write block receipts: %v", err)
}
if rs := GetBlockReceipts(db, hash, 0); len(rs) == 0 {
t.Fatalf("no receipts returned")
} else {
for i := 0; i < len(receipts); i++ {
rlpHave, _ := rlp.EncodeToBytes(rs[i])
rlpWant, _ := rlp.EncodeToBytes(receipts[i])
if !bytes.Equal(rlpHave, rlpWant) {
t.Fatalf("receipt #%d: receipt mismatch: have %v, want %v", i, rs[i], receipts[i])
}
}
// Delete the receipt slice and check purge
DeleteBlockReceipts(db, hash, 0)
if rs := GetBlockReceipts(db, hash, 0); len(rs) != 0 {
```

```
t.Fatalf("deleted receipts returned: %v", rs)
}
}
func TestMipmapBloom(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
receipt1 := new(types.Receipt)
receipt1.Logs = []*types.Log{
{Address: common.BytesToAddress([]byte("test"))},
{Address: common.BytesToAddress([]byte("address"))},
}
receipt2 := new(types.Receipt)
receipt2.Logs = []*types.Log{
{Address: common.BytesToAddress([]byte("test"))},
{Address: common.BytesToAddress([]byte("address1"))},
}
WriteMipmapBloom(db, 1, types.Receipts{receipt1})
WriteMipmapBloom(db, 2, types.Receipts{receipt2})
for _, level := range MIPMapLevels {
bloom := GetMipmapBloom(db, 2, level)
if !bloom.Test(new(big.Int).SetBytes([]byte("address1"))) {
t.Error("expected test to be included on level:", level)
}
}
// reset
db, _ = ethdb.NewMemDatabase()
receipt := new(types.Receipt)
receipt.Logs = []*types.Log{
{Address: common.BytesToAddress([]byte("test"))},
WriteMipmapBloom(db, 999, types.Receipts{receipt1})
receipt = new(types.Receipt)
receipt.Logs = []*types.Log{
{Address: common.BytesToAddress([]byte("test 1"))},
WriteMipmapBloom(db, 1000, types.Receipts{receipt})
```

```
bloom := GetMipmapBloom(db, 1000, 1000)
if bloom.TestBytes([]byte("test")) {
t.Error("test should not have been included")
}
func TestMipmapChain(t *testing.T) {
dir, err := ioutil.TempDir("", "mipmap")
if err != nil {
t.Fatal(err)
}
defer os.RemoveAll(dir)
var (
db, _ = ethdb.NewLDBDatabase(dir, 0, 0)
key1, _ =
crypto.HexToECDSA("b71c71a67e1177ad4e901695e1b4b9ee17ae16c6668d313eac2f96dbcda3f
291")
addr = crypto.PubkeyToAddress(key1.PublicKey)
addr2 = common.BytesToAddress([]byte("jeff"))
hash1 = common.BytesToHash([]byte("topic1"))
defer db.Close()
gspec := &Genesis{
Config: params.TestChainConfig,
Alloc: GenesisAlloc{addr: {Balance: big.NewInt(1000000)}},
genesis := gspec.MustCommit(db)
chain, receipts := GenerateChain(params.TestChainConfig, genesis, db, 1010, func(i int, gen
*BlockGen) {
var receipts types.Receipts
switch i {
case 1:
receipt := types.NewReceipt(nil, new(big.Int))
receipt.Logs = []*types.Log{{Address: addr, Topics: []common.Hash{hash1}}}
gen.AddUncheckedReceipt(receipt)
receipts = types.Receipts{receipt}
case 1000:
receipt := types.NewReceipt(nil, new(big.Int))
receipt.Logs = []*types.Log{{Address: addr2}}
```

```
gen.AddUncheckedReceipt(receipt)
receipts = types.Receipts{receipt}
}
// store the receipts
err := WriteReceipts(db, receipts)
if err != nil {
t.Fatal(err)
}
WriteMipmapBloom(db, uint64(i+1), receipts)
})
for i, block := range chain {
WriteBlock(db, block)
if err := WriteCanonicalHash(db, block.Hash(), block.NumberU64()); err != nil {
t.Fatalf("failed to insert block number: %v", err)
}
if err := WriteHeadBlockHash(db, block.Hash()); err != nil {
t.Fatalf("failed to insert block number: %v", err)
}
if err := WriteBlockReceipts(db, block.Hash(), block.NumberU64(), receipts[i]); err != nil {
t.Fatal("error writing block receipts:", err)
}
}
bloom := GetMipmapBloom(db, 0, 1000)
if bloom.TestBytes(addr2[:]) {
t.Error("address was included in bloom and should not have")
}
}
73:F:\git\coin\ethereum\go-ethereum\core\error.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import "errors"
var (
// ErrKnownBlock is returned when a block to import is already known locally.
ErrKnownBlock = errors.New("block already known")
```

```
// ErrGasLimitReached is returned by the gas pool if the amount of gas required
// by a transaction is higher than what's left in the block.
ErrGasLimitReached = errors.New("gas limit reached")
// ErrBlacklistedHash is returned if a block to import is on the blacklist.
ErrBlacklistedHash = errors.New("blacklisted hash")
)
74:F:\git\coin\ethereum\go-ethereum\core\events.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/types"
)
// TxPreEvent is posted when a transaction enters the transaction pool.
type TxPreEvent struct{ Tx *types.Transaction }
// PendingLogsEvent is posted pre mining and notifies of pending logs.
type PendingLogsEvent struct {
Logs []*types.Log
// PendingStateEvent is posted pre mining and notifies of pending state changes.
type PendingStateEvent struct{}
// NewMinedBlockEvent is posted when a block has been imported.
type NewMinedBlockEvent struct{ Block *types.Block }
// RemovedTransactionEvent is posted when a reorg happens
type RemovedTransactionEvent struct{ Txs types.Transactions }
// RemovedLogsEvent is posted when a reorg happens
type RemovedLogsEvent struct{ Logs []*types.Log }
type ChainEvent struct {
Block *types.Block
Hash common. Hash
Logs []*types.Log
```

```
}
type ChainSideEvent struct {
Block *types.Block
}
type ChainHeadEvent struct{ Block *types.Block }
75:F:\git\coin\ethereum\go-ethereum\core\evm.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"math/big"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/core/vm"
)
// ChainContext supports retrieving headers and consensus parameters from the
// current blockchain to be used during transaction processing.
type ChainContext interface {
// Engine retrieves the chain's consensus engine.
Engine() consensus. Engine
// GetHeader returns the hash corresponding to their hash.
GetHeader(common.Hash, uint64) *types.Header
}
// NewEVMContext creates a new context for use in the EVM.
func NewEVMContext(msg Message, header *types.Header, chain ChainContext, author
*common.Address) vm.Context {
// If we don't have an explicit author (i.e. not mining), extract from the header
var beneficiary common. Address
if author == nil {
beneficiary, _ = chain.Engine().Author(header) // Ignore error, we're past header validation
} else {
beneficiary = *author
}
```

```
return vm.Context{
CanTransfer: CanTransfer,
Transfer: Transfer.
GetHash:
            GetHashFn(header, chain),
Origin: msg.From(),
Coinbase: beneficiary,
BlockNumber: new(big.Int).Set(header.Number),
Time:
          new(big.Int).Set(header.Time),
Difficulty: new(big.Int).Set(header.Difficulty),
GasLimit: new(big.Int).Set(header.GasLimit),
GasPrice: new(big.Int).Set(msg.GasPrice()),
}
}
// GetHashFn returns a GetHashFunc which retrieves header hashes by number
func GetHashFn(ref *types.Header, chain ChainContext) func(n uint64) common.Hash {
return func(n uint64) common.Hash {
for header := chain.GetHeader(ref.ParentHash, ref.Number.Uint64()-1); header != nil; header =
chain.GetHeader(header.ParentHash, header.Number.Uint64()-1) {
if header.Number.Uint64() == n {
return header.Hash()
}
}
return common.Hash{}
}
}
// CanTransfer checks wether there are enough funds in the address' account to make a transfer.
// This does not take the necessary gas in to account to make the transfer valid.
func CanTransfer(db vm.StateDB, addr common.Address, amount *big.Int) bool {
return db.GetBalance(addr).Cmp(amount) >= 0
}
// Transfer subtracts amount from sender and adds amount to recipient using the given Db
func Transfer(db vm.StateDB, sender, recipient common.Address, amount *big.Int) {
db.SubBalance(sender, amount)
db.AddBalance(recipient, amount)
}
76:F:\git\coin\ethereum\go-ethereum\core\fees.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
```

```
package core
import (
"math/big"
var BlockReward = big.NewInt(5e+18)
77:F:\git\coin\ethereum\go-ethereum\core\filter_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
78:F:\git\coin\ethereum\go-ethereum\core\gaspool.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import "math/big"
// GasPool tracks the amount of gas available during
// execution of the transactions in a block.
// The zero value is a pool with zero gas available.
type GasPool big.Int
// AddGas makes gas available for execution.
func (gp *GasPool) AddGas(amount *big.Int) *GasPool {
i := (*big.Int)(gp)
i.Add(i, amount)
return gp
}
// SubGas deducts the given amount from the pool if enough gas is
// available and returns an error otherwise.
func (gp *GasPool) SubGas(amount *big.Int) error {
i := (*big.Int)(gp)
if i.Cmp(amount) < 0 {
return ErrGasLimitReached
i.Sub(i, amount)
return nil
```

```
}
func (gp *GasPool) String() string {
return (*big.Int)(gp).String()
}
79:F:\git\coin\ethereum\go-ethereum\core\genesis.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"errors"
"fmt"
"math/big"
"strings"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/common/hexutil"
"github.com/ethereum/go-ethereum/common/math"
"github.com/ethereum/go-ethereum/core/state"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/params"
"github.com/ethereum/go-ethereum/rlp"
)
//go:generate gencodec -type Genesis -field-override genesisSpecMarshaling -out gen_genesis.go
//go:generate gencodec -type GenesisAccount -field-override genesisAccountMarshaling -out
gen_genesis_account.go
var errGenesisNoConfig = errors.New("genesis has no chain configuration")
// Genesis specifies the header fields, state of a genesis block. It also defines hard
// fork switch-over blocks through the chain configuration.
type Genesis struct {
         *params.ChainConfig `json:"config"`
Config
                         `ison:"nonce"`
Nonce
          uint64
                           `json:"timestamp"`
Timestamp uint64
ParentHash common.Hash
                                 `json:"parentHash"`
ExtraData []byte
                         `json:"extraData"`
```

```
GasLimit uint64
                        `json:"gasLimit" gencodec:"required"`
Difficulty *big.Int
                      `json:"difficulty" gencodec:"required"`
Mixhash common.Hash
                             `ison:"mixHash"`
Coinbase common.Address
                               `ison:"coinbase"`
Alloc
        GenesisAlloc
                         `ison:"alloc"
                                        gencodec: "required"`
}
// GenesisAlloc specifies the initial state that is part of the genesis block.
type GenesisAlloc map[common.Address]GenesisAccount
// GenesisAccount is an account in the state of the genesis block.
type GenesisAccount struct {
Code []byte
                          `json:"code,omitempty"`
Storage map[common.Hash]common.Hash `json:"storage,omitempty"`
Balance *big.Int
                           `ison:"balance" gencodec:"required"`
Nonce uint64
                           `ison:"nonce,omitempty"`
}
// field type overrides for gencodec
type genesisSpecMarshaling struct {
Nonce
         math.HexOrDecimal64
Timestamp math.HexOrDecimal64
ExtraData hexutil.Bytes
GasLimit math.HexOrDecimal64
Difficulty *math.HexOrDecimal256
Alloc
        map[common.UnprefixedAddress]GenesisAccount
}
type genesisAccountMarshaling struct {
Code hexutil.Bytes
Balance *math.HexOrDecimal256
Nonce math.HexOrDecimal64
}
// GenesisMismatchError is raised when trying to overwrite an existing
// genesis block with an incompatible one.
type GenesisMismatchError struct {
Stored, New common. Hash
}
func (e *GenesisMismatchError) Error() string {
return fmt.Sprintf("database already contains an incompatible genesis block (have %x, new %x)",
e.Stored[:8], e.New[:8])
```

```
}
// SetupGenesisBlock writes or updates the genesis block in db.
// The block that will be used is:
//
//
                 genesis == nil genesis != nil
               +-----
//
//
    db has no genesis | main-net default | genesis
    db has genesis | from DB
//
                                      | genesis (if compatible)
//
// The stored chain configuration will be updated if it is compatible (i.e. does not
// specify a fork block below the local head block). In case of a conflict, the
// error is a *params.ConfigCompatError and the new, unwritten config is returned.
//
// The returned chain configuration is never nil.
func SetupGenesisBlock(db ethdb.Database, genesis *Genesis) (*params.ChainConfig,
common.Hash, error) {
if genesis!= nil && genesis.Config == nil {
return params.AllProtocolChanges, common.Hash{}, errGenesisNoConfig
}
// Just commit the new block if there is no stored genesis block.
stored := GetCanonicalHash(db, 0)
if (stored == common.Hash{}) {
if genesis == nil {
log.Info("Writing default main-net genesis block")
genesis = DefaultGenesisBlock()
} else {
log.Info("Writing custom genesis block")
block, err := genesis.Commit(db)
return genesis.Config, block.Hash(), err
}
// Check whether the genesis block is already written.
if genesis != nil {
block, _ := genesis.ToBlock()
hash := block.Hash()
if hash != stored {
return genesis.Config, block.Hash(), &GenesisMismatchError{stored, hash}
}
}
```

```
// Get the existing chain configuration.
newcfg := genesis.configOrDefault(stored)
storedcfg, err := GetChainConfig(db, stored)
if err != nil {
if err == ErrChainConfigNotFound {
// This case happens if a genesis write was interrupted.
log.Warn("Found genesis block without chain config")
err = WriteChainConfig(db, stored, newcfg)
}
return newcfg, stored, err
}
// Special case: don't change the existing config of a non-mainnet chain if no new
// config is supplied. These chains would get AllProtocolChanges (and a compat error)
// if we just continued here.
if genesis == nil && stored != params.MainnetGenesisHash {
return storedcfg, stored, nil
}
// Check config compatibility and write the config. Compatibility errors
// are returned to the caller unless we're already at block zero.
height := GetBlockNumber(db, GetHeadHeaderHash(db))
if height == missingNumber {
return newcfg, stored, fmt.Errorf("missing block number for head header hash")
}
compatErr := storedcfg.CheckCompatible(newcfg, height)
if compatErr != nil && height != 0 && compatErr.RewindTo != 0 {
return newcfg, stored, compatErr
return newcfg, stored, WriteChainConfig(db, stored, newcfg)
}
func (g *Genesis) configOrDefault(ghash common.Hash) *params.ChainConfig {
switch {
case g != nil:
return g.Config
case ghash == params.MainnetGenesisHash:
return params.MainnetChainConfig
case ghash == params.TestnetGenesisHash:
return params. Testnet Chain Config
default:
return params.AllProtocolChanges
```

```
}
}
// ToBlock creates the block and state of a genesis specification.
func (g *Genesis) ToBlock() (*types.Block, *state.StateDB) {
db, _ := ethdb.NewMemDatabase()
statedb, _ := state.New(common.Hash{}, state.NewDatabase(db))
for addr, account := range g.Alloc {
statedb.AddBalance(addr, account.Balance)
statedb.SetCode(addr, account.Code)
statedb.SetNonce(addr, account.Nonce)
for key, value := range account.Storage {
statedb.SetState(addr, key, value)
}
root := statedb.IntermediateRoot(false)
head := &types.Header{
Nonce: types.EncodeNonce(g.Nonce),
Time:
          new(big.Int).SetUint64(g.Timestamp),
ParentHash: g.ParentHash,
         g.ExtraData,
Extra:
GasLimit: new(big.Int).SetUint64(g.GasLimit),
Difficulty: g.Difficulty,
MixDigest: g.Mixhash,
Coinbase: g.Coinbase,
Root:
         root.
if g.GasLimit == 0 {
head.GasLimit = params.GenesisGasLimit
if g.Difficulty == nil {
head.Difficulty = params.GenesisDifficulty
}
return types.NewBlock(head, nil, nil, nil), statedb
}
// Commit writes the block and state of a genesis specification to the database.
// The block is committed as the canonical head block.
func (g *Genesis) Commit(db ethdb.Database) (*types.Block, error) {
block, statedb := g.ToBlock()
if _, err := statedb.CommitTo(db, false); err != nil {
return nil, fmt.Errorf("cannot write state: %v", err)
```

```
}
if err := WriteTd(db, block.Hash(), block.NumberU64(), g.Difficulty); err != nil {
return nil, err
if err := WriteBlock(db, block); err != nil {
return nil, err
if err := WriteBlockReceipts(db, block.Hash(), block.NumberU64(), nil); err != nil {
return nil. err
}
if err := WriteCanonicalHash(db, block.Hash(), block.NumberU64()); err != nil {
return nil, err
if err := WriteHeadBlockHash(db, block.Hash()); err != nil {
return nil, err
if err := WriteHeadHeaderHash(db, block.Hash()); err != nil {
return nil, err
config := g.Config
if config == nil {
config = params.AllProtocolChanges
}
return block, WriteChainConfig(db, block.Hash(), config)
// MustCommit writes the genesis block and state to db, panicking on error.
// The block is committed as the canonical head block.
func (g *Genesis) MustCommit(db ethdb.Database) *types.Block {
block, err := g.Commit(db)
if err != nil {
panic(err)
}
return block
}
// GenesisBlockForTesting creates and writes a block in which addr has the given wei balance.
func GenesisBlockForTesting(db ethdb.Database, addr common.Address, balance *big.Int)
*types.Block {
g := Genesis{Alloc: GenesisAlloc{addr: {Balance: balance}}}
return g.MustCommit(db)
}
```

```
// DefaultGenesisBlock returns the Ethereum main net genesis block.
func DefaultGenesisBlock() *Genesis {
return &Genesis{
Config:
       params.MainnetChainConfig,
Nonce:
        66.
ExtraData:
hexutil.MustDecode("0x11bbe8db4e347b4e8c937c1c8370e4b5ed33adb3db69cbdb7a38e1e50b1
b82fa"),
GasLimit: 5000,
Difficulty: big.NewInt(17179869184),
Alloc:
      decodePrealloc(mainnetAllocData),
}
}
// DefaultTestnetGenesisBlock returns the Ropsten network genesis block.
func DefaultTestnetGenesisBlock() *Genesis {
return &Genesis{
Config:
       params.TestnetChainConfig,
Nonce:
        66.
ExtraData:
53535"),
GasLimit: 16777216,
Difficulty: big.NewInt(1048576),
Alloc:
      decodePrealloc(testnetAllocData),
}
}
// DefaultRinkebyGenesisBlock returns the Rinkeby network genesis block.
func DefaultRinkebyGenesisBlock() *Genesis {
return &Genesis{
       params.RinkebyChainConfig,
Timestamp: 1492009146,
ExtraData:
hexutil.MustDecode("0x52657370656374206d7920617574686f7269746168207e452e436172746
d616e42eb768f2244c8811c63729a21a3569731535f067ffc57839b00206d1ad20c69a1981b489f77
000000000000000000").
GasLimit: 4700000,
```

Difficulty: big.NewInt(1),

```
Alloc:
        decodePrealloc(rinkebyAllocData),
}
}
// DevGenesisBlock returns the 'geth --dev' genesis block.
func DevGenesisBlock() *Genesis {
return &Genesis{
Config:
        params.AllProtocolChanges,
Nonce:
          42.
GasLimit: 4712388,
Difficulty: big.NewInt(131072),
Alloc:
        decodePrealloc(devAllocData),
}
}
func decodePrealloc(data string) GenesisAlloc {
var p []struct{ Addr, Balance *big.Int }
if err := rlp.NewStream(strings.NewReader(data), 0).Decode(&p); err != nil {
panic(err)
}
ga := make(GenesisAlloc, len(p))
for _, account := range p {
ga[common.BigToAddress(account.Addr)] = GenesisAccount{Balance: account.Balance}
return ga
}
80:F:\git\coin\ethereum\go-ethereum\core\genesis_alloc.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
// Constants containing the genesis allocation of built-in genesis blocks.
// Their content is an RLP-encoded list of (address, balance) tuples.
// Use mkalloc.go to create/update them.
const mainnetAllocData =
"\xfa\x04]X\u0793\r\x83b\x011\x8e\u0189\x9agT\x06\x908'\x80t2\x80\x89\n\u05ce\xbcZ\xc6
\x00\x00\u0793\x17bC\x0e\xa9\u00e2nWI\xaf\xdbp\xda_x\u077b\x8c\x89\n\u05ce\xbcZ\xc6
\x00\x00\u0793\x1d\x14\x80K9\x9cn\xf8\x0edWoev`\x80O\xec\v\x89\u3bb5sr@\xa0\x00\x00\u079
xcd\xc0\xe0\xb9c\xd7R\xb2)j\u02c7\u0682\x8b$\x89\n\x8fd\x9f\xe7\xc6\x18\x00\x00\u0793K\xfb\x
```

 $\label{thm:convolu0793} $$ \x 6^\nu 02ed\xff\xbd\r\u007f\xe4O\x8d\xfd\xa7\x9d\r\x1a\x1c\x9c\x8965\u026d\xc5\u07a0\x00\x00\u0793\x95\xa3\xdebxh\xf9\x1f\xa8\xbf\xe1\xc1\xb7\xaf\xaf\b\x18\xx89\x1cg\xf5\xf7\xba\xa0\xb0\x00\u0793\x96\x97G\xf7\xa5\xb3\x06E\xfe\x00\xe4I\x01CZ\xce\xc7\x89\(=A\x03\x94\x10\x00\x00\u0793\x9am\xb3\xg\x9bw\xc9\x03\x91\xa7Gm\#\x8f;\xa3>\x89\n\xdaUGK\x814\x00\x00\u0793\x9e\xef\n\b\x86\x05n?i!\x18S\xb9\xb7E\u007f7\x82\u4262\xa8x\x06\x9b\(\xe0\x00\x00\x00\x00\x00\x00\x0793\x9f\xdb\xf4N\x1f\Jcb\xb7i\u00daG\x95\xa9I+\u01c9\x1e\x93\x12\x83\xcc\xc8P\x00\x00\x00\x00\x00fR\xc9\u054f\x18\x9f6\xb1\xd4\]\x1b\xf6\x04\x1f\x8a\x01'\u0473F\x1a\xcd\x1a\x00\x00\u0793\xaaS\x81\xb2\x13\x8e\xbe\xff\xc1\x91\xd5\xd8\u00d1\u;p\x98\u04895\xab\xb0\x9f\xfe\u07b6\x80\x00\u0793\xaa\xda\%\xea\x01'\x86\x9a\xbbB-$

 $A \times 92? \u04c0 \times cd \times 04 \times 01c9 \# = \xf3) \times 9far \times 00 \times 00 \times 0793 \times ac \times bf \times b2 \times f2ZT \times 85 \times c79 \times efp \times a4N \times ee \times be \| e \times 89 \times 05 \times c7^- \| e \times b \| e \times$

 $c\x10\x00\x00\u07d3\xac\xc6\xf0\x82\xa4B\x82\x87d\xd1\x1fX\u0589J\xe4\b\xf0s\x8a\f\xb4\x9bD\xba^- -$

c\x10\x00\x00\u07d4\x01\r\xf1\xdfK\xed#v\r-

\x89H\xa4<T`/p\x00\x00\u07d4\x01\"n\n\xd8\xd6\"w\xb1bb\x1cb\xc9(\xe9n\v\x9a\x8c\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x01\\"n\n\xd8\xd6\"w\xb1bb\x1cb\xc9(\xe9n\v\x9a\x8c\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x01&\xe1.\xbc\x17\x03_5\xc0\xe9\xd1\x1d\xd1H9<@]z\x89lf\x06E\xaaG\x18\x00\x00\u07d4\x01/9j+^\xb85Y\xba\xc5\x15\xe5!\r\xf2\xc8\xc3b\xba\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\x014\xff8\x15_\xab\xae\x94\xfd5\xc4\xff\xe1\u05dd\xe7\xef\x9cY\x895e\x9e\xf9?\x0f\xc4\x00\x00\u07d4\x016\xa5\xafl2\x99\u01b5\xf0\x05\xfd\xad\xdb\x14\x8c\a\v)\x9b\x89\x01\x1a\xa9\xac\x15\xf1(\x00\x00\u07d4\x01H\x8a\xd3\xda`<L\xdd\xb0\xb7\xa1\xe3\r*0\xc8\xfc8\x89\n\u0

5ce\xbcZ\xc6

 $\label{ta2} $$ \xecD\x1a\xf7\#\xfd\x90\x99\xf2\u02f7\x9dbc\x89uy*\x8a\xbd\xef|\x00\x00\u07d4\x01\x91\xeb $$ T\sim {\xf6\x97k\x9b\x1bWuFv\x1d\xe6V\"\xe2\x89|kLM\xa6\u077e\x00\x00\u07d4\x01\x9dp\x95y\xffK \xc0\x9f\xdc\xdd\xe41\xdc\x14G\xd2\xc2\xbc\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x01\xa2 $$ Z_Z\xf0\x16\x9b0\x86L;\xe4\xd7V<\xcdD\xf0\x9e\x89M\x85<\x8f\x89\b\x98\x00\x00\x00\x00\x94\x01\xa2 $$ a7\xd9\xfa\x0e\x5M\xa8<.u\xdbi\u37ca\x01\x9dJ\xdd\xd0\u063c\x96\x00\x00\u07d4\x01\xa8\x13ZAB\x10\xc3\b\xb6\%\xac\xa1\xa5F\x11\xac6\x89\x0e\x189\x8ev\x01\x90\x00\x00\u07d4\x01\xb1\xca\xe9\x1a;\x95Y\xaf\xb3<\xdcmh\x94B\xfd\xbf\xe07\x89\n\u05ce\xbcZ\xc6 $$ \x00\x00\u07d4\x01\xb5\xb5\xbcZ\x11\u007f\xa0\x8b4\xed\x1d\xb9D\x06\bYz\xc5H\x89\n\u05ce\xbcZ\xc6 $$ \xc6$$

 $\x a b x a 5 x 9 f x f 6 x a 6 x d e [\x 8 a x 0 2 x 0 5 x d f x e 5 v x 8 1 x c 8. x 0 0 x 0 0 u 0 7 d 4 x 0 1 u 0 5 5 9 x e e r_ x 8 c 8 x a b - 9., e x b 7 L < x e 3 x 1 8$

 $0\xe4\xe8\xa6\x11\xd8\xc5Z\x89\lk\x93[\x8b\xbd@\x00\x00\u07d4\x01\xfb\x8e\xc1$\%\xa0O\x81>F\xc5L\x05t\x8c\xa6\xb2\x9a\xa9\x89\x0e\x15s\x03\x85F\x00\x00\u07d4\x01\xff\x1e\xb1\u07adP\xa7\xf2\xf9c\x8f\xde\xe6\xec\xcf:{*\u0209}$

 $\label{thm:linear} $$ \x86\xac5\x10R`\x00\x00\u07d4\x02\x03b\u00ed\xe8x\u0290\u05b2\u0609\xa4\xccU\x10\xee\xd5\xf3\x898\x88\xe8\xb3\x11\xad\xb3\x80\x00\u07d4\x02\x03\xae\x01\xd4\xc4\x1c\xae\x18e\xe0K\x1f\x60\x1a-$

 $\label{thm:condition} $$ \x86fS\xdc\va\x89\x02*\xc7H2\xb5\x04\x00\x00\u07d4\x02\x1fi\x04=\xe8\x8cl\x17\xca\x10\xf1\x84 (\x97\xee\xc0X\x9c|\x89kD\u03f8\x14\x87\xf4\x00\x00\u07d4\x02)\x0f\xb5\xf9\xa5\x17\xf8(E\xac\xde\xca\x0f\xc8F\x03\x9b\xe23\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x029\xb4\xf2\x1f\x8e\x05\xcd\x01Q++\xe7\xa0\xe1\x8am\x97F\a\x8965\u026d\xc5\u07a0\x00\x00\x00\u07d4\x02Gr\x12\xff\xddu\xe5\x15\VQ\xb7e\x06\xb1dfq\xa1\xeb\x89_h\xe8\x13\x1e\u03c0\x00\x00\x00\u07d4\x02J\t\x8a\xe7\x02\xbe\xf5@l\x9c\"\xb7\x8b\xd4\xeb\x01e2\x93\x89\xd8\xd7\x8b\xd7\x17z\x80\x00\x00\x00\u07d4\x02K\xdd, $$ \xfdP\x0e\xe7@O\u007f\xb3\xe9\xfb1\xdd $$$

\x00\x00\\u07d4\x02\u0523\th\xa3\x9e+4\x98\u00e6\xa4\xedE\xc1\xc6dh\"\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x02\xdf\xcb\x17\xa1\xb8tA\x03ct\xb7b\xa5\xd3A\x8b\x1c\xb4\u0509H\xb0+\xa9\u047\aF\x00\x00\u07d4\x02\xe4\xcb\"\xbeF%\x8a@\xe1mC8\xd8\x02\xff\xfd\x00\xc1Q\x89\x14\x96\x96\xea\u03ba\x81\x00\x00\u07d4\x02\xe8\x16\xaf\xc1\xb5\xc0\xf3\x98R\x13\x19Y\xd9F\xeb;\a\xb5\x\ad\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x02\xf7\xf6r\t\xb1j\x17U\fil_rX8\x19\xc8\v7\xad\x89\x05\U\x93\x06\xa7\x8ap\x00\x00\x00\u07d4\x03\ts\x80{/Bi\x14\xad\x00\x18\x12p\xac\xd2\x8f\xf6\xb8\x15T\b\x84\xb9\,\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\x03\x0f\xb3@\x1fr\xbd4\x18\xb7\xd1\xdau\xbf\x8cQ\x9d\xd7\a\u0709\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\x03\x1e%\xdbQk\x0f\t\x9f\xae\xbf\xd9O\x89\f\xf9\f\x83k\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\x03]\x18\x8f\b\x06\w18\x19J\x98\xd6|3\xac\xf2\xf9M`\x8x8\x85\x89\v\xbfQ\r\xdf\xcb&\x00\x00\u07d4\x031\x&\xd1\xf7\n\xa4\xbd\u07e0\x9b\xe0\xc4\x10UR\xd2\x5\x8b\x89\x02\x1auJm\xc5(\x00\x00\u07d4\x031\x&\xd1\xf7\n\xa4\xbd\u07f\xf3\xee\u007fi|@>w\x80\x18\x8b\xf0\xef\x89\n\u07ce\xbcZ\xc6

 $x01\x0f\f\xf0d\xddY$

 $c\x10\x00\x00\u07d4\x03\x60\vxe7\xfd\xbdd\x1d\xb5\xb6\xbe\xa2\xa8x\n\x83\xfa\u1009\a\x96\xe3\xea?\x8a\xb0\x00\x00\x00\x00\x83\#\xb1\x84\xcf\xf7\xa8*\xe2\u1f67y?\xe41\x9c\xa0\xbf\x8a\x04<3\xc1\x93\ud\x80\x00\x00\u07d4\x03\x87y\xca-$

\xbef>c\xdb?\xe7\\x83\xea\x0e\xc6.#\x83\x89Z\x87\xe7\xd7\xf5\xf6X\x00\x00\xe0\x94\x03\x8eE\x

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\x03\xb0\xf1\xde\xde\u03f7\xdai~\x82\xa9\x1a_\x9ewt\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x03\xb4\x1bQ\xf4\x1d\xf2\r\xd2y\xba\xe1\x8c\x12w_w\xadw\x1c\x8965\u026\d\xc5\u07a0\x00\x00\u07d4\x03\xbe[F)\xae\xfb\xbc\xab\x9d\xe2m9WI\xb7\xf6\x91\xd7d\x89\n\xdf0\xbap\u0217\x00\x00\u07d4\x03\xc6G\xa9\xf9)\xb0x\x1f\xe9\xae\x01\u02a3\xe1\x83\xe8vw~\x89\x18^x\xb7\xc2\f\xe5\x00\x00\u07d4\x03\xc9\x1d\x92\x946\x03\xe7R$

 $> \x054\x0eV^\x13\xb9\x00E\x89+|\xc2\xe9\xc3\|''\\x00\x00\u07d4\x03\xcbLOE\x16\xc4\xffy\xa1\xb6\\0\xbfW.\x1c\u007f\xeay\x89\x94\x89\#z\u06daP\x00\x00\u07d4\x03\u02d8\u05ec\xd8\x17\u079d\x88m\|''\xfa\xb3\xf1\xb5\\x92\xa6\b\x89V\xbcu\xe2\xd61\x00\x00\x00\u07d4\x03\u031d-$

 $!\xf8k\x84\xac\x8c\xea\xf9q\u06e7\x8a\x90\xe6\%p\x89WG=\x05\u06ba\xe8\x00\x00\u07d4\x03\xd1rO\xd0\x0eT\xaa\xbc\xd2\xde*\x91\xe8F+\x10I\xdd:\x89\x8f\x1d\x1c\xae7@\x00\x00\u07d4\x03\xde\xdf\xcd\v<.\x17\xc7\x05\xda\x87\x90\uf626\xbdWQ\x89Hz\x9a0E9D\x00\x00\u07d4\x03\u8c04SuW\xe7\t\xea\xe2\xe1\u1966\xbc\xe1\xef\x83\x14\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x03\xeam&\u0400\xe5z\xee9\&\xb1\x8e\x8e\xd7:N[(\&\x89\n\u05ce\xbcZ\xc6$

\b\x81:\xe0\xa6v\xeb!(\x14\xaf\xab5\"\x10i\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x04\x11p\xf5\x81\u0780\xe5\x8b*\x04\\\x8f|\x14\x93\xb0\x01\xb7\u02c90<t\xa1\xa36\x94\x00\x00\u07d4\x04\x13\xd0\xcfx\xc0\x01\x89\x8a7\x8b\x91\x8c\xd6\xe4\x98\xeaw<M\x89\x0f-

 $\label{thm:condition} $$ \operatorname{thm} \operatorname{t$

 $\label{thm:linear} $$ \xb20\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\x04\x04\x08\xf7\xd1\xfc\xe3\xb0\x13S\xa8Xb\xa9H\xac\x04\x9f>\x89P\xc5\xe7a\xa4D\b\x00\x00\u07d4\x04\u007f\x9b\xf1R\x9d\xaf\x87\xd4\a\x17^o\x17\x1b^Y\xe9\xff>\x89\#<\x8f\xe4'\x03\xe8\x00\x00\xe0\x94\x04\x85'2\xb4\xc6R\xf6\xc2\u53b3e\x87\xe6\nb\xda\x14\u06ca\x04<3\xc1\x93ud\x80\x00\x00\xe0\x94\x04\x8a\x89p\xeaAE\xc6M$

 $\label{thm:likelim} $$U\x17\xb8\xde[F\xd0YZ\xad\x06\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\x04\x04\x9c]K\xc6\xf2]NEIi{R\xa0x\x11\xcc\u045f\xb1\x89\x10D\x00\xa2G\x0eh\x00\x00\u07d4\x04\xa1\xca\xda\x1c\xc7Q\b/\xf8\u0692\x8e<\xfa\x00\b}$$$ $$xfa\x00\b$$$$

 $\label{thm:composition} $$ \xe9\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\x04\xa8\n\xfa\xd5>\xf1\xf8Ae\xcf\xd8R\xb0\xfd\xf1\xb1\xc2K\xa8\x89\x03\xe9d\xb3\xec\xa8\x00\x00\u07d4\x04\xaa\xfc\x8a\xe5\xceol\x03\u021\d\u007f\xac\x9c\xb1\x95\x12\"Gw\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x04\xbaK\xb8q@\x02,!Jo\xacB\xdbZ\x16\u0755@E\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x04\xba\x8a?\x03\xf0\x8b\x89P\x95\x99M\xdaa\x9e\u06ac\xee>z\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x04\xc2\xc6K\xb5\L>\xcc\xd0U\x85\xe1\x0e\xc6\xf9\x9a\f\xdb\x01\xa3\x89\x05k\xc7^-$

c\x10\x00\x00\u07d4\x04\xceE\xf6\x00\xdb\x18\xa9\u0405\x1b)\xd99>\xbd\xaa\xfe=\u0149\x01\x1 5\x8eF\t\x13\xd0\x00\u07d4\x04\u05b8\xd4\u0686t\a\xbb\x99wI\u07bb\xcd\xc0\xb3XS\x8a\x8 965\u026d\xc5\u07a0\x00\u07d4\x04\xd78\x96\xcfe\x93\xa6\x91\x97*\x13\xa6\xe4\x87\x1f\xf2 \xc4+\x13\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\x04\xd8*\xf9\xe0\x1a\x93m\x97\xf8\xf8Y@\xb9p\xf 9\xd4\u06d96\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convention} $$ \x8a\x01:k+VHq\xa0\x00\u07d4\x05\x17D\x8d\xad\xa7a\xcc[\xa4\x03>\xe8\x81\xc807\x03d\x00\x89|O\xd1\xee\nx\x00\x00\u07d4\x05\x1dBBv\xb2\x129fQ\x86\x13=e;\xb8\xb1\x86\x89\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x05!\xbc:\x9f\x87\x11\xfe\xcb\x10\xf5\a\x97\xd7\x10\x83\xe3A\ub749\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4\x05\#mL\x90\xd0e\xf9\u34c3X\xaa\xff\xd7w\xb8j\xecl\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x05^*X\xe05\xf1\xfe\x9c\xdd\x16\x9b\xcf$

 $\label{thm:colline} $$ \x97\x03E\xd1+\x9cQ\x89P\xc5\xe7a\xa4D\b\x00\x00\u07d4\x05.\xab\x1fa\xb6\xd4U\x17(?A\xd1D\x18\x87\x87\u0409\xd8\xd7\&\xb7\x17z\x80\x00\u07d4\x053n\x9ar'(\xd9c\xe7\xa1\xcf'Y\xfd\x02tS\x0f\u02891\xa2D?\x88\x8ay\x80\x00\u07d4\x054q\u035aA\x92[9\x04\xa5\xa8\xff\xca6Y\xe0 4\xbe#\x89\n\xd2\x01\xa6yO\xf8\x00\x00\u07d4\x056\x1d\x8e\xb6\x94\x1dN\x90\xfb\xx14\x18\xa9 Z2\xd5\%w2\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x05B:T\xc8\xd0\xf9p\xpAs\xd9\#\xb9F\xed\xc8\xe7\x00\x89\x06\xea\x03\u00bf\x8b\xa5\x80\x00\u07d4\x05D\xf[\arxeb] $$$

\x9d\xff\x88\t\x0e\a\xc4\xf6\xf5\x89E\u04977\xe2/

\x00\x00\u07d4\x05Z\xb6X\xc6\xf0\xedO\x87^\xd6t.K\xc7)-

\x1a\xbb\xf0\x89\x04\x86\u02d7\x99\x19\x1e\x00\x00\u07d4\x05[\xd0,\xaf\x19\xd6

+\xbc\u0703m\x18{\xd1\xc0\x1c\xf2a\x89\x05k\xc7^-

 $c\x10\x00\x00\u07d4\x05^\xacO\x1a\xd3\xf5\x8f\v\xd0\u058e\xa6\r\xbe\x01\u01af\xb3\x89\x05k\xc^{--}$

 $\label{lem:convolu07d4} $$ c\x10\x00\x00\u07d4\x05fQU\xccl\xf6\xaa\xbd\u056e\x92\xcb\xfa\xad\x82\xb8\xc0\xc1\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\x05f\x86\a\x8f\xb6\xbc\xf9\xba\n\x8a\x8d\xc6:\x90o_\xea\xc0\xea\x89\x1b\x1e\xx6.\x90o_\x90\x91k\xd3\x03>\x05R\x1e2\x11\xdf\xec\x02n\x98\xe4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x05k\x15F\x89O\x9a\x85\xe2\x03\xfb3m\xb5i\xb1l\%\xe0\x89\x89\x.\xdb\t\xff\b\u0600\x00\u07d4\x05yl\xe1\xca\x05pF\x9eL\xe3\u0190\xaea:k\x01\xc5Y\x89\x00\x00\x00\u07d4\x05\}\u049f-$

 $z \times 9e\& \times 15\% \times 8965 \times 026d \times c5 \times 000 \times 000$

\x9e\x19\xae\x89\u3bb5sr@\xa0\x00\x00\xe0\x94\x05\xbfO\xcf\xe7r\xe4[\x82dC\x85.I5\x13P\xcer\ ddNo\x8a\x03m\xc4.\xbf\xf9\v\u007f\x80\x00\xe0\x94\x05\xc76\xd3e\xaa7\xb5\xc0\xbe\x9c\x12\u0 22d\\xd9\x03\xc3,\xf9\x8a\x01E^{\x80\n\x86\x88\x00\x00\xe0\x94\x05\xcbl;\x00r\xd3\x11ga\xb52\ xb2\x18D;S\xe8\xf6\u014a\x1e\x02\xc3\xd7\xfc\xa9\xb6(\x00\x00\u07d4\x05\xd0\xf4\xd7(\xeb\xe8. \x84\xbfYu\x15\xadA\xb6\v\xf2\x8b9\x89\u3bb5sr@\xa0\x00\x00\u07d4\x05\u058d\xada\u04fb\u07 f3\xf7y&\\IGJ\xff?\xcd0\x89\x02\"\xc5]\xc1Q\x9d\x80\x00\u07d4\x05\xe6q\xdeU\xaf\xec\x96K\aM\x e5t\xd5\x15\x8d]!\xb0\xa3\x89\u0556{\xe4\xfc?\x10\x00\x00\u07d4\x05\xe9{\tI,\u058fc\xb1+\x89.\x d1\xd1\x1d\x15,\x0e\u02897\b\xba\xed=h\x90\x00\x00\u07d4\x05\xf3c\x1fVd\xbd\xad]\x012\xc88\x 8d6\xd7\u0612\t\x18\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\xe0\x94\x06\t\xd8:I\xe1\xff\u0276\x90\xf 3\xe9\xa8\x1e\x98>\x8b\xdcM\x9d\x8a\x0e\u04b5%\x84\x1a\xdf\xc0\x00\x00\u07d4\x06\x1e\xa4\x 87|\u0409D\xebd\u0096n\x9d\xb8\xde\xdc\xfe\xc0k\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x06%\ xd0`V\x96\x8b\x00\"\x06\xff\x91\x98\x01@\$+\xfa\xa4\x99\x8965\u026d\xc5\u07a0\x00\x00\u07d4\ x06(\xbf\xbeU5x/\xb5\x88@k\xc9f`\xa4\x9b\x01\x1a\xf5\x89Rf<\u02b1\xe1\xc0\x00\x00\u07d4\x06 1\u044b\xbd0\xd9\xe1s+\xf3n\xda\xe2\u0389\x01\xab\x80\x89\xa3\xf9\x88U\xec9\x90\x00\x00 \u07d4\x061\xdc@\xd7NP\x95\xe3r\x9e\xdd\xf4\x95D\xec\xd49og\x89\b\xacr0H\x9e\x80\x00\x00\ xe0\x94\x067Y\xdd\x1cN6.\xb1\x93\x98\x95\x1f\xf9\xf8\xfa\xd1\xd3\x10h\x8a\x02\x1e\x19\xe0\u02 7a\xb2@\x00\x00\u07d4\x06 \xf5u\xfd\x9c\x16\xd3\xcbo\u058f\xfc\x8fH?\xc3.\xc85\x89\n\u05ce\x bcZ\xc6

\x8c\xa1T\xb2D\xd7l\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x06xeJ\xc6v\x1d\xb9\x04\x a2\xf7\xe8Y^\xc1\xea\xacsC\b\x89/\x98\xb2\x9c(\x18\xf8\x00\x00\u07d4\x06\x86\n\x93RYU\xffbI @\xfa\xdc\xff\xb8\xe1I\xfdY\x9c\x89Ih\xcc\u041b\x02,\x00\x00\x00\xe0\x94\x06\x8c\xe8\xbdn\x90*E\u 02c3\xb5\x15A\xb4\x0f9\xc4F\x97\x12\x8a\x01\x1c\x0f\x9b\xadJF\xe0\x00\x00\u07d4\x06\x8e)\xb 3\xf1\x91\xc8\x12\xa699\x18\xf7\x1a\xb93\xaehG\xf2\x89Ij\xccg\u05f1\xd4\x00\x00\u07d4\x06\x8e eWf\xb9D\xfb&6\x19e\x87@\xb8P\xc9J\xfa1\x89\x01\xe8\u007f\x85\x80\x9d\xc0\x00\x00\u0794\x 06\x96N-\x17\xe9\x18\x9f\x88\xa8

 $96\xb4\n\xc9nS<\x06\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\x06\x99L\xd8:\xa2d\n\x97\xb2\vA3\\\x9d\x1e\r>\xdel\x89\r\x8d\r\xqw\xa8\x00\x00\u07d4\x06\x9e\u042bz\xa7\xe5q\xf1a\x06\x05\x1d\x92\xaf\xe1\x95\xf2\u0409\n\u05ce\xbcZ\xc6$

+\xe5\xe88.\x8b\x80\x00\u07d4\x06\xd6\xcb0\x84\x81\xc36\xa6\xe1\xa2%\xa9\x12\xf6\xe65Y@\x a1\x89_h\xe8\x13\x1e\u03c0\x00\x00\u07d4\x06\xdc\u007f\x18\xce\xe7\xed\xab[yS7\xb1\xdf]\x9e\ x8b\u062eY\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\x06\xf6\x8d\xe3\xd79\xdbA\x12\x1e\xac\x f7y\xaa\xda=\xe8v!\a\x89\x01\x84\x93\xfb\xa6N\xf0\x00\x00\u07d4\x06\xf7\u070d\x1b\x94b\xce\xf 6\xfe\xb13h\xa7\xe3\x97K\t\u007f\x9f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\a\x01\xf9\xf1G\xecHhV \xf5\xe1\xb7\x1d\xe9\xf1\x17\xe9\x9e!\x05\x89\te\xdaq\u007f\u0578\x00\x00\u007d4\a\x1d\xd9\r\x14\xd 4\x1f0\xf7\xc4\x13\xc2B8\xd35\x9c\xd6\x1a\a\x8a\a\xb5?y\xe8\x88\xda\xc0\x00\x00\x00\u07d4\a&\xc4 \x13\xc2B8\xd35\x9c\xd6\x1a\a\x8a\a\xb5?y\xe8\x89X\x00>?\xb9G\xa3\x80\x00\x00\xe0\x94\a\x1\x00\x94\a\x1\xbe\n*\x00!

Jw\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\as\xee\xac\xc0P\xf7G

\x00\x00\u07d4\a\xa8\xda\xde\xc1BW\x1a}S\xa4)pQxm\a,\xbaU\x89\x01;m\xa1\x13\x9b\u0680\x00\u07d4\a\xaf\x93\x8c\x127\xa2|\x900\tM\xcf\$\aP\$n=,\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\x00\xe0\x94\a\xb1\xa3\x06\xcbC\x12\xdffH,,\xaer\xd1\xe0a@\x0f\u034a\x04<3\xc1\x93\ud\x80\x00\x00\u07d4\a\xb7\xa5p3\xf8\xf1\x130\xe4f^\x18]#N\x83\xec\x14\v\x89\xea~\xe9*\f\x9a\v\x80\x00\u07d4\a\xb7\x17z\x80\x00\u07d4\a\xb7\x12\x80\x00\u07d4\a\xb7\x17z\x80\x00\u07d4\a\xb7\x17z\x80\x00\u07d4\a\xb7\x17z\x80\x00\u07d4\a\xb7\x17z\x80\x00\u07d4\a\xb7\x17z\x80\x00\u07d4\a\xb8\xa3FO\x0f'\xf8J\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4\a\xd4\x00\x00\u07d4\a\xda\xe6\"c\r\x1168\x193\u04adk\"\xb89\xd8!\x02\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\a\xdc+\xf8;\u01af\x19\xa8B\xff\xeaf\x1a\xf5\xb4\x1bg\xfd\xa1\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4\a\xdd\xd0B,\x86\xef\xb7\r107f\xc3E(b\xb1\"\x8b\b\xb8\x89o\xf5\u04aa\x8f\x9f\xcff\x00\x00\u07d4\a\xdd\xd0B,\x86\xef\x\xf1\u007f\xc3E(b\xb1\"\x8b\b\xb8\x89o\xf5\u04aa\x8f\x9f\xcff\x00\x00\u07d4\a\xe1\x16.\xea\xe3\xcff\xa3\xf6-

 $x98\xfay\xadQH/x89\x17\xd2$ -

 $\label{thm:convolu07d4} $$\x00\u07d4\b\xb7\xbd\u03d4MUp\x83\x8b\xe7\x04\$:\x86\x94HXX\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\b\xbE6\xb7L\x8c\x01T=\x88\x8b\x84\u05cb\xb9WG\xd8\"\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\b\xc2\xf26\xacJ\xdc\xd3\xfd\xa9\xfb\xc6\xe4S\"S\xf9\xda;\xec\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\b\xc8\x02\xf8wX4\x9f\xa0\x62\xe2\xfd\a\x91\x19\xua689lk\x93[\x8b\xbd\@\x00\x00\u07d4\b\xc9\U0007fd89\xfd\xf8\x04\xd7\xf8!\#6\x02\x15\xaf\xf9;\x89j\xcb=\xf2\x1f\x88\x00\x00\x00\u07d4\b\xca\u0215\&A\xd8\xfcRn\xc1\xabO-$

4\t!`_\x99\x16N;\xcc(\xf3\x1c\xae\xcex\x971\x82V\x1d\x89+\ai*\x90e\xa8\x00\x00\xe0\x94\t&\x1f\x 9a\xcbE\x1c7\x88\x84O\f\x14Q\xa3[\xadP\x98\xe3\x8a\x01\u056d'P)

`\x00\x00\xe0\x94\t'\"\x04\x92\x19K.\u069f\u013b\xe3\x8f%\u0581\xdf\xd3l\x8a\x01EB\xba\x12\xa 37\xc0\x00\x00\u0794\t*\xcbbK\b\xc0U\x10\x18\x9b\xbb\xe2\x1ee\$\xd6D\u032d\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\t.\x81UX@-

 $g\xf9\rk\xfem\xa0\xb2\xff\xfa\x91EZ\x89\x03@\xaa\xd2\x1b;p\x00\x00\u07d4\tP0\xe4\xb8\&\x92\xdc\xf8\xb8\u0411\x94\xb9\xb3x\xec\x93(\x89H\xa4<T`/p\x00\x00\u07d4\tRp\xccB\x14\x1d\u0658\xad(b\xdb\xd1\xfe\x9bD\xe7\xe6P\x89A\rXj)$

 $\label{thm:condition} $$ \x9c\xcaC\xb3\xc2\b\xa2\x1e\u050b\x89\b!\xd2!\xb5)\x1f\x80\x00\xe0\x94\t\xd6\xce\xfdu\xb0\u013 $$ 3\xf8\xf1\u0587\xa5\"\xc9a\#\xf1\xf59\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\x00\xe0\x94\t\xe47\xd4H\x86\x12\xe82\xb6.\xe8\xd3\ye\xa9\x04\ud70a\x04\x98\xcf@\x1d\xf8\x84.\x80\x00\u07d4\t\xee\x12\xb1\xb4+\x05\xaf\x9c\xf2\a\xd5\xfc\xac\%[.\xc4\x11\xf2\x89\x031\xcd\xddG\xe0\xfe\x80\x00\u07d4\t\xf3\xf6\x01\xf6\x05D\x11@XI\xe0eo\xa2J\xa5\xb1\u066e\x89S\xo0\xe8\xc4T\x00\x00\u07d4\t\xf9 $$W[\xe5\x00G\x93\u01e4\ub137\x15\x87\xf9\]\x89\n\u05ce\xbcZ\xc6$$

 $\label{thm:convolve} $$\x00\x00\x00\x01\x19\x95\u0181\xbc\x99\x9f\xddyuN\x9a2J\xe3\xb3y\x8a\b\xc1\x9a\xb0n\xb0x9a\xf6\x00\x00\u07d4\nX\xfd\xddq\x89\x8d\xe7s\xa7O\xda\xe4^{\xd8N\xf46F\x89\x01\x15\x8e}$$ F\t\x13\xd0\x00\x00\u07d4\n[y\xd8\xf2;d\x83\xdb\u2f6ab\xb1\x06L\xc7cf\xae\x89j\u0202\x10\tR\u01c0\x00\u07d4\ne.*\x8bw\xbd\x97\xa7\x90\xd0\xe9\x13a\u0248\x90\u06f0N\x8965\u026d\xc5\u07a0\x00\x00\u07d4\nn\xber;n\xd1\xf9\xa8ji\xdd\xdah\xdcGF\+\x1b\x89\@=-$

\xb5\x99\xd5\xe4\x00\x00\u07d4\nw\xe7\xf7+C{WO\x00\x12\x8b!\xf2\xac&Q3R\x8c\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\n\x91\u007f;\\\xb0\xb8\x83\x04\u007f\u0676Y=\xbc\xd5W\xf4S\xb9\x8965\u026d\xc5\u07a0\x00\x00\u07d4\n\x93\x1bD\x9e\xa8\xf1,\xdb\xd5\xe2\xc8\xccv\xba\xd2\xc2|\x069\x89\x01?\x9e\x8cy\xfe\x05\x80\x00\u0794\n\x98\x04\x13x\x03\xbahh\xd9:U\xf9\x98_\xcdT\x04Q\u4239\x8b\xc8)\xa6\xf9\x00\x00\u07d4\n\x9a\xb2c\x8b\x1c\xfdeM%\u06b0\x18\xa0\xae\xbd\u07c5\xfdU\x89\x01.\x8c\xb5\xfeLJ\x80\x00\u07d4\n\xb3f\xe6\xe7\u056b\xbc\xe6\xb4JC\x8di\xa1\u02bb\x90\xd13\x89\x11X\xe4`\x91=\x00\x00\x00\u07d4\n\xb4(\x1e\xbb1\x85\x90\xab\xb8\x9a\x81\xdf\a\xfa:\xf9\x04\x6\x8a\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u0794\n\xb5\x9d9\a\x02\xc9\xc0Y\xdb\x14\x8e\xb4\xf3\xfc\xfa}\x04\xc7\xe7\x88\xfc\x93c\x92\x80\x1c\x00\x00\x00\u07d4\n\u029aV&\x91;\b\xcf\u0266\m@P\x8d\xceR\xb6\x0f\x87\x89g\x8a\x93

M%\x8a\x01\a\x14\xe7{\xb4:\xb4\x00\x00\u07d4\v6\x9e\x00.\x1bLy\x13\xfc\xf0\x0f-

 $$$ \x 19 \u 0.141 eG\x 8f\x 89\x 0.3 \u 0.07 fe\x 16 (\x 8c4\x 0.0)\x 0.00 \u 0.7 d4\v C\x bd\#\x 9.1\x 0.2 U\x 8.1\u 0.615 \x e.4^*\x e.4^*\x 0.00 \x 0.00 \u 0.7 d4\v P\x f.5 SV\x 8d\x e.a\x f.6 U\x 0.4\x e.N \x e.4^*\x e.4 \x e.4$

5\xf7l\rE\nU(C\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\v^

\x11\xeb\xc2Z\x00\u007f!6)`I\x8a\xfb\x8a\xf2\x80\xfb\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\vd\x9d\xa3\xb9j\x10,\xdcm\xb6R\xa0\xc0}e\xb1\xe4C\xe6\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\vi\xa6K6;\x8d]\x90\x80\$\x94\xcfVKT|C\r\x89A\rXj

 $\& \x 16 \x 89 \x 16 \x 93 \x 10 \x 90 \x 00 \$

 $p\xd1;1\x01,\x95\xcd\x1c\u0589lk\x93[\x8b\xbd@\x00\x00\u07d4\v\xe2\xb9J\xd9P\xa2\xa6\&@\xc3[\xfc\xcdlg\xda\xe4P\xf6\x89i*\xe8\x89p\x81\xd0\x00\x00\xe0\x94\v\u681eC\a\xfeH\xd4\x12\xb8\u0 461\xa8(M\xceHba\x8a\x04\x0f\xbf\xf8\)\x0180\x00\x00\u07d4\v\xef\xb5G\a\xf6\x1b,\x9f\xb0G\x15\xab\x02n\x1b\xb7$

 $B\xbd\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\v\xf0dB\x8f\x83bg\"\xa7\xb5\xb2j\x9a\xb2\x04!\xa7\x89\a?u\u0460\x85\xba\x00\x00\u07d4\v\xfb\xb6\x92]\xc7^R\xcf\&\x84\"K\xbe\x05P\xfe\xa6\x85\u04c9j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\fb\x80\x06\xc6K0\xc4\u076f\xbc6\xcb_\x05F\x9e\xb6(4\x89)\k\x93[\x8b\xbd@\x00\x00\u07d4\f}$

 $s\aD\a077d\xb69\xc0N\x19\x109\xa7\x17\x16\#\u007f\x89M\x85<\x8f\x89\b\x98\x00\x00\xe0\x94\f\,|A\u0270H\xef\xcc\xe0\xa22CCb\xe1-$

g;\x8a\x02\x1e\x83Yivw8\x00\x00\xe0\x94\f(\b\xb9Q\ud787-

af|NS\x0fY\u0200\xfe\x8965\u026d\xc5\u07a0\x00\x00\u07d4\f-

 $x02\x90\x8bI\xf6\x0f\xc6\x1e+b\xd3\x14\v\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\fH\xaeb\xd1S\x97\x88\xeb\xa0\x13\xd7^\xa6\vd\xee\xbaN\x80\x89w\xfb\xdcC\xe00\x99\x80\x00\u07d4\fU\x89\xa7\xa8\x9b\x9a\xd1[\x02u\x190AYH\xa8u\xfb\xef\x89\x06\u0519\xeclc8\x00\x00\u07d4\fg\x03=\xd8\xee\u007f\fx8a\xe54\xd4^Q\xf7\xd9\xd4\xf7\x97\x8f\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:cond} $$ \x00\x00\u07d4\fhE\xbfA\xd5\xee'<>\u6d70\u059fo\xd5\xea\xbb\xf7\x89\xa2\xa1\xb9h.X\t\x00\x00\x00\x00\x00\x00f\x86\x90\xd5?\xdc\x03\u8c81\x9b\x01k\x9d\x18\xeb&\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\f\x86\x92\xee\xff*S\xd6\xd1h\x8e\xd5j\x9d\u06fdh\u06bb\xa1\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\f\x8ff\xc6\x01{\xce}[$

 $4r\x04\xb6\x02\xb7C\xba\u05cd`\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\f\x8f\xd7w^T\xa6\xd9\u02\\63\xbf\x89\x0ev\x1fewi?\xf0\x8a\x02\x15\xf85\xbcv\x9d\xa8\x00\x00\u07d4\f\x92Z\xd5\xeb5,\x8e\xf7m\f''-$

c\x10\x00\x00\xe0\x94\f\xa1*\xb0\xb9fl\xf0\xce\xc6g\x1a\x15)/&SGj\xb2\x8a,x'\xc4-

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\rg\x87\x06\xd07\x18\u007f>\label{thm:convolu07d4} $$ \x00\x00\u07d4\ri\x10\f9\lxe6\xc5\xea\xad\xf9\]\x05\xd8\rx83~\xde\xdd\lx89\x15\xaf\x1dx\xb5\x8c@\x00\x00\x00\xe0\x94\rr\x80\dw8\x1do\xe3\xa2@\lxd0\xd8\xce'\x8a\x15-\x02\xc7\xe1\J\xf6\x80\x00\x00\u07d4\r\x80\#\x92\x9d\x91\r4\xae@Q+\x1a\xab\xb5\xe8\xa4Q\rq\x89\b\x05\xe9\x9f\xdc\xc5\xd0\x00\x00\x00\xe0\x94\r\x8a\xab\x8ff\xea\x86,\xdfvh\x05\x00\x9d\?>B\xd8\xd0\x01\x8a\x01\x8a\x01\x8b\x9e\x2Q\xee\x10\u$

 $0408 \ 0001. \ x80 \ x89 \ x066 \ x60 \ x00 \$

 $\x 8a x 0 2 x b 5 x e 3 x a f x 16 x b 1 x 88 x 0 0$

\x86\xac5\x10R`\x00\x00\u07d4\r\xa52\xc9\x10\xe3\xac\r\xfb\x14\xdba\xcds\x9a\x935?\xd0_\x89H x\xbe\x1f\xfa\xf9]\x00\x00\u07d4\r\xa7@\x12b8N.\x8bK&\xdd\x15G\x99\xb5QE\uf809\x10CV\x1a\x88)0\x00\x00\u07d4\r\xae>\xe5\xb9\x15\xb3d\x87\xf9\x16\x1f\x19\x84m\x10\x1431\x8a\x89g\x8a\x93

 $\x0f\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:c4} $$ \x94\xa1\xc4\u04e4\v\xb8\xc1}\xa7\U000d6209\x13h?\u007f<\x15\xd8\x00\x00\u007d4\x0e!\xaf\x1b\x8d\xbf'\xfc\xf6?7\xe0G\xb8z\x82\\x82\\x82\xa1]\tQ\x9b\xe0\x00\x00\u007d4\x0e.PJ-$

 $\label{thm:link} $$ \x11'''xb5xa9'xfe'xee''xb1E'x1b'xf4'u00ac'xe8{x89'u0556{xe4'xfc?'x10'x00'x00'u07d4'x0e/x8e'(xa6'x81'xf7|X;'xd0'xec'xde'x16cK'xdd~'x00'u0349'x05'8'xf6Y'xbc'xa2'x00'x00'u07d4'x0e2'x02'x19'x83'x8e'x85'x9b/x9f'x18'xb7.=@s'xcaP'xb3}'x89lk'x93['x8b'xbd@'x00'x00'u07d4'x0e3'xfc'xbb'xc0'x03Q'v'xe3W'x85'xb5*'x9c]!k'xc0'x05'xf4'x89e'xea='xb7UF'\x00'x00'u07d4'x0e6'x96'xcf'x1fB'x17'xb1c'u047c'x12'xa5'xeas'x0f'x1c2'xa1J'x89'xd8'xd7&'xb7'x17z'x80'x00'x00'u07d4'x0e9'x0fD'x05='xdf'xce'xf0'xd6'b'xb3'M'x9c,'xbe'x98q'xbb'x89j'xcb='xf2~'x1f'x88'x00'x00'u07d4'x0ee'(xc1'u07ef'xb0P['xdc'xe1'x9f'xe0'%'xf5'x06'xa6'xd0'x1c'xeb'x89lk'x93['x8b'xbd@'x00'x00'u07d4'x0ed'x0e='xd7'xd4'xe4)'xfe90'xa6A@5'xf5+'xdcY'x9dxM'x89'x02,'xa3X|'xf4'xeb'x00'x00'u07d4'x0eGey'x03Rek'xc6Vh,$'xfc'\xf3'xe7j#'u01c9'x02'x86'xd7'xfc'f'xb4'xf5'x00'x00'u07d4'x0ek'xaa'xa3'u07b9'x89'xf2'x89b'x00'f'x86'x18'xe9'xac3(e'x89'n'u05ce'xbcZ'xc6$

\x00\x00\xe0\x94\x0el\xd6d\xad\x9c\x1e\xd6K\xf9\x87I\xf4\x06D\xb6&\xe3y,\x8a\f\xb4\x9bD\xba`-

 $\label{thm:convention} $$ \x00\x00\u07d4\x0e\xe4\x14\x94\x04\x87\xfd\xe3\x907\x82\x85\xc5\u05f93M\x8be\x89\x91Hx\xa88\xc0^\xe0\x00\x00\u07d4\x0e\xf5J\xc7\&M\"T\xab\xbb_\x8bA\xad\u0787QW\xdb|\x89\x02+\x1c\x88c\x12'\xa0\x00\x00\u07d4\x0e\xf8[I\u040au\x19\x86\x92\x91N\u0774\xb2,\xf5\xfaDP\x89I\xae0b\x1dG$$$

 $\label{thm:cond} $$ \x00\x00\u07d4\x0e\xfd\x17\x89\xeb\x12D\xa3\xde\xde\x0f]\xe5\x82\u0616<\xb1\xf3\x9f\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\xe0\x94\x0f\x04\x9c\xb1\x87f\xf86\xbbY\xf75\xf2}\xc3)\xfe<\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x0f\x04\x9a\x8b\xdf\xd7a\u078e\xc0,\xee()\xc4\x00[\#\xc0\xx89\r\xa93\xd8\xd8\xc6p\x00\x00\xe0\x94\x0f\x05\xf1$

 $\label{thm:condition} $$ \x8d\xaf\x04\xb5AJ\x02a\xf5I\xffdw\xb8\x0f/\x1d\a\x8a*Z\x05\x8f\u0095\xed\x00\x00\x00\u07d4\x0f\x84\u0022a\xffoT:\xc6\"\x8b\u040eO`\xb0\xa5\xfd\x89\xaa}\xa4\x85\x13k\x84\x00\x00\u07d4\x0f2\xd9\xcbM\x0f\u06a0\x15\x06\V\xbb`\x8d\xccC\xed\x93\x01\x89(\u07cb\xf4@\xdby\x00\x00\u007d4\x0f6e\u050e\x9f\x14\x19\u0358O\xc7\xfa\x92x\x87\x10\xc8\xf2\xe4\x89lk\x93[\x8b\xbd@\x00]$

 $0 \times 00 \times 07 + x \times 00 \times 07 +$

 $\label{thm:linear} $$ \ab\x3\x92pk\x13\x1f\xb1\xdeo\x89\x1b\x1a\xb3\x19\xf5\xecu\x00\x00\u07d4\x0fn\x84\n?*$ $$ d\x8eC\xe0\x9dE\xc7\xc35\xdfBH\x89\x87\x86\x2n\xac\x90\x00\x00\u07d4\x0fu\x15\xff\x0e\x80\x8fi^f $$$

H_\xf9n\xd2\xf7\xb7\x93\x10\x8968\"\x16`\xa5\xaa\x80\x00\u07d4\x0fx\x9e09|S\xbf%o\xc3d\xe6\x ef9\xf8SPA\x14\x89\xc5S%\xcat\x15\xe0\x00\x00\u07d4\x0f{a\u015b\x01c\"\xe8\"|\xaf\xae\xe9\xd9 \xe7mP\xa1\xb3\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x0f{\xeaN\xf3\xf7:\xe0#=\xf1\xe1\x00q \x8c\xbe)1\v\xb0\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\x0f{\xf67?w\x1aF\x01v,M\xae_\xbb\xf4\xfe\u 075c\u0249lk\x93[\x8b\xbd@\x00\x00\u07d4\x0f\x83*\x93\u07dd\u007ft\xcd\x0f\xb8Tkq\x98\xbfSw \xd9%\x89\a\xc0\x86\x0eZ\x80\xdc\x00\x00\u07d4\x0f\x83F\x1b\xa2\$\xbb\x1e\x8f\u075d\xaeSQr\ xb75\xac\xb4\xe0\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\x0f\x85\xe4+\x1d\xf3!\xa4\xb3\xe85\xb5\f\x00\xb0as\x96\x846\x895e\x9e\xf9?\x0f\xc4\x00\x00\x00\xe0\x94\x0f\x88\xaa\xc94l\xb0\xe74\u007f\xbap\x90Tu\xba\x8b>^\u038a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x0f\x92\x9c\xf8\x95\xdb\x01z\xf7\x9f>\xad\"\x16\xb1\xbdi\xc3}\u01c9lk\x93[\x8b\xbd@\x00\x00\u07d4\x0f\xa0\x10\xce\fs\x1d;b\x8e6\xb9\x1f\W\x13\x00\u477e\xab\x8963\x03\"\xd5#\x8c\x00\x00\u07d4\x0f\xa5\xd8\u0173\xf2\x94\xef\u0515\xabi\xd7h\xf8\x18rP\x85 H\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x0f\xa6\u01f0\x97=\v\xae)@T\x0e\$}6"\xe3|\xa3G\x8965\u026d\xc5\u07a0\x00\u07d4\x0f\xad\x05P|\u070f\$\xb2\xbeL\xb7\xfa]\x92\\u06d1\x1b\x88\x89\xa2\xdf\x13\xf4A\xf0\t\x80\x00\u07d4\x0f\xb5\xd2\xc6s\xbf\xb1\xdd\xca\x14\x1b\x98\x94\xfdm?\x05\xdaq \x89\x05k\xc7^-

\xf9\x99#B\xf6\x0f\xf6\x8d\x89\x12

\u007f\x0e\xdc\xe9q\x80\x00\u07d4\x0f\ue06c3\x1e\xfd\x8f\x81\x16\x1cW8+\xb4P{\xb9\xeb\xec\x 89\x15\xaf\x88\r\x8c\u06c3\x00\x00\u07d4\x0f\xfe\xa0mq\x13\xfbj\xec(i\xf4\xa9\u07f0\x90\a\xfa\xc e\xf4\x89\f8F\x81\xb1\xe1t\x00\x00\u07d4\x10\tq\x98\xb4\xe7\xee\x91\xff\x82\xcc/;\xd9_\xeds\xc5 @\xc0\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x10\vM\tw\xfc\xba\xd4\u07bd^d\xa0lz\xea\xe5\x16\x8f \xab\x89\x11\f\x90s\xb5\$Z\x00\x00\x00\x00\u07d4\x10\vM\tw\xfc\xba\xd4\u07bd^d\xa0lz\xea\xe5\x16\x8f \xab\x89\x11\f\x90s\xb5\$Z\x00\x00\x00\x00\x00\u07d4\x10\x1a\nd\xf9\xaf\xccD\x8a\x8a\x13\rM\xfc\xbe\xe8\x 957\xd8T\x8a\x037\xfe_\xea\xf2\u0440\x00\x00\x00\u07d4\x10,G}i\xaa\u06e9\xa0\xb0\xf6+tY\xe1\u00 7f\xbb\x1c\x15a\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\x101\xe0\xec\xb5l\x85\xae!\xaf\x17\x93\x95\ r\xc8\x11\x88\x8f\xde|\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x104\x104\x108\x98X\xb8\x00\xe6\xd6\x135YF\xcc@\x9b\x89\n\u05ce\xbcZ\xc6

\x00\x00\xe0\x94\x10Y\xcb\xc6>6\xc4>\x88\xf3\x00\b\xac\xa7\xce\x05\x8e\ua816\x8a\x15-\x02\xc7\xe1J\xf6\x80\x00\x00\xe0\x94\x10n\xd5\xc7\x19\xb5&\x14w\x89\x04%\xaeuQ\xdcY\xbd%\\\x8a\x02\x89jX\xc9[\xe5\x88\x00\x00\u07d4\x10q\x1c=\xda21x\x85\xf0\xa2\xfd\x8a\xe9.\x82\x06\

x9b\r\v\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x10sy\xd4\xc4gFO#[\xc1\x8eU\x93\x8a\xad>h\x8a\u05c9\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\x00\xe0\x94\x10v!-

\xdf,\x89\x90\xf54`\x8ar\x88\x00\x00\xe0\x94\x10\x8a+|3oxGy\u0635M\x02\xa8\xd3\x1d\x9a\x13\x\9c\n\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x10\x8b\xa7\u0089\\P\xe0r\xdco\x96I2\xd5\f(-

 $04\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x10\x8f\xe8\xee*\x13\xdaH{\''\u01abmX.\xa7\x10} d\u064c\x89\x15\xacV\xed\xc4\xd1,\x00\x00\xe0\x94\x10\x91\x17k\u16d9d\xa8\xf7.\x0e\xcek\xf8\xe3\u03edn\x9c\x8a\x02\x1f/o\x0f\xc3\xc6\x10\x00\x00\u07d4\x10\x98\xc7t\xc2\f\xa1\u06ac]\xdbb\x03e1m5?\x10\x9c\x89\x05k\xc7^-c\x10\x00\x00\u0794\x10\x98\xcc$

 $c\x10\x00\x00\u07d4\x10\xd9E3N\xcd\xe4{\ub723\x81}\x17=\xfb\xbd\vS3\x89K\xe4\xe7\&{j}\xe0\x00\x00\u07d4\x10\xdfh\x15\x06\xe3I0\xacz\g\xa5L>\x89\u0392\xb9\x81\x89t\xc1\xfa\xb8\xad\xb4T\x00\x00\u07d4\x10\xe1\xe37x\x85\xc4-$

 $\label{thm:linear_conj} $$ \xf2\x18R.\xe7vh\x87\xc0^j\x89\x10C\xc4<\xde\x1d9\x80\x00\u07d4\x10\u342d+\xa3=\x82\xb3s\x80\u041cED\u01b0\"]\xe5\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\x10\xf4\xbf\xf0\u02a5\x02\nj-\xcf\xc9R\x82M\xe2\x94\t\t\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x11\x00\x1b\x89\xed\x87>:\xae\xc1\x15V4\xb4h\x16C\x98c\#\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x11\x027\u03d1\x17\xe7g\x92/\u0121\xb7\x8dyd\u0682\xdf$

 $\label{thm:convolv00} $$ \x00\x00\u07d4\x11L\xbb\xbfo\xb5^*\xc4\x14\xbe~\xc6\x1f{\xb7\x14\x95\xce\x1d\xfa\x89\xa2\xa1]\tQ\x9b\xe0\x00\u07d4\x11L\xfe\xfeP\x17\r\xd9z\xe0\x8f\nDTIx\u0159T\x8d\x89.\u0207\xe7\xa1J\x1c\x00\x00\u07d4\x11a\b\xc1$$

 $13\x04\fx89<\x89\kx93\fx8b\xbd@\x00\x00\u07d4\x11o\xef^`\x16B\xc9\x18\u02c9\x16\x0f\xc2); \x87\x1d\x896\x89+|\xc2\xe9\xc3\"\\x00\x00\u07d4\x11xP\x1f\xf9J\xdd\x1cX\x81\xfe\x88a6\xf6\xdf\xdf\xdb\xe6\x1a\x94\x89\b\x90\xb0\xc2\xe1O\xb8\x00\x00\u07d4\x11y\xc6\r\xbd\x06\x8b\x15\v\aM\xa4\xbe#\x03;$

 $\label{thm:linear} $$ \a0\x00\x00\u07d4\x11}\x9a\xa3\xc4\xd1;\xee\x12\xc7P\x0f\t\xf5\xdd\x1cf\xc4e\x04\x89\v^*\xd3\x04\x90\xb2x\x00\x00\x00\x94\x11}\xb867\u007f\xe1TU\xe0,.\xbd\xa4\v\x1c\xebU\x1b\x19\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\x00\xe0\x94\x11\x8c\x18\xb2\xdc\xe1p\xe8\xf4Eu;\xa5\xd7Q<\xb7cm-$

 $\x 94\x 80\x 00\u 07d4\x 12m\x 91\x f7\x ad\x 86\u 07bb\x 05W\x c6\x 12\x ca'n\x b7\x f9m\x 00\x a1\x 89\x 05k\x c7^-$

 $= xe2x94xc4Axc7xe2nx86xeagx89&xabx14xe0xc0xe1<x00x00xe0x94x12x93xu01cc} j$

 $D; \x9dt \xb0 \xba^\xe7 \xbbG \xfdA \x85 \x88 \x8a \x01 je \x02 \xf1Z \x1eT \x00 \x00 \x007 d4 \x12 \x96 \xac \xde \xd1 \xe0c \xaf9 \xfe \x8b \xa0 \xb4 \xb6 = \xf7 \x89 \xf7 \x05 \x17 \x89 \x05 \xxf9 \x1b \x1ae \xb0 \x00 \x00 \x00 \x000 \x0000 \x000 \x000$

\xaa\xb6v\xfei\xab\xd9\xe0\x185-

\x00\x00\u07d4\x137\x1f\x92\xa5n\xa88\x1eC\x05\x9a\x95\x12\x8b\xdcMC\u0166\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x13<|\x0f\xa5\xbf\u007f7(\x88\xe6\a\xd9X\xfa\xb7\xf9U\xba\xe1\x89U\xa6\xe7\x9c\xcd\x1d0\x00\x00\u07d4\x13>O\x15\xe1\xe3\x9cSCY0\xaa\xed\xf3\xe0\xfeV\xfd\xe8C\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x13Ac\xbe\x9f\xbb\xe1\xc5in\xe2U\xe9\v\x13%C\x95\xc3\x18\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\x13]\x17\x19\xbf\x03\xe3\xf8f1\$y\xfe3\x81\x18\xcd8~p\x89|k\x93[\x8b\xbd@\x00\x 00\xe0\x94\x13^\xb8\xc0\xe9\xe1\x01\xde\xed\xec\x11\xf2\xec\xdbf\xae\x1a\xae\x88g\x8a\x04<3\x c1\x93ud\x80\x00\x00\u07d4\x13`\xe8}\xf2Li\xeemQ\xc7nsv\u007f\xfe\x19\xa2\x13\x1c\x89\x04\xf c\xc1\xa8\x90'\xf0\x00\u07d4\x13`\xe8}\xf2Li\xeemQ\xc7nsv\u007f\xfe\x19\xa2\x13\x1c\x89\x04\xf c\xc1\xa8\x90'\xf0\x00\u07d4\x13|\x83K\xf1\x112m s\x95)[.X>\xa7\xf35r\x89\x05k\xc7^-c\x10\x00\x00\u07d4\x13mKf+\xbd\x10\x80\xcf\xe4D[\x0f\xa2\x13\x86D5\xb7\xf1\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x13ol\a\u02b4\x1e'\bK\x98E\x06\x9f\xf2\xfd\f\x9a\xdey\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x13\xfa\xcd{?\x8dhd\x9d`\xd4U\x0e\xe6\x9f\xf0HA3\x89\x0e\x9e\xd6\xe1\x11r\xda\x00\x00\u07d4\x13\xf3A\xe8Q|\x81X\x14\xeb\xcds\xe6V\x9a\xf1L\xf7\xbc\x8965\u026d\xc5\u07a0\x00\x00\x00\x00\x00\x00\u07d4\x13\x84\x8bF\xeau\xbe\xb7\xea\xa8_Y\xd8f\xd7\u007f\xd2L\xf2\x1a\x8a\n\x96\x81c\xf0\xa5{@\x00\x00\u07d4\x13\x9651\u0252*\xd5bi\xf60\x9a\xa7\x89\xfb\x85\xf9\x8c\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x13\x9eG\x97d\xb4\x99\xd6f\x8c\x82\x88\xd2\x97\x041c\u0749\w!*\xffm\xf0\x00\x00\u07d4\x13\xa5\xee\xcb80]\xf9|q\xef-

 $\label{thm:condition} $$ \exp(x17)x9a\\xe6\\u03ba\\xb37\\x89\\x11\\u3ac3\\x95\\xc6\\xe8\\x00\\x00\\u07d4\\x13\\xac\\xad\\xa13\\xb9\\xb1\\a\\x15qL\\thm:condition} $$ f(xc7PI!\\xbe\\x84\\xebID\\xc8\\xfb\\xb2\\xb1\\xd5\\x13\\x89\\xcb=\\xf2-\\x1f\\x88\\x00\\x00\\u07d4\\x13\\xce3-\\xfe\\xa6\\xab\\x938\\x97X\\x8a\\xa2>\\x00\\t\\x80\\xfa\\x82\\x89\\x0e\\x02\\x056\\xf0\\(xf0\\x00\\x00\\u07d4\\x13\\xde\\xe0>7\\x99\\x95-\\$

f6D\x04\xdbP\xf0\xd0\u05cduJ\"\x19\x8e\xf4\x89e\xea=\xb7UF`\x00\x00\u07d4\x14\xab\x16K;RL\x 82\u05ab\xfb\xc0\u0783\x11&\xae\x8d\x13u\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x14\xb1`>\xc6+\x02

 $3\xee\xc4\xd6\xd6eZ\xc2J\x01Z\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\xe0\x94\x14\xc6;\xa2\u00731\xddM\xf3=\u006b1\x1cO\x00\a\xfa\x96\xa6-$

\x8a\x03HA\xb6\x05z\xfa\xb0\x00\x00\xe0\x94\x14\xcd\u077c\x8b\t\xe6gZ\x9e\x9e\x05\t\x1c\xb9\" 8\u00de\x1e\x8a\x01\x14x\xb7\xc3\n\xbc0\x00\x00\u07d4\x14\xd0\n\xad9\xa0\xa7\u045c\xa0SP\xf

 $7\xb07'\xf0\x8d\xd8.\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x14\xee\xc0\x9b\xf0>5+\xd6\xff \x1b\x1e\x87k\xe6d\xce\xff\xd0\u03c9\x01\x16\xdc:\x89\x94\xb3\x00\x00\u07d4\x14\xf2!\x15\x95\x18x;\u0127\x06go\xc4\xf3\xc5\xee@X)\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:convolu07d4} $$\and $\and $$\and $$\and $\and $$\and $\and $\and $\and $\and $\and $\and $\and $\and $\and $$

\x9c\x0e\x1e9\xa2\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x15/N\x86\x0e\xf3\xee\x80jP'w\xa1\xb8\xdb\xc9\x1a\x90vh\x89

 $\label{thm:converse} $$ \x81\xc7\xf4\x13'\x89\x02\xb8\xaa:\al\x9c\x00\x00\u07d4\x15e\xaf\x83~\xf3\xb0\xbdN+#V\x8dP\#\xc4\xb1d\x98\x89\x15Q\xe9rJ\u013a\x00\x00\u07d4\x15f\x91\x80\xde\u2558\x86\x9b\b\xa7!\xc7\xd2LL\x0e\xe6?\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94\x15r\xcd\xfa\xb7*\x01\u0396\x8ex\xf5\xb5D\x8d\xa2\x98S\xfb\u074a\x01\x12bll\x06\x0f\xa6\x00\x00\x00\xe0\x94\x15uY\xad\xc5Wd\xccm\xf7\x93\#\t%4\xe3\xd6dZf\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\x00\u07d4\x15x\xbd\xbc7\x1bM$8E3\x05V\xff\xf2\xd5\xefM\xfg\x89\x05k\xc7^-$

c\x10\x00\x00\u07d4\x15~\xb3\xd3\x11;\u04f5\x97qM:\x95N\xdd\x01\x89\x82\xa5\u02c9lk\x93[\x8 b\xbd@\x00\x00\u07d4\x15\x84\xa2\xc0f\xb7\xa4U\xdb\u05ae(\a\xa73N\x83\xc3_\xa5\x89\a\f\x1c\ xc7;\x00\xc8\x00\x00\u07d4\x15\x87F\x86\xb6s=\x10\xd7\x03\xc9\xf9\xbe\xc6\xc5.\xb8b\x8dg\x89 Ik\x93[\x8b\xbd@\x00\x00\u07d4\x15\x8a\ra\x92S\xbfD2\xb5\xcd\x02\u01f8b\xf7\u00b7V6\x89\a[\x ac|[\x12\x18\x80\x00\u07d4\x15\x98\x12\yx82\xf2\xf8\xad;k\x8f\xc3\xcf'\xbfax\x01\xba+\x89\t`\xdb wh\x1e\x94\x00\x00\xe0\x94\x15\x9a\xdc\xe2z\xa1\vG#d)\xa3JZ\xc4,\xad[d\x16\x8a\x06\xbf\x90\x a9n\xdb\xfaq\x80\x00\u07d4\x15\xa0\xae\xc3\u007f\xf9\xff=T\t\xf2\xa4\xf0\xc1!*\xac\xcb\x02\x96\x 8965\u026d\xc5\u07a0\x00\x00\u07d4\x15\xaaS\r\xc3iX\xb4\xed\xb3\x8e\xeem\xd9\xe3\xc7\L\x91 E\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\x15\xac\xb6\x15h\xecJ\xf7\xea(\x198a\x81\xb1\x16\xa6\x c5\xeep\x8a\x06\x90\x83I\n\xf5\xf5`\x00\x00\u07d4\x15\xb9o0\xc2;\x86d\xe7I\x06Q\x06k\x00\xc49 \x1f\xbf\x84\x89\x16B\xe9\xdfHv)\x00\x00\u07d4\x15\xc7\xed\xb8\x11\x8e\xe2{4\"\x85\xebY&\xb4 z\x85[\u01e5\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x15\u0654hPz\xa0A?\xb6\r\xca*\xdc\u00 7f\/x9c\xb3kT\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\x15\u06f4\x8c\x980\x97d\xf9\x9c\xed6\x92\x dc\xca5\xee0k\xac\x8a\x1f\u00c4+\xd1\xf0q\xc0\x00\x00\x00\x94\x15\u072f\xcc+\xac\xe7\xb5[T\xc 0\x1a\x1cQF&\xbfa\xeb\u060a\x01\xfd\x934\x94\xaa_\xe0\x00\x00\u07d4\x15\u3d44\x05kb\xc9s\x cf^\xb0\x96\xf1s>T\xc1\\x91\x892\xc7Z\x02#\xdd\xf3\x00\x00\u07d4\x15\xeb\xd1\xc7\xca\u04af\xf $1\x92u\xc6W\xc4\xd8\b\xd0\x10\xef\xa0\xf5\x89\n\xdf0\xbap\u0217\x00\x00\u07d4\x15\xee\x0f\xc$ 6>\xbf\x1b\x1f\u011d{\xb3\x8f\x88c\x82:.\x17\u0489g\x8a\x93

 $b \times 4 \times 18 \times 00 \times 00 \times 07 \times 15 \times 11 \times 90 \times 10 \times 10 \times 10 \times 10 \times 10^{-10} \times 1$

 $\label{thm:convoluo7d4} $$\x00\x00\u07d4\x15\xf2\xb7\xb1d2\xeeP\xa5\xf5[A\#/c4\xedX\xbd\xc0\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\x16\x01\xabC\xf4\u067fAc\xfa\xe0\x84\x8a\xfc\xa2\x89\x01[\xc7\x019\xf7J\x00\x00\u07d4\x16\x02\&\xef\xe7\xb5:\x8a\xf4b\xd1\x17\xa0\x10\x80\x89\xbd\xec\xc2\u0449\n\xdf0\xbap\u0217\x00\x00\u07d4\x16\f\xebo\x98\x0e\x041_S\xc4\xfc\x98\x8b+\xf6\x9e(M)\x89\x01\t\x10\xd4\xcd\xc9\xf6\x00\x00\x00\x00\x00\x00\x00\x07d4\x16\x1c\xafZ\x97*\u0383y\xa6\u0420J\xe6\xe1c\xfe!\xdf+\x8a\x15-\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\x16\x1d\x8xefgY\xba[\x9f]$

\xfd\xcdf\xf1a2\xc3RA^\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x16!\x10\xf2\x9e\xac_}\x02\xb5C\xd8\\xdc\u057bY\xa5\xe3;s\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\x16+\xa5\x03'b\x14\xb5\t\xf9u\x86\xbd\x84!\x10\xd1\x03\xd5\x17\x8a\x01\xe7\xff\u0609\\\"h\x00\x00\u07d4\x16-

c\x10\x00\x00\u07d4\x16\x9b\xbe\xfcA\xcf\xd7\xd7\u02f8\xdf\xc60

\xe9\xfb\x06\u0515F\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x16\xa5\x8e\x98]\xcc\xd7\a\xa5\x94\u04 53\xe7\u0327\x8b]\x02xl\x89l\xb9\u029aiC@\x00\x00\u07d4\x16\xa9\xe9\xb7:\u92c6M\x17(y\x8b\ x87f\xdb\xc6\xea\x8d\x12\x893\xe7\xb4K\r\xb5\x04\x00\x00\u07d4\x16\xaaR\xcb\vUG#\xe7\x06\x 0f!\xf3'\xb0\xa6\x83\x15\xfe\xa3\x89\r\x8drkqw\xa8\x00\x00\u07d4\x16\xab\xb8\xb0!\xa7\x10\xbd\u 01ce\xa54\x94\xb2\x06\x14\xffN\xaf\xe8\x89\b\x90\xb0\xc2\xe1O\xb8\x00\x00\u07d4\x16\xaf\xa7\ x87\xfc\x9f\x94\xbd\xffiv\xb1\xa4/C\n\x8b\xf6\xfb\x0f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x16\xba\ xe5\xd2N\xff\x91w\x8c\u064bM:\x1c\xc3\x16/D\xaaw\x89\x15\xbeat\xe1\x91.\x00\x00\u07d4\x16\x bc@!Z\xbb\u066e](\v\x95\xb8\x01\vE\x14\xff\x12\x92\x89\n\u05ce\xbcZ\xc6

\x00\x00\xe0\x94\x16\xbeu\u9299Z9R\"\xd0\v\u05df\xf4\xb6\xe68\u144a\a\x9f\x90\\o\xd3N\x80\x0 0\x00\u07d4\x16\xc1\xbf[}\xc9\xc8<\x17\x9e\xfa\xcb\xcf.\xb1t\xe3V\x1c\xb3\x8965\u026d\xc5\u07 a0\x00\x00\u07d4\x16\u01f3\x1e\x8c7b\x82\xac\"qr\x8c1\xc9^5\xd9R\u00c9lk\x93[\x8b\xbd@\x00\

 $;g\xbc\xca\xd0\x00\x00\xe0\x94\x17\x12[Y\xacQ\xce\xe0)\xe4\xbdx\xd7\xf5\x94\x1e\xa4\x9b\xb2\x8a\x04\xa8\x9fT\xef\x01!\xc0\x00\x00\u07d4\x17\x1a\u0660K\xed\u0238a\xe8\xedK\xdd\xf5qx\x13\xb1\xbbH\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\x17\x1c\xa0*\x8bmb\xbfL\xa4~\x90i\x14\a\x98a\x97,\xb2\x89\n\u05ce\xbcZ\xc6$

\x00\x00\xe0\x94\x17e6\x1c.\xc2\xf86\x16\u0383c\xaa\xe2\x10%\xf2Vo@\x8a\x01\x0f\f\xf0d\xddY \x00\x00\u07d4\x17gR_Z\"\xed\x80\xe9\xd4\xd7q\x0f\x03b\u049e\xfa3\x89\x15\xaf\x1dx\xb5\x8c @\x00\x00\u07d4\x17v%`\xe8*\x93\xb3\xf5\"\xe0\xe5\$\xad\xb8a,:tp\x8965\u026d\xc5\u07a0\x00\x 00\u07d4\x17\\xaex\xbc\x01\x13\xd8\u04dcD\x02\xf2\xa6A\xae*\x10Z\xb8\x89b\x92BV

 $\label{thm:convention} $$ \xb4Hx00\x00\xe0\x94\x17\x84\x94\x8b\xf9\x98H\u021eDV8PM\u0598'\x1bY$\x8a\x01GLA\r\x87\xba\xee\x00\x00\u07d4\x17\x88\u069bW\xfd\x05\xed\xc4\xff\x99\xe7\xfe\xf3\x01Q\x9c\x8a\n\x1e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x17\x8e\xafk\x85T\xc4]\xfd\xe1kx\xce\f\x15\u007f.\xe3\x13Q\x89\x11X\xe4\x91=\x00\x00\u07d4\x17\x96\x1dc;\xcf$

\x00\x00\u07d4\x17\xe8.px\xdcO\xd9\xe8y\xfb\x8aPf\u007fS\xa5\xc5E\x91\x89\n\u05ce\xbcZ\xc6

 $\label{thm:linear_label} $$ \x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x17\xf5\#\xf1\x17\xbc\x9f\xe9x\xaaH\x1e\xb4\xf5V\x17\x117\x117\x1b\u0209li\xf7>)\x13N\x00\x00\u07d4\x17\xfd\x9bU\x1a\x98\xcba\xc2\xe0\u007f\xbfA\xd3\xe8\u02650\u02e5\x89\x01v\x8c0\x81\x93\x04\x80\x00\u07d4\x18\x04x\xa6U\u05cd\x0f;\fO$

 $+aH[\xc4\x00/\u0549lk\x93[\x8b\xbd@\x00\x00\u07d4\x18\x13l\x9d\xf1g\xaa\x17\xb6\xf1\x8e\"\xa7\x02\u020fK\u0082E\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\x00\x94\x18\x15'\x9d\xff\x99R\xda;\xe8\xf7rl\xdb\xe2\"C7{\xe7\x8a\x01\x01|\xb7n{&d\x00\x00\u07d4\x18\x1f\xbb\xa8R\xa7\xf5\x01x\xb1\xc7\xf0>\xd9\xe5\x8dT\x16))\x89$\x1a\x9bOaz(\x00\x00\x00\x94\x18'\x03\x9f\tW\x02\x94\b\x8f\xdd\xf0G\x16\x3\u65a4\x92\x8a\x02\x05\xb4\u07e1\xeetx\x00\x00\x00\u07d4\x18-$

\xb8R\x93\xf6\x06\u8248\xc3pL\xb3\xf0\xc0\xbb\xbf\xcaZ\x89\a?u\u0460\x85\xba\x00\x00\u07d4\x 18H\x00<%\xbf\u052a\x90\xe7\xfc\xb5\u05f1k\xcd\f\xff\xc0\u060965\u026d\xc5\u07a0\x00\x00\xe 0\x94\x18JO\v\xebq\xff\xd5X\xa6\xb6\xe8\xf2(\xb7\x87\x96\xc4\xcf>\x8a\x02\x8a\x85t%Fo\x80\x0 0\x00\xe0\x94\x18M\x86\xf3Fj\xe6h;\x19r\x99\x82\xe7\xa7\u1903G\xb2\x8a\x02\x1e\x19\xe0\u027 a\xb2@\x00\x00\u07d4\x18Q\xa0c\xcc\xdb0T\x90w\xf1\xd19\xe7-

\x00\x00\xe0\x94\x18X\xcf\x11\xae\xa7\x9fS\x98\xad+\xb2\"g\xb5\xa3\xc9R\xeat\x8a\x02\x15\xf85\xbcv\x9d\xa8\x00\x00\xe0\x94\x18Z\u007f\u012c\xe3h\xd23\xe6

 $\label{thm:linear_continuous} $$ \xb2\xa4Y5f\x12\x92\xbd\xf2\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\x18d\xa3\u01f4\x81UD\x8c T\u020cp\x8f\x16g\tsm1\x89\a?u\u0460\x85\xba\x00\x00\u07d4\x18j\xfd\xc0\x85\xf2\xa3\xdc\xe4a ^\xfb\xad\xf7\x1a\x11x\x0fP\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:convoluo7d4} $$ \x00\x00\u07d4\x18k\x95\xf8\xe5\xef\xfd\xdc\xc9O\x1a1[\xf0)]; $$ \x1e\xa5\x88\x89|j\xccg\u05f1\xd4\x00\x00\u07d4\x18\x9f\fa\xaa\xd1^\xb0\{\x80Dt\x17\xf7\x82\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x18\x95\xa0\xebJCrr/\xcb\u016f\xe6\x93o(\x9c\x88\xa4\x19\x891T\xc9r\x9d\x05x\x00\x00\x00\u07d4\x18\x99\xf6\x9fe; $$\x05\xa6\xe8\x1fH\a\x11\u041b\xbf\x97X\x8c\x89i\xfb\x13=\xf7P\xac\x00\x00\u07d4\x18\xa6\xd2\xfcR\xbes\b@\#\xc9\x18\x02\xf0[\xc2JK\xe0\x9f\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\x18\xb0@|\xda\xd4\xceR\x06\#\xbd^\x1f\x81\xaba\xf0\&\x89\x11Q\xcc\xf0\xc6T\u0180\x00\u07d4\x18\xb8\xbc\xf9\x83!\xdaa\xfbN>\xac\xc1\xecT\x17'-$

\x15k\u060d\x89Hz\x9a0E9D\x00\x00\u07d4\x193j#m\xeduXrA\x1f.\x04\x91\xd8>>\x00\x15\x9e\x

892\xf5\x1e\u06ea\xa30\x00\x00\x00\x94\x193\xe34\xc4\x0f:\u02ed\f\v\x85\x11X

i\$\xbe\xca:\x8a\x01\x99^\xaf\x01\xb8\x96\x18\x80\x00\xe0\x94\x197\xc5\xc5\x15\x05uS\u033dF\u 0546dU\xcef)\x02\x84\x8a\xd3\xc2\x1b\xce\xcc\xed\xa1\x00\x00\x00\u07d4\x19:\xc6Q\x83e\x18\x 00\xe25\x80\xf8\xf0\xea\u04fbY~\xb8\xa4\x89\x02\xb6*\xbc\xfb\x91\n\x00\x00\u07d4\x19=7\xed4}\x1c/N55\r\x9aDK\xc5|\xa4\xdbC\x89\x03@\xaa\xd2\x1b;p\x00\x00\x00\xe0\x94\x19@\u0713d\xa8R\x1 6 GAN'\xf5\x00\$E\xa4\xf1C\x8a\x02L-

 $\label{thm:convolu07d4} $$ \left(\frac{H\x00\x00\u07d4\x19E\xfe7\u007f\xe6\u0537\x1e>y\x1fo\x17\xdb$<\x9b\x8b\x00f\x89\yu07fb9} \\ \x886\x00\x00\u07d4\x19Jk\xb3\x02\xb8\xab\xa7\xa5\xb5y\u07d3\xe0\xdf\x15t\x96\y%\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x19L\ubd12\x98\x82\xbf;K\xf9\x86L+\x1b\x0fb\u0083\xf9\x89\x1e\x68aS\x1ft\xaa\x00\x00\u07d4\x19O\xf4J\xef\xc1{\xd2\x0e\xfdz} \right)$$$

LG\xd1b\f\x86\xdb]\x89\xa2\x99\th\u007fj\xa4\x00\x00\xe0\x94\x19O\xfex\xbb\xf5\xd2\r\u044a\x1f\ x01\xdaU.\x00\xb7\xb1\x1d\xb1\x8a\x01\x\x83\xc0i\x16`\x00\x00\u07d4\x19S1>*\xd7F#\x9c\xb2'\x 0fH\xaf4\u063b\x9cDe\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x19W\x1a+\x8f\x81\u01bc\xf6j\xb3\xa 1\x00\x83)\V\x17\x15\x00\x03\x89\x1a\xb2\xcf|\x9f\x87\xe2\x00\x00\x00\u07d4\x19h}\xaa9\xc3h\x13\ x9bn\xe6\r\xc1u:\x9f\f\xbe\xa3\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\x19l\x02!\nE\n\xb0\xb3 cpe_qz\xa8\xd1\xc0\x04\x89\x0e\x10\xac\xe1W\xdb\xc0\x00\x00\u07d4\x19n\x85\xdf~s+J\x8f\x0e\ \xd06#\xf4\u06dd\xb0\xb8\xfa1\x89\x01\%\xb9\\\\xef\x80\x00\u07d4\x19s+\xf9s\x05]\xbd\x91\xa4 S:\u06a2\x14\x9a\x91\u04c3\x80\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\x19y\x8c\xbd\xa7\x15\ua69 b\x9dj\xab\x94,U\x12\x1e\x98\xbf\x91\x89A\rXj

 $\label{thm:convoluo7d4} $$ \a4\xc0\x00\x00\u07d4\x19\x8b\xfc\xf1\xb0z\xe3\b\xfa,\x02\x06\x9a\xc9\xda\xfeq5\xfbG\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\xe0\x94\x19\x8e\xf1\xec2Z\x96\xcc5Lrf\xa08\xbe\x8b\U\x8fg\x8a\x80\xd1\xe47>\u007f!\xda\x00\x00\x00\x94\x19\x91\x8a\xa0\x9e\IN\x98\xff\xa5\xdbP5\b\x92\xf7\x15j\u0\\ 18a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x19\xb3k\f\x87\xeafN\xd8\x03\x18\xdcw\xb6\x8\\ 8\xdd\xe8\x95\xa5\x89i\x9f\x89\x020=\x00\x00\u07d4\x19\x07d4E\xa8\x1c\x1b=\x80J\xea\xebon\\ NB6f?\x89\x02\x06\xd9\Njl\x87\x80\x00\u07d4\x19\xe5\u07a37\n,tj\xae4\xa3|S\x1fA\xda&N\x83\x8\\ 9\n\u05ce\xbcZ\xc6\x00\x00\u07d4\x19\xe7\xf3\xeb\x6\u007f5\x99$

\x9e\xbe\b\xb6*\xd32\u007f\x8c\u0789lk\x93[\x8b\xbd@\x00\x00\u07d4\x19\xe9Nb\x00P\xaa\xd7f\xb9\xe1\xba\xd91#\x83\x12\u053fl\x89\x81\xe3-

 $\label{thm:cond} $$ \xf9r(xab)xf0(x00)x00(u07d4)x19(xec)xf2(xab)xf4(f)x9e(x85{\%/xe1)xdb)xfd=L](x8f(x81n)x89](x8f(x81n)x89](x8b)xbd@(x00)x00(u07d4)x19(xf5)xca)xf4(xc4)x0ei(b)x81
<math display="block">\xf9r(xab)xf0(x00)x00(u07d4)x19(xf5)xca)xf4(xc4)x0ei(b)x81
<math display="block">\xf9r(xab)xf0(xe1)x8f(xe1)x8f(xe1)x8e(xae)x8e($

\x89IO\xd1\xee\$nx\x00\x00\u07d4\x1a\n\x1d\u07f01\xe5\xc8\xcc\x1dF\xcf\x05\x84-

P\xfd\xdcq0\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94\x1a\x1c\x9a&\xe0\xe0\xe0\x18\xa5\xcfh}\xa7Z'\

\b.\x94@\x8a\x01\x0f\f\xf0d\xddY\x00\x00\u07d4\x1a

\x1bC'\u03a7\xf3\x99\x04bF\xa3\xc8~n\x03\xa3\u0368\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x1 a\$4\xccwD\"\u050dS\u055c]V,\u0384\a\xc9K\x89\x01\xa0Ui\r\x9d\xb8\x00\x00\u07d4\x1a%\xe1\u 017c~_P\xec\x16\xf8\x88_!\x0e\xa1\xb98\x80\x0e\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4\x1a &\x94\xec\a\xcf^Mh\xba@\xf3\xe7\xa1LS\xf3\x03\x8cn\x8966\xcd\x06\xe2\xdb:\x80\x00\u07d4\x1a 5 E5\x82\xc7\x18\xa2\x1cB7[\xc5\as%RS\xe1\x89*\xd3s\xcef\x8e\x98\x00\x00\x00\u07d4\x1a 7n\x1b-\Y\ai\xbb\x85\x8dEu2\rN\x14\x99p\x8a\x01\x06q%v9\x1d\x18\x00\x00\u07d4\x1a:3\x0eO\xcbi\xdb\ xef^i\x01x;\xf5\x0f\xd1\xc1SB\x89\u3bb5sr@\xa0\x00\x00\u07d4\x1aP^b\xa7N\x87\xe5wG>O:\xfa\x16\xbe\xdd<\xfaR\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x1adJP\xcb\u00ae\xe8#\xbd+\xf2 C\xe8%\xbeMG\xdf\x02\x89\x05k\xe0<\xa3\xe4}\x80\x00\u07d4\x1apD\xe28?\x87\b0[I[\xd1\x17k\x92\xe7\xef\x04\x02\x89\x05k\xe0<\xa3\xe4}\x80\x00\u07d4\x1apD\xe28?\x87\b0[I[\xd1\x17k\x92\xe7\xef\x04\x02\x89\x05k\xe0<\xa3\xe4}\x80\x00\u07d4\x1apD\xe28?\x87\b0[I[\xd1\x17k\x92\xe7\xef\x04\x02\x89\x05k\xe0<\xa3\xe4}\x80\x00\u07d4\x1apD\xe28?\x87\b0[I[\xd1\x17k\x92\xe7\xef\x04\x02\x89\x05k\xe0<\xa3\xe4}\x80\x00\u07d4\x1apD\xe28?\x87\b0[I[\xd1\x17k\x92\xe7\xef\x04\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\x1ay\xc7\xf4\x03\x9cg\xa3\x9du\x13\x88L\xdc\x0e,4\"\$\x90\x89\x01\x15\x8eF\t\x1 3\xd0\x00\x00\u07d4\x1a\x89\x89\x9c\xbe\xbd\xbbd\xbb&\xa1\x95\xa6<\bl\x1f\u035e\xee\x89lk\x9 3[\x8b\xbd@\x00\x00\x00\x00\x00\x94\x1a\x8a\\\xe4\x14\u079c\xd1r\x93~7\xf2\u055c\xffq\xceW\xa0\x8a\x 02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x1a\x95\xa8\xa8\b.FR\xe4\x17r\xf9\x1c\xb4\xbbC\x0 5\xf0\xb2\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4\x1a\x95\u0277Tk]\x17\x86\u00c5\x8f\x b1#dF\xbc\f\xa4\u0389j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\x1a\x98~?\x83\xdeu\xa4\x1b\xde|\x99|\x19!\{J_\$\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x1a\x9ep/8]\xcd\x10^\x8b\x9f\xa4(\xee\xa2\x1cW\xff R\x8a\x89K\xe4\xe7&\{j\xe0\x00\x00\u07d4\x1a\xa1\x02\x1fU\n\xf1X\xc7Gf\x8d\xd1;F1`\xf9Z@\x8 90\xb0Y\x1b\x9b08\x00\x00\u07d4\x1a\xa2\xy99\xca\u068d\u00e7oy3\xaaf\xc7\x19\x19\x04\x0e\x88\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\x1a\xa4\x02\x1e\\\u0786\xb6\m\x1a\xc3\xc5 3lKy\xed\x89\x01\x15\x8eF\f\x13\xd0\x00\x00\u07d4\x1a\xa4\x02\x1a\xb5\\x6\\x11\xbc\x6=\u07ea@\xa0+\x9e\x1 8d\x96\u037b\x8a\xff\x89!?*\xac\x80\f\x00\x00\x00\u07d4\x1a\xbc\%;\b\n\xebCy\x89\u00fcM\x82\xf0j\x05\x1a\x9ds-

\xc0\xe74\xcba\x89%\xf6\x9dc\xa6\xce\x0e\x00\x00\x00\x94\x1a\xd4V>\xa5xk\xe1\x15\x995\xab\x\b0\xf1\u0547\x9c>sr\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\x1a\xd7-

 $\label{loxa6} $$ \and $\and $$ \and $\and $$ \and $\and $$ \and $\and $$ \an$

 $\xdf!\xdb\\\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x1a\xfc\u0145\x89l\xd0\xed\xe1)\xee-property (a.c., a.c., a$

 $\label{thm:condition} $$ \operatorname{xe5} xc1\x9e\xa8\x11T\vd\x89\xaf^*\xba\f\x8e\xe6\x00\u07d4\x1b\x05\xeajj\u022f\xb6\xa8\xb9\x11\xa8\xcc\xe8\xfe\x1a^*\xcf\u0209lk\x93[\x8b\xbd@\x00\x00\u07d4\x1b\v1\xaf\xffKm\xf3e:\x94\xd7\xc8\yx\xae5\xf3J\xae\x89\x139\x10E?\xa9\x84\x00\x00\u07d4\x1b\r\ah\x17\xe8\u058e\xe2\xdfN\x1d\xa1\xc1\x14-$

 $\label{thm:convoluo} $$ \xd6\xfe\x00\x00\x00\u07d4\x1bC\#,\xcdH\x80\xd6\xf4o\xa7Q\xa9\|\xd8\$s1XA\x89\x04\V9\x18\$O@\x00\x00\u07d4\x1bK\xbc\xb1\x81e!\x1b\&[(\a\x16\xcb?\x1f!!v\xe8\x89\x19\x9a\xd3\xd3\xd0\x80\x00\x00\u07d4\x1bM\a\xac\u04c1\x83\xa6\x1b\xb2x=+{\x17\x8d\xd5\x02\xac\x8d\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\x1bK\x00\x00\u07d4\x1bCok\x89\x13\x88\xea\x95\xc3?\x1d\x00\x00\u07d4\x1bd\x95\x89\x12@\xe6NYD\x93\xc2f!q\xdb^0\xce\x13\x89\tX\x87\u0595\xedX\x00\x00\u07d4\x1bf\x10\xfbh\xba\xd6\xed\x1c\xfa\xa0\xbb\xe3:\xeb.\x96\xfa\xfb\x89\b=|z\xabc\x00\x00\u07d4\x1by\x903\xefm\xc7\x12x\"\xf7EB\xbb\"\xdb\xfc\t\xa3\b\x89\x05\xx67\x-$

\u0096\x0eL\xb9@\x8ft\x05\x82|\x9bY\a\x16\x12\xfd\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94\x1b\xa9\"\x8d8\x87'\xf3\x89\x15\x0e\xa0;s\xc8-

\xe8\xeb.\ti\x8a\x01\x89t\xfb\xe1\w\xc9(\x00\x00\u07d4\x1b\xa9\xf7\x99~S\x87\xb6\xb2\xaa\x015\x\\ ac\$R\xfe6\xb4\xc2\r\x89.\x14\x1e\xa0\x81\xca\b\x00\x00\u07d4\x1b\xba\x03\xffkJ\u057f\x18\x18J\\ xcb!\xb1\x88\xa3\x99\xe9\xebJ\x89a\t=|,m8\x00\x00\u07d4\x1b\xbc\x19\x9eXg\x90\xbe\x87\xaf\xed\xc8|\xc0G&t\|]\{\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x1b\xbc\x19\x9eXg\x90\xbe\x87\xaf\xed\xc8|\xc0G&t\|]\{\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x1b\xbc\x19\x9eXg\x90\xbe\x87\xaf\xed\xc5\aj\x1\\ f\n@\xa8=\xae\x86\{\x89\k\x93\[\x8b\xbd@\x00\x00\u07d4\x1b\xc4L\x87a#\x1b\xa1\xf1\x1f_\xaa@\xfaf\x9a\x01>\x12\u0389\v\tR\xc4Z\xea\xad\x00\x00\u07d4\x1b\xc4L\x87a#\x1b\xa1\xf1\x1f_\xaa@\xfaf\x9a\x01>\x12\u0389\v\tR\xc4Z\xea\xad\x00\x00\u07d4\x1b\xcf4A\xa8f\xbd\xbe\x960\txce3\xc8\x1c\xbb\x02a\xb0,\x89\txdd\xc1\xe3\xb9\x01\x18\x00\x00\u07d4\x1b\xd8\xbb\xbd\xavt\xbb\x1\\x89\xx1c\xbb\x00\x00\u07d4\x1b\xd9\t\xac\rJ\x11\x02\xec\x98\xdc\xf2\u0329j\n\xdc\u05e9Q\x89\x01\x16Q\xac>zu\x80\x00\u07d4\x1b\xeaM\xf5\x12\xaf\u07b3`~\xdd\xd\xa\xae\x89\x84\x1d\x85\xb1pXj\x9b\x89\x82\x1a\xb0\xd4Al\x80\x00\x00\u07d4\x1b\xecM\x02\u0385\xfcH\xfe\xb6\x89\x84\x1d\x85\xb1pXj\x9b\x89\x82\x1a\xb0\xd4Al\x80\x00\x00\u07d4\x1b\xecM\x02\u0385\xfcH\xfe\xb6\x89\x84\x1d\x85\xb1pXj\x9b\x89\x82\x1a\xb0\xd4Al\x80\x00\x00\u07d4\x1b\xf9t\u0650OE\u0381\x88E\xe1\x1e\xf4\xcb\xcf'\xaf\q\x9e\x89\x05k\xc7\-

 $\label{thm:convap} $$ \x00\x00\u07d4\x1c\xb6\xb2\xd7\xcf\xc5Y\xb7\xf4\x1eoV\xab\x95\xc7\xc9X\xcd\x0eL\x89Hz\x9a0 E9D\x00\x00\u07d4\x1c\xc1\xd3\xc1O\x0f\xb8d\x0e6rM\xc42)\xd2\xeaz\x1eH\x89\(=A\x03\x94\x10\x00\x00\u07d4\x1c\xc9\bv\x00A\t\xcdy\xa3\u07a8f\u02c4\n\xc3d\xba\x1b\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x1c\xd1\xf0\xa3\x14\u02f2\x00\xde\n\f\xb1\xef\x97\xe9 $$$

p\x9d\x97\u0089lk\x93[\x8b\xbd@\x00\x00\u0794\x1c\xdaA\x1b\xd5\x16;\xae\xca\x1eU\x85c`\x1c\xe7

\xe2N\xe1\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\x1c\xe8\x1d1\xa7\x920\"\xe1%\xbfH\xa3\xe06 \x93\xb9\x8d\xc9\u0749lk\x93[\x8b\xbd@\x00\x00\u07d4\x1c\xeb\xf0\x98]\u007fh\n\xaa\x91\\D\xc cb\xed\xb4\x9e\x8965\u026d\xc5\u07a0\x00\x00\x00\xe0\x94\x1c\xedg\x15\xf8b\xb1\xff\x86\ x05\x82\x01\xfc\xceP\x82\xb3nb\xb2\x8a\x01j^`\xbe\xe2s\xb1\x00\x00\u07d4\x1c\xf0L\xb1C\x80\x 05\x9e\xfd?#\x8be\u057e\xb8j\xfa\x14\u0609\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x1c\xf1\x05\x ab#\x02;ULX>\x86\u05d2\x11y\xee\x83\x16\x9f\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\x1c\xf2\xeb z\x8c\xca\u00ad\xea\xef\x0e\xe8sG\xd55\u04f9@X\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x1c\xfc\xf7Q\u007f\f\bE\x97

\x94+dz\u0452\xaa\x9c\x88(\x89+^:\xf1k\x18\x80\x00\x00\x00\x94\x1d\t\xad\$\x12i\x1c\u0141\xc1\ xab6\xb6\xf9CL\xd4\xf0\x8bT\x8a\x01{x\x83\xc0i\x16`\x00\x00\u07d4\x1d\x15|Xv\xc5\xca\xd5S\xc9\x12\xca\xf6\xce-

 $Rw\xe0\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\x1d\&\x15\xf8\xb6\xcaP\x12\xb6c\xbd\u0414\xb0\xc5\x13]w\x8d\u07ca\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x1d)\u01ea\xb4+$

H\u04b2R%\u0518\u06e6z\x03\xfb\xb2\x89\n\u05ce\xbcZ\xc6

\xab\xd5i\xbd\xdc\xe7\x16\x86\xf2\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x1d7aky?\x94\x91\x188 \xac\x8e\x19\xee\x94I\u07d2\x1e\u0109QP\xae\x84\xa8\xcd\xf0\x00\x00\x00\x94\x1d9[0\xad\xda\ x1c\xf2\x1f\t\x1aOJ{u3q\x18\x94A\x8a\x15-

\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\x1dEXn\xb8\x03\xca!\x90e\v\xf7H\xa2\xb1t1+\xb5\a\x89K\xe

4\xe7&{j\xe0\x00\x00\u07d4\x1dW.\xdd-

 $P\x89Hz\x9a0E9D\x00\x00\u07d4\x1d\xbe\x8e\x1c+\x8a\x00\x9f\x85\xf1\xad<\xe8\r.\x0055\x0e\u3709\aW\rn\x9e\xbb\xe4\x00\x00\u07d4\x1d\xc7\xf7\xda\xd8]\xf5?\x12q\x15$\x03\xf4\xe1\xe4\xfd\xb3\xaf\xa0\x89\n\u05ce\xbcZ\xc6$

\xe9\x10|=\xc3\x069\xd8P\x05\u0589|k\x93[\x8b\xbd@\x00\x00\u07d4\x1d\xf6\x91\x16rg\x9b\xb0\ xef5\t\x03\x8c\f'\xe3\x94\xfd\xfe0\x89\x1dF\x01b\xf5\x16\xf0\x00\x00\u07d4\x1d\xfa\xee\ar\x12\xf1 \xbe\xaf\x0eo\x18@Sz\xe1T\xad\x86\x8965\u026d\xc5\u07a0\x00\x00\x00\x94\x1e\x06\r\xc6\xc5\ xf1\u02cc\xc7\xe1E.\x02\xee\x16u\b\xb5eB\x8a\x02\xb1O\x02\xc8d\xc7~\x00\x00\x00\x94\x1e\x1 3\xecQ\x14,\ubde2`\x83A,<\xe3QD\xbaV\xa1\x8a\x01\x0f\f\xf0d\xddY

Q\x89K\xe4\xe7&{j\xe0\x00\x00\u07d4\x1e\x1dz_\$h\xb9N\xa8&\x98-

 $\xsp{1}\% y < nJZ \xsp{6}4 \xf4 \xsp{3} \xsp{1} @ \xsp{1} \xsp{0} \xs$

 $\label{thm:convoluo7d4} $$\x00\x00\u07d4\x1e+\xf4\xba\x8e^\xf1\x8d7\xdemj\xd66\xc4\xca\xe4\x89\xd0\u0309lk\x93[\x8b\xbd\a2\xb2\x83\xee\xeb\x89] $$\d(a)\x00\x00\u07d4\x1e3\xd1\xc2\xfb^\bO/\x1dT\xbcRgr\u007f\xec?\x98]\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x1e8\x1a\xdc\xf8\x01\xa3\xbf\x9f\u05ff\xac\x9c\xcc+\x84\x82\xad^f\x89$$

\x89r\xc0\x01\rt\x00\x00\xe0\x94\x1e;\xad\xb1\xb6\xe18\x0e*\x03\x9cWj\xe6\".\x96:[S\x8a\x04<3\x c1\x93ud\x80\x00\x00\x00\x00\x00\x00\x00\x06!\xf0\xf53\x1b5\xd5@\x8d\x9a\xaeN\xb1\xac\xf2\x1e\x89\ x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x1eYj\x81\xb3W\xc6\xf2lp\xcc1=\xf6\xdb\u06ab\xd0\u041e\x89lk\x9 \ x1\xb1\x8a\x00\x00\x00\u07d4\x1eYj\x81\xb3W\xc6\xf2lp\xcc1=\xf6\xdb\u06ab\xd0\u041e\x89lk\x9 \ x1\xb0\x00\x00\u07d4\x1e\x1e\x00\x00\x00\u07d4\x1e\x1e\x01S\xfc\x16\x1b\xc0^ek\xbb\x14Lq\x87\xbf0\xe8 \ M\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\x1epfU\xe2\x84\xdc\xf0\xbb7\xfe\a]a:\x18\xdc\x12\xffJ\x89\ xedC\xbf\x1e\ue0ac\x00\x00\x00\u07d4\x1e\x1e\x07\xdf\n\u02ac\x9e\xee\xd3Y09\xe5\xacuy\x8a+\x 14F\xddj\xef\xe4\x1c\x00\x00\u07d4\x1e\x1e\x8e\x9b\x02\x91|\xdc\\$]\f\x9ch\xb0\x94\xb4\x1a\x9e\u0589l k\x93[\x8b\xbd@\x00\x00\u07d4\x1e\x8eh\x9b\x02\x91|\xdc\\$]\f\x9ch\xb0\x94\xb4\x1a\x9e\u0589l k\x93[\x8b\xbd@\x00\x00\u07d4\x1e\x8eh\x9b\x02\x91|\xdc\\$]\f\x9ch\xb0\x94\xec_(\xaaw\u03c9\x1

 $a\xb2\xcf\x9f\x87\xe2\x00\x00\u07d4\x1e\xa4qU\x04\u01af\x10\xo1\x94\xf4\xf7\xb1\xcbo\xcc\xcdoK\x89$

 $\x 041\x 97\x e 0\x 00\x 00\u 07d4\x 1 e\x a 4\x 92\x b c\x e 1\x a d\x 10~3\u 007fK\u 0527\x a c\x 9a\x a b\x c\x 036b\x 89\x 05k\x c7^-$

 $c\x10\x00\x00\u07d4\x1e\xa6\xbf/\x15\xae\x9c\x1d\xbcd\u06a7\xf8\xeaM\r\x81\xaa\xd3\xeb\x89\u3bb5sr@\xa0\x00\x00\u07d4\x1e\xb4\xbfs\x15j\x82\xa0\xa6\x82$

\x80\xc6\xed\xf4\x9cF\x9a\xf8\xb9\x89g\x8a\x93

b\xe4\x18\x00\x00\xe0\x94\x1e\xba\xcbxD\xfd\xc3\"\xf8\x05\x90O\xbf\x19b\x80-

 $\label{thm:convention} $$\x8dk\x89\x01K\x8d\xe1\xeb\x88\u06c0\x00\u07d4\x1f}\x8e\x86\xd6\xee\xb0\%E\xaa\xd9\x0e\x912 $$ {\x03i\xd7\xd2\xf3\x89\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4\x1f\x81\x16\xbd\n\xf5W\x0e\xaf\fV\u011cz\xb5\xe3zX\x04X\x89lk\x93[\x8b\xbd@\x00\x00\u0794\x1f\x88\xf8\xa13\x8f\xc7\xc1\tv\xab\xc2\xb0\x00\x00\u07d4\x1f\x9c2hE\x8d\xa3\x01\xa2\xbeZ\xb0\x82W\xf7\xb5\xa9\x8a\xa4\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\x1f\xa21\x9f\xed\x8c-$

 $F*\xdf.\x17\xfe\xecjo0Qn\x95\x89\x06\xca\xe3\x06!\xd4r\x00\x00\u07d4\x1f\xb4c\xa08\x99\x83\xdf\\ \}Y?\{\xddmxI\u007f\xed\x88y\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x1f\xb7\xbd1\r\x95\xf2\xa6\u067a\xaf\x8a\x8aC\n\x9a\x04E:\x8b\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\x1f\xcc|\xe6\xa8H\\ X\x95\xa3\x19\x9e\x16H\x1fr\xe1\xf7b\xde\xfe\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x1f\xcf\xd1\xxd1\xxd5\u007f\x87\x90\x90\x16\x96-$

\x02d\xa0\x9f\x8ch\xe3\xe6b\x97\x95(\x0fV%O\x86@\u0409\x01\x15\x8eF\t\x13\xd0\x00\u07

\x03qy\a\xa7%`\xf40\u007f\x1b\xee\xccT6\xf4=!\xe7\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4 \r\xfc\vq\xe3Y\xb2\xb4eD\n6\xa6\xcd\xc3Rw0\a\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4 \x13L\xbf\xf8\x8b\xfa\xdcFkR\xec\ua9d8W\x89\x1d\x83\x1e\x8965\u026d\xc5\u07a0\x00\x00\u07d4 \x14&\x1f\x01\b\x9fSyV0\xba\x9d\xd2O\x9a4\xc2\xd9B\x89Hz\x9a0E9D\x00\x00\u07d4 \x16\x89]\xf3,\x8e\xd5G\x82iF\x84#\xae\xa7\xb7\xfb\xceP\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4 \x18\x1cKA\xf6\xf9r\xb6iX!_\x19\xf5p\xc1]\xdf\xf1\x89V\xbcu\xe2\xd61\x00\x00\x00\u07d4 \x18d\xa8\xf7\x84\xc2'\{\v|\x9e\xe74\xf7\xb3w\xea\xb6H\x89\xf2(\x14\x00\xd1\xd5\xec\x00\x00\u07d4 \xb8\x1a\xe59&\xac\xe9\xf7\xd7AZ\x05\f\x03\x1dX_

\x89\x12\u007f\x19\xe8>\xb3H\x00\x00\xe0\x94

J\u0248g\xa7\xc9\xc7\xedq\x1c\xb8/(\xa8x\xca\xf6\x9bH\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4 R7\u013e\x14o\xba\x99G\x8f:}\xad\x17\xb0\x918\u0695\x89lk\x93[\x8b\xbd@\x00\x00\u07d4 S\xac\x97T\x8a\fN\x8b\x80\xbcrY\f\u05a0\x98\xfeu\x16\x89\n#%u;F\f\x00\x00\u07d4 _Qf\xf1\$@\xd8Wb\xc9g\u04ee\x86\x18O\x8fM\x98\x89\x17r\$\xaa\x84Lr\x00\x00\x00\x94 _\xc8C\xe1\x9al\x13\u0448\x1e\xb6\x9bi\xc0\xfa;\xe5\xc5\v\x8a\x02\r\u058a\xaf2\x89\x10\x00\x00\x00\x00\u07d4

 $d\x82\xeeo\x13\x8aw\x8f\xe1\xadb\xb1\x80\u0385o\xbb\#\xe6\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94 fwM\x82'\x93\xff\%\xf1v\t\tG\x9c\xf6$\x91\xbf\x88\x8a\v\xae:\u0185\xcbr\xe0\x00\x00\u07d4 mU\xd5y^2QN\xc1\b\xe0\x90Y\x9f^\times\x06^P\x11\x85\x89\n\xdf0\xbap\u0217\x00\x00\u07d4 p~B]^\times\x11\xd2\u021f9\x1b+\x80\x9fUlY\$!\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94 -\xf8\v]`\xb6\xfb\xff\xc5\x1f:d\xb8\xc7 6\xa5\xab\xbd\x8a\x01je\x02\xf1Z\x1eT\x00\x00\x94 \x82K\xa1\xdb\xbe\xf9\x84n\xf3\xd0\xf6\xc1\xb0\x17\xe6\x91.\u010a\x01\x84\xb2nM\xaf\x1d5\x00\x00\u07d4$

 $\x84\xfc\xe5\x05\xd9{\xeb\xf1\xad\x8c_\xf6\x82o\xc6E7\x1f\xb2\x89\x01\xa0Ui\r\x9d\xb8\x00\x00\u007d4$

2\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d4!

l\xe2.\xa4\x80\xe8Y@\xd3\x13\x14\xe0\xd6ONM:\x04\x8965\u026d\xc5\u07a0\x00\x00\u07d4!2\x c0Qj.\x17\x17J\xc5G\xc4;{\x00

 $\label{thm:calcon} $$ \xd1\timesebLY\x895e\x9e\xf9?\x0f\xc4\x00\x00\x00\x94!@\x8bMz,\x0en\xcaAC\xf2\xca\u037b\u033a\x12\x1b\u060a\x04<3\xc1\x93ud\x80\x00\x00\u07d4!Kt9U\xa5\x12\xden\r\x88j\x8c\xbd\x02\x82\xbe\e\x60\u04a2\x89lk\x93[\x8b\xbd@\x00\x00\u07d4!L\x89\u017d\x8e]\"\xbcWK\xb3^H\x95\x02\x11\xc6\xf7v\x89\x01\x06T\xf2X\xfd5\x80\x00\xe0\x94!Ti\x14\xdf\u04ef*\xddA\xb0\xff>\x83\xff\xdat\x14\xe1\xe0\x8a\x01C\x95\xe78ZP.\x00\x00\u07d4!X.\x99\xe5\x02\xcb\xf3\xd3\xc2;\xdf\xfbv\xe9\x01\xemV\xb2\x89\x05k\xc7^-$

c\x10\x00\x00\u07d4!Y\$\b\x13\xa70\x95\xa7\xeb\xf7\u00f3t>\x80(\xae_\t\x89lk\x93[\x8b\xbd@\x00 \x00\u07d4!`\xb4\xc0,\xac\n\x81\u0791\b\xdeCE\x90\xa8\xbf\xe6\x875\x89j\xcb=\xf2~\x1f\x88\x00\ x00\xe0\x94!nA\x86N\xf9\x8f\x06\r\xa0\x8e\xca\xe1\x9a\xd1\x16j\x17\xd06\x8a\x016\x9f\xb9a(\xac 00\xe0\x94!\xa6\xdbe'F{\xc6\xda\xd5K\xc1n\x9f\xe2\x95;g\x94\xed\x8a\x02\xf6\xf1\a\x80\xd2,\xc0\ x00\x00\u07d4!\xa6\xfe\xb6\xab\x11\xc7f\xfd\xd9w\xf8\xdfA!\x15 G\xa1\xc0\x89\x03\x19\xcf8\xf1\ x00X\x00\x00\u07d4!\xb1\x82\xf2\xda+8D\x93\xcf_5\xf8=\x9d\x1e\xe1O*!\x89lk\x93[\x8b\xbd@\x0 0\x00\u07d4!\xbf\xe1\xb4\\\xac\xdebt\xfd\x86\b\u0661x\xbf>\xebn\u0709I\xee\x06\u077e\x15\xec\x 00\x00\u07d4!\xc0s\x80HOI\xbc\x87\$\xad2\xbc\x86L;Z\xd5\x00\xb7\x8965\u026d\xc5\u07a0\x00\x 00\xe0\x94!\u00e8\xbb\xa2g\xc8\u0322{\x1a\x9a\xfa\xba\xd8o`z\xf7\b\x8a\x01\xe4\xa3ll\u06580\x 00\x00\u07d4!\xcem[\x90\x18\xce\xc0J\u0596yD\xbe\xa3\x9e\x800\xb8\x89\x01\x15\x8eF\t\x1 3\xd0\x00\x00\u07d4!\xd0'\x05\xf3\xf6I\x05\xd8\x0e\xd9\x14y\x13\xea\x8cs\a\u0595\x89I\xed\xb1\ xc0\x98\x876\x00\x00\u07d4!\xd1?\f@\$\xe9g\xd9G\a\x91\xb5\x0f\"\xde:\xfe\xcf\x1b\x89\xf1Z\xd3^. 1\xe5\x00\x00\x94!\xdb\u06c1z\r\x84\x04\u01bd\xd6\x15\x047N\x9cC\xc9!\x0e\x8a\x02\x1e\x 18\xb9\xe9\xabE\xe4\x80\x00\xe0\x94!\xdf\x1e\xc2KNK\xfey\xb0\xc0\x95\u03ba\xe1\x98\xf2\x91\x fb\u044a\x04<3\xc1\x93ud\x80\x00\x00\xe0\x94!\xdf-

\u036ft\xb2\xbf\x804\x04\xddM\xe6\xa3^\xab\xec\x1b\xbd\x8a\x01w\"J\xa8D\xc7

 $\label{thm:convolu07d4!} $$ \x00\x00\u07d4!\xe2\x19\u021c\xa8\xac\x14\xaeL\xbaa0\xee\xb7}\x9em9b\x89*\u035f\xaa\xa08\xee\x00\x00\u07d4!\xe5\u04ba\xe9\x95\xcc\xfd\b\xa5\xc1k\xb5$\xe1\xf60D\x8f\x82\x89\x97\xc9\xceL\xf6\xd5\xc0\x00\x00\u07d4!\xe5\xd7s 0L$

 $\x00\x00\u07d4!\xec\xb2\u07e6Wy\xc7Y-$

 $\label{thm:cond} $$ \xb7\xfa\x90q\x16\x04\x05\x99m\x00\x89\tx18T\xfc\x18bc\x00\x00\u07d4\t^_\x9e\xb3\xfbo\xf3\xe9\xe3\xc8D\x14\xa6n\x8dO7y\xf6\x89lk\x93[\x8b\xbd@\x00\x00\x00\x00\x00\x94\t^xx18n\xf2]\xcb\xe2\xf5\xfc70P\xfd\xae\u007f^\xce#\x16\x8a\x03h\xc8b:\x8bM\x10\x00\x00\u07d4\t^s\xba\u05fcNHv\t^xd1u\xefzf\x98\x8bj\x93\xc4\xee\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\x00\u07d4\t^v\x8E\xec\x85\xc0\xc0\xc0\xf2p\gz\xba\xf4\xf0\xe4A\xe1g\x8965\u026d\xc5\u07a0\x00\x00\x00\x00\x94\t^x82B\xf83n\xec\xd8\$.\x1f\x00\x0fA\x93\xe0\xdf\xfb\xbf\x8a\x01\x0f\f\xf0d\xddY$

\x00\x00\u07d4\"\x84*\xb80\xdaP\x99\x13\xf8\x1d\xd1\xf0O\x10\xaf\x9e\xdd\x1cU\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\"\x94O\xbc\xa9\xb5yc\bN\xb8M\xf7\xc8_\xb9\xbc\u07f8V\x89\xfc\x11\x8f\uf4 3a8\x80\x00\u07d4\"\x9e\xc4q\x1bbu^\xa2\x96DZ\u00f7\u007f\xc63\x82\x1c\xf2\x89\x02#\xe8\xb0 R\x192\x80\x00\u07d4\"\x9e\c\r\xe2\xb7OD&Q\xdd\u0377\x01v\xbc\x05L\xadT\x88\xbb\xf9\x81\xb cJ\xaa\x80\x00\u07d4\"\x9fO\x1a*OT\atP[G\a\xa8\x1d\xe4D\x10%[\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\"\x9fO\x1a*OT\atP[G\a\xa8\x1d\xe4D\x10%[\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\"\x9f\x89\xf2\x12\xabV\xdc\xc4#\x17^\xd1\u062d\xac\xce3\xcd\x18\x10\x89dI\x88\x00\x00\x00\\u07d4\"\xbd\xf9\x2\x\x12\xabV\xdc\xc4\#\x17^\xd1\u062d\xac\xce3\xcd\x18\x10\x89dI\x88\x02\x1 e\x19\xe0\u027a\xb2@\x00\x00\u07d4\"\xbd\xff\xc2@\xa8\x8f\xf7C\x1a\xf3\xbf\xf5\x0e\x14\xda7\x d5\x18\x\8965\u026d\xc5\u07a0\x00\u07d4\"\xdbU\x9f,<\x14u\xa2\xe6\xff\xe8:YyY\x91\x96\xa7\xfa\x8965\u026d\xc5\u07a0\x00\u07d4\"\xdbU\x9f,<\x14u\xa2\xe6\xff\xe8:YyY\x91\x96\xa7\xfa\x8965\u026d\xc5\u07a0\x00\u07d4\"\xdbU\x9f,<\x14u\xa2\xe6\xff\xe8:YyY\x91\x96\xa7\xfa\x8965\u026d\xc5\u07a0\x00\x00\u07d4\"\xdbU\x9f,<\x14u\xa2\xe6\xff\xe8\x032\xe3\u6a6cl\u0675^\u034\9\b\xacr0H\x9e\x80\x00\x00\u07d4\"\xe2H\x8e-

j\x0e\xda\x00\x00\u07d4\"\xf3\xc7y\xddy\x02>\xa9*x\xb6\\\x1a\x17\x80\xf6-

\\J\x89\\xcb=\xf2~\x1f\x88\x00\x00\u07d4\"\xfe\x88M\x907)\x1bMR\xe6(Z\xe6\x8d\xea\v\xe9\xff\xb5\x89\\k\x93\\x8b\xbd@\x00\x00\u07d4#\x06\u07d3\x1a\x94\rX\xc0\x16e\xfaM\b\x00\x80,\x02\xed\xfe\x8965\u026d\xc5\u07a0\x00\x00\x00\x00\x95\t\x8a\x02\xa7\x0fO\x10\x02\\x95\t\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4#\x12\x00F\xf6\x83\\x02\xa7R\xa7fVi\x1c\x86>\x17\u5709\x11\xe0\xe4\xf8\xa5\v\xd4\x00\x00\u07d4#\x1a\x15\xac\xc1\x99\u021f\xa9\xcb\"D\x1c\xc7\x030\xbd\xcc\xe6\x17\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4#\x1d\x94\x15\]\xbc\xfe*\x93\xa3\x19\xb6\x17\x1fc\xb2\v\u04b6\xfa\x89\xc1\x14\{\xb9\x06\xe2\xf8\x00\x00\u07d4#,m\x03\xb5\xb6\xe6q\x1e\xff\xf1\x90\xe4\x9c(\xee\xf3\x82\xb0\x89\x21\x90E9D\x00\x00\x00\u07d4#,\xb1\xcd\x99<\x14J?\x88\xb3\x1e#5i\xa8k\u058a\x03L`\B\u042c`\x00\x00\u07d4#\R]U\x85\x9b\N`\x8d

 $\label{thm:linear} $H (007f) = \frac{x89}{x} - \frac{x}{x} - \frac$

 $e9I(p\xaf\xea\%7\xf3\x89\xac/\x83\x83\x02\xa3<\x06\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\#;\xdd\xdd]\xa9HR\xf4\xad\xe8\xd2\x12\x88V\x82\xd9\ak\u0189\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\#OF\xba\xb7?\xe4]1\xbf\x87\xf0\xa1\xe0Fa\x99\xf2\ubb09\x1aJ\xba\"\$

t\x00\x00\u07d4#U\x1fV\x97_\xe9+1\xfaF\x9cl\xeaf\xeefb\xf4\x1e\x89g\x8a\x93

 $\label{thm:c4g} $$ \x81w\x64g\x8a\a\x12\x9e\x1c\x6f7>\xe0\x00\x00\x00\x94\#r\xc4\xc1\u0253\x9fz\x8fl\xfa\xc0@ $$ \x90\xf0\x04t\x84\n\t\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\#s\f5z\x91\x02nD\xb1\xd0\xe2\xfc^Q\xd0q\xd8\xd7\x89\xd8\xd7\xb7\x17z\x80\x00\x00\u07d4\#v\xad\xa9\x033\xb1\u0441\bL\x97\xe6E\xe8\x10\xaa[v\xf1\x89(\xa8WBTf\xf8\x00\x00\u07d4\#x\xfdC\x82Q\x1e\x96\x8e\u0452\xe10g7\xd3\xf4T\xb55\x8965\u026d\xc5\u07a0\x00\x00\u07d4\#x\x82\xa9\u050e\xc8>\xa3e(\x90\xfd\x0e\u7710\{-$

 $s\x85\xe09\x89JD\x91\xbdm\xcd(\x00\x00\u07d4\#\x9as>k\x85Z\u0152\xd6c\x15a\x86\xa8\xa1t\xd2D\x9e\x89X\xbe7X\xb2A\xf6\x00\x00\x94\#\xab\t\xe7?\x87\xaa\x0f;\xe0\x13\x9d\xf0\xc8\xebk\xe5cO\x95\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\xe0\x94\#\xab\xd9\xe9>yW\xe5\xb66\xbeey\x05\x1c\x15\xe5\xce\v\x0e\x8a\x03\xa3\xc8\xf7\xcb\xf4,8\x00\x00\u07d4\#\xb1\u0111\u007f\xbd\x93\xee=H8\x93\x06\x95s\x84\xa5II\xbf\x89\xd8\xd8X?\xa2\xd5\x00\x00\x00\xe0\x94\#\xba8d\xdaX=\xabV\xf4\x87<7g\x96\x90\xe0\x00\x8a\x02\x13BR\r\xec$

 $\label{thm:colored} $$\x00\x00\u07d4\#\xc5Z\xebW9\x87o\n\xc8\xd7\xeb\xea\x13\xber\x96\x85\xf0\x00\x89Hz\x9a0E9D\x00\x00\u07d4\#\u025b\xa0\x87D\x8e\x19\xc9p\x1d\xf6n\f\xabR6\x831\xfa\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\#\xcc\xc3\u01ac\xd8\.F\fO\xfd\xd8+\xc7]\xc8l\xea\x14\x89\xd8\xd7\xb7\x17z\x80\x00\x00\u07d4\#\xcd\%\x98\xa2\x0e\x14\x9e\xad*\u0593yWn\xce\xdb`\u3389lk\x93[\x8b\xbd@\x00\x00\u07d4\#\u07cfH\xee\x00\x92V\xeay~\x1f\xa3i\xbe\xeb\xcfk\xc6c\x89|\xd3\xfa\xc2m\x19\x81\x80\x00\u07d4\#\xe2\u01a8\xbe\x8e\n\u03e5\xc4\xdf^6\x05\x8b\xb7\u02ecZ\x81\x89lk\x93[\x8b\xbd\@\x00\x00\u07d4\#\xeaf\x9e5d\x81\x9a\x83\xb0\xc2l\x00\xa1m\x9e\x82olF\x89M\x8dl\xa9h\xca\x13\x00\x00\u07d4\#\xebo\xd8Vq\xa9\x06:\xb7g\x8e\xbe\x2$

\x89\u007f\x1fi\x93\xa8S\x04\x00\x00\xe0\x94\$CJ>2\xe5N\xcf'/\xe3G\v_oQ/gU

\x8a\x01@a\xb9\xd7z^\x98\x00\x00\u07d4\$HYo\x91\xc0\x9b\xaa0\xbc\x96\x10j-

 $\label{thm:convolu07d4} $$\x6\x6\x93\cx92\x80\x1c\x00\x00\u07d4\\\xb2\xbe\x11\x8b\x16\u0632\x17Gi\xd1{L\xf8O\a\u0294m\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\\\xb8\xb4F\u07bd\x19G\x95]\u0404\xf2\xc5D\x933F\u04ed\x89\xeaim\x90@9\xbd\x80\x00\u07d4\\\xb9\xbe\xf7\x95\x00\xba\xa0\xa0\xa0\xa7. $$ w\xf8wA]\xf7\3\x891T\xc9r\x9d\x05x\x00\x00\u07d4\\\xb9\xe6dOk\xa4\xcd\xe1&'r\x81\xf6\xab`\xf2\x86\xdf\xf4\x89\a?u\u0460\x85\xba\x00\x00\u07d4\\\xbdY\x04\x05\x90\x91\xd2\xf9\xe1-$

 $j\&\xa0\x10\xca\"\xab\x14\xe8\x89e\xea=\xb7UF`\x00\x00\u07d4\\\xc0\u020bT\xa3TG\t\x82\x8a\xb04\xab\x00\x00\x00\u07d4\\\xc1\x17\xd1\u04b3\xa92\xb1\x1aFy\u025awJ\x9e\xad\xe8\u044965\u026d\xc5\u07a0\x00\x00\u07d4\\\xcf\xf0\xe93j\x9f\x80\xf9\xb1\u02d6\x8c\xafk\x1d\x1cl2\xa4\x89\n\xdaUGK\x814\x00\x00\u07d4\\\u06aa\xdd\xf7\xb0k\xbc\ua6\c0Y\x00\x85\xa8\x85gh+N\x89\x11K$

 $2\xd9\xd5\Kc>\xdf7\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4\\xfcs\xd2\a\x93\t\x8e\t\u076b\x98\pb\xfa\x1e\x18\pha9\n\u05ce\xbcZ\xc6$

 $\# \x97 \xf2@F \x95 H \xbe \xb5bj \xf4 \xf2 < \x89 \x05 \x03 \xb2 \x03 \xe9 \xfb \xa2 \x00 \x00 \u07d4\% \niC \av \xf64w \x03 \xf9R \x97 \x83 \x95 \Za \x97 \xb6 \x89 \x89 \x89p \x81 \xd0 \x00 \x00 \u07d4\% \x0e \xb7 \xc6o \x86 \x9d \xdf \u0685 \xf39 > \x98 \f \x02 \x9a \xa44 \x89 \xd8 \xd7 \xb7 \x17z \x80 \x00 \x00 \u07d4\% \x10j \xb6u] \xf8mkc \xa1 \x87p; \f \xfe \xa0 \u5520 \x89 \x01 \@Z \xd4 \x1d \xb4 \x00 \x00 \x00 \x94\% \x18_2 \xcf-dP \x06 \x98 \xf6 \v \x9d \xdf \h0 \x16 \x02 \x8a \x01 \x0f \f \xf0d \xdd \Y$

 $\label{thm:convolu07d4} $$\x00\x00\u07d4\%o\xa1P\u0307\xb5\x00j\a\xd0\x00\x00\u07d4\%r\x1c\x87\xb0\xdc!7|r\x00\xe5$\xb1J\"\xf0\xafi\xfb\x89\xd8\xd7\&\xb7\x17z\x80\x00\u07d4\%\x899\xbb\xf0\f\x9d\xe9\xafS8\xf5\xd7\x14\xab\xf6\xd0\xc1\xc6q\x89T\x06\x923\xbf\u007fx\x00\x00\xe0\x94\%\x90\x12hp\xe0\xbd\xe8\xa6c\xab\x04\nr\xa5W=\x8dA\u008a\x01\x0f\f\xf0d\xddY$

7o\x82r\xd9\xc1\a\f=x\x89\n\u05ce\xbcZ\xc6

 $\label{thm:conuou2d6} $$ \x96K$q\xeb\x1c`oN\u02d6\x16\x89>\x8e\xf7\x95\u0610\xc8\x00\x00\u07d4&\xa6\x8e\xab\x90Z\x8e\xce\x00\xe3\x170\x82\%u06b1\xb9\xf6\xb8\x89k\x\x05\x15\x82\xa9p\x00\x00\u07d4&\xb1\x1d\x06e\x88\xcet\xa5r\xa8Zc(s\x92\x12\xaa\x8b@\x89lk\x93[\x8b\xbd@\x00\x00\u07d4&\xc0\x05Kp\x1=\x06\xcf8a\xfd\xd4\#j^GHH\xb3X\x8965\u026d\xc5\u07a0\x00\x00\u07d4&\xc0\x05Kp\x1=\xcb\xe2uh\x9dOL\xad\x16\xa35\x89lk\x93[\x8b\xbd@\x00\x00\u07d4&\xc2\xff\xc3\x0e\xfd\xc5'>v\x18:\x16\xc2i\x8dnS\x12\x86\x89*\x11)\u0413g$

\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4'\x14i\x13V:\xa7E\xe2X\x840\xd94\x8e\x86\xea|5\x10\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4'\x1d=H\x1c\xb8\x8evq\xad!iI\xb66^\x060=\xe0\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4'

e+

 $\xf9\xcaBn\xf2\xf2\xcb\xd2\xfe\xcd9\x92\fO\x1a\x89\xe1m\x89lk\x93[\x8b\xbd@\x00\x00\u07d4'*\x13\x1aZeiz:\xca5\u023d$

\"\"\xa7Y\"X\x89\x90\xf54`\x8ar\x88\x00\x00\u07d4'D\xffgFA!\xe3Z\xfc)\"\x17qd\xfa/\xcb\x02g\x89\x 05k\xc7^-

 $\label{thm:convoluo7d4'kv05!} $$\x00\x00\u07d4'kv05!\x00\x06\x8b'}\xf0\xb02\xf3\xfdH2cP\xbf\xb2\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4'o\xd7\xd2O\x8f\x88?Zz()[\xf1qQ\u01e8K\x03\x89lk\x93[\x8b\xbd@\x00\x00\u07d4'\x90\x00\u07d4'\xw03\x1eY3L\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4'\xw0x ab\xa1\xe5,;S\xbf\xa2\a\x1dN\x85\x9a\n\xf7\xe8\xe1\x8965\u026d\xc5\u07a0\x00\x00\u07d4'\x82Ff\xd2x\xd7\x04\#\xf0=\xfe\x1d\u01e3\xf0/C\u2d4966\xc2^f\xec\xe7\x00\x00\u07d4'\x83\f_`#\xaf\xaa\xf7\x97Egl$

\x00\x00\u07d4'\xfc\x85\xa4\x9c\xff\x90\xdb\xcf\xda\u071d\xdd@\u05b9\xa2!\nl\x89\x05k\xc7^-c\x10\x00\x00\u07d4(\x05A^\x1d\u007f\xde\xc6\xde\u07f8\x9eR\x1d\x10\y-t<\x10\x89\x05k\xc7^-c\x10\x00\x00\u07d4(\a>\xfc\x17\xd0\\\xab1\x95\xc2\xdb3+a\x98Gw\xa6\x12\x8965\u026d\xc5\u07a0\x00\x00\u07d4(\x12P\xa2\x91!'\nN\xe5\u05cd\$\xfe\xaf\xe8,p\xba:\x8965\u026d\xc5\u07a0\x00\x00\u07d4(\x13P\x2E\x92\x97\x05\x95\u05b6\xb5`\xf8\xd6\xd6\u0449lk\x93[\x8b\xbd@\x00\x00\u07d4(\x13\xd2c\xfc_\xf2G\x9e\x97\x05\x95\u05b6\xb5`\xf8\xd6\xd6\u0449lk\x93[\x8b\xbd@\x00\x00\u07d4(\x80\xa5T\x87ZVy\x9f\xa0\xa9\u007fU\x10\u7557LN\x8965\u026d\xc5\u07a0\x00\x00\u07d4(3\x96\xce<\xac9\x8b\xcb\xe7\"\u007f2>x\xff\x96\u0407g\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4(4\x9f~\xf9t\xeaU\xfe6\xa1X;4\xce\xc3\xc4Pe\xf0\x89\f\xb63\u051eeY\x00\x00\u07d4(6\x120F\xb2\x84\xe5\xef\x10+\xfd\"\xb1v^P\x81\x16\xad\x89\x16S\xfb\xb5\xc4'\xe4\x00\x00\u07d4(<\\x\x92\u0530d\xf0\xae\xf9\xbbRF\xa7\x00\u007f9\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4(>\x11

7l\xb1\xfaO2\xfe\xbbq\xe4\x9d\x13Y\x198*\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94(>bR\xb4\xef\xcfFT9\x1a\xcbu\xf9\x03\u015bx\xc5\xfb\x8a\x02\x8a\x85t%Fo\x80\x00\x00\x00\xe0\x94(Q\x0en\xff\x1 f\xc8)\xb6WoC(\xbc98\xecze\x80\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4(X\xac\xac\xaf! \xea\x81\u02b7Y\x8f\xdb\xd8kE.\x9e\x8e\x15\x89\$\x1a\x9bOaz(\x00\x00\u07d4(Z\xe5\x1b\x95\x0 0\u014dT\x13e\xd9ui\xf1K\xb2\xa3p\x9b\x89lk\x93[\x8b\xbd@\x00\x00\u07d4(f\xb8\x1d\xec\xb0.\x e7\n\xe2P\xce\xe5\xcd\xc7{Y\u05f6y\x89lk\x93[\x8b\xbd@\x00\x00\u07d4(i\x06\xb6\xbd\ir\xe3\xc7\x16U\xe0K\xaf6&\f|\xb1S\x89\x12nr\xa6\x9aP\xd0\x00\x00\u07d4(k\x18ma\xea\x1f\u05cd\x990\xf e\x12\xb0e7\xb0\\=Q\x8965\u026d\xc5\u07a0\x00\x00\x00\x94(f\xf3\xe2\x98]_{@f'\xe1{\xaaw+\x0}1\xab\u031e\x8a\x01F\x05\x05\x04\x10v_8\x00\x00\x00\x00\x00\x00\x00\x12\xb0\x11\xb3\x11\xb3\x1d\xf6\xf e}(x15\u036d\xc9\xf5\x8965\u026d\xc5\u07a0\x00\x00\x00\u07d4(\x86\x83\$3~\x11\xba\x10\xb4\x81\x\)

 $u0696/: \x84S\x80\x8d\x89Ik\x93[\x8b\xbd@\x00\x00\xe0\x94(\x90K\xb7\xc40)C\xb7\t\xb1Myp\xe4+\x83\u184a\x02\x1f\x97\x84j\a-$

 $\label{thm:convolu07d4} $$\x00\x00\u07d4(\xa3\xda\t\xa8\x19H\x19\xae\x19\x9f.m\x9d\x13\x04\x81~(\xa5\x89Ik\x93[\x8b\xbd\@\x00\x00\u07d4(\xab\x16_\xfbi\xed\xa0\xc5I\xae8\xe9\x82o_\u007f\x92\xf8S\x89FM\xf6\xd7\xc8\DY\x00\x00\u07d4(\xb7u\x85\xcb=U\xa1\x99\xab)\x1d:\x18\u018f\u8684\x8a\x89j@v\xcfy\x95\xa0\x00\x00\x00\x94(\xd4\xeb\xf4\x1e=<E\x1e\x94;\xdd~\x1f\x17_\xae\x93*=\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\x00\x00\x94(\xd7\xe5\x86o\x1d\x85\xfd\x1c\xeb2\xbf\xbe\x1d\xfc6\xdbCEf\x8a\x01\x86B1\xc6\x105\x1c\x00\x00\u0794(\xd8\xc3_\xb7\xee\xa6\"X!5\xe3\xadG\xa2'\u0266c\xbd\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4(\xe4\xaf0\u0353\xf6\x86\xa1\"\xad\{\xb1\x9f\x8a\x87\x85\xee\xe3B\x89\q\xe5;pl\u01f4\x00\x00\u07d4(\xea\xeax\xcdM\x95\xfa\xec\xfbh\x83\n\xaf\xe85$

\U000fbdc9\n\u05ce\xbcZ\xc6

\xf3\xe5\xee\xfd\xd3qc\x8e;z\xf4\x99\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4)\x01\xf8\a\u007f4\x19\v\xb4z\x8e\"\u007f\xa2\x9b0\xce\x11;1\x89\x05k\xc7^-

c\x10\x00\x00\u07d4)\x05\xb1\x92\xe8<\xe6Y\xaa5[\x9d\f

z\xbasoq\xde\a\x92\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4)yt\x11t\xa8\xc1\xea\v\u007f\x9e\xdfe\x81w\x85\x94\x17\xf5\x12\x89\x19\x01\x96I\ x84\x96\x83\x80\x00\u07d4)z\x88\x92\x1b_\xca\x10\u5edd\xed`\x02T7\xae\"\x16\x94\x89\n\u05ce

\xbcZ\xc6

\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4)\xb3\xf5a\xeezn%\x94\x1e\x98\xa52[x\xad\u01d7\x85\xf3\x89\x05k\xc7^-

 $\label{thm:continuous} $$ \times 1\cdot x_1 + u_068cB \cdot u_038fU \cdot u_0589 \cdot x_00Z \cdot u_007f \cdot x_0f \cdot x_00 \cdot x_00 \cdot u_07d4) \cdot x_f8 \cdot x_00X \cdot x_0$

\x00\x00\xe0\x94*D\xa7!\x8f\xe4Me\xa1\xb4\xb7\xa7\u0671\xc2\xc5,\x8c>4\x8a\r-

q\x89i*\xe8\x89p\x81\xd0\x00\x00\xe0\x94*\x9cW\xfe{k\x13\x8a\x92\rgo<v\xb6\u00a0\xee\xf6\x99\

x8a\x01\xfd\x934\x94\xaa_\xe0\x00\x00\u07d4*\x9c\x96\xc1\x91Q\xff\xcb\xe2\x9aF\x16\xd0\xc5+9 3\xb4e\x9f\x89\x03\xc17\x9b\x87e\xe1\x80\x00\u07d4*\xa1\x92w|\xa5\xb9x\xb6\xb2\xc2\xff\x80\n\ xc1\x86\x0fu?G\x89\x12)\x0f\x15\x18\v\xdc\x00\x00\x00\xe0\x94*\xaa5'Mt%Fg\vt&&E!\x03*\xf4\xf4\u0 0ca\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4*\xae\xa1\xf1\x04o0\xf1\t\xfa\xec\x1cc\xef\\u\x94 \xeb\b\u0689\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4*\xb9~\x8dY\xee\xe6H\xabl\xaf\x86\x96\xf8\x 997\x148d\u0589\xcf\x15&@\xc5\xc80\x00\x00\x00\xe0\x94*\xbc\u1009@\xcdN\xf5\xb5\xe0R\x85\xf8-\xf7\xa9\xab^\x03\x8a\x02\x13BR\r_\xec

 $\label{thm:convex} $$ \a6c\x89\ue86b\xb9\x01\xd1\xd5\u007fZ\xea\vx89lk\x93[\x8b\xbd@\x00\x00\u07d4*\uc01d\xf92[\x9fH9\x96\xe9\x9fs1\t\u007f\b\xaa\x0e\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\x00\xe0\x94*\xed,\xe51\xc0V\xb0\t-\xfc<m\xe1\fGb\x00N\u064a\x025iS\xab}\xdc8\x00\x00\u07d4*\xfb\x05\x8c=1\x03+5;\xf2O\t\xae$

 $\label{thm:colored} $$ \x05M\xe5\xe0\x89;\xa1\x91\v\xf3A\xb0\x00\x00\xe0\x94+\x03bc6\x14\xbf\xcbX5iC\x8e\xccN\xa5{\x1d3}\x1d3~\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4+\x10\x1e\x82,\xd9b\x96*\x06\x80\n,\b\u04f1]\x82\xb75\x89\b=|z\xabc\x00\x00\u07d4+\x12\x9c&\xb7]\xde\x12\u007f\x83$

 $< \x 19z = & \x 15 \x 18 \x 15 \x 5 \x a 7 \x 98 \x d 2qh \u 0 70a \x 0 1j \x 1f \x 9f_\x d 7 \x d 9 \x 0 0 \x 0 0 \u 0 7 d 4 + \x 8a \r \x e \\ \x b 0 \x e 1 \x e 9 \x 15 \x e 1 \x e 9 \x 15 \x e 1 \x e$

 $xab\x0f\xbe(\u0544\xb5)$

 $6w\ln x12 xf9 x95* \end{align} 6w\ln x12 xf9 x95* \end{align} 2x17 x89 xc5 xc80 x00 x00 u07d4 + \end{align} 2x17b x0f u05349 xac x97 x15zA x02 xa9 xf7 x89 xd8 xd7 & xd7 x17z x80 x00 u07d4 + xaf x8dn \" x11t x11t x12H$

 $\label{thm:condition} $$ \operatorname{thm:condition} $$$

\x00\x00\xe0\x94,\x06\u0752+aQJ\xaf\xed\xd8D\x88\xc0\u008em\xcf\x0e\x99\x8a\x15-

 $\label{thm:colored} $$ \x02\xc7\xe1J\xf6\x80\x00\x00\xe0\x94,\f\xc3\xf9QH,\u0222\x92X\x15hN\xb9\xf9N\x06\x02\x00\x88\xe01EB\xba\x12\xa37\xc0\x00\u07d4,\x0e\xe14\u0633aE\xb4{\xee\u7bcd'8\xdb\xda\b\xe8\x89\x01\xe5} $$ 9\n\xe5os\x0em\x84\x00\x00\u07d4,\x0f[\x9d\xf46\%y\x8e-\x03\xc1\xa5\xfdjm\t\x1a\xf8+\x89\x01\xb0\xfc\xaa\xb2\x000\x00\u07d4,\x12\x8c\x95\xd9W!Q\x01\xf0C\u074f\u0142EmA\x01m\x89-C\xf3\xeb\xfa\xfb,\x00\x00\u07d4,\x18\x00\xf3_\xa0-$

c\x10\x00\x00\u07d4,\x1c\xc6\xe1\x8c\x15\$\x88\xba\x11\xc2\xcc\x1b\xce\xfa-

 $\label{thm:linear_continuous} $$ \frac{xf3\\x06\\xab\\u0449Z\\x87\\xe7\\xd7\\xf5\\xf6X\\x00\\x00\\xe0\\x94,\\x1d\\xf8\\xa7oH\\xf6\\xb5K\\u03dc\\xafV\\xf0\\xee\\x1c\\xf5z\\xb3=\\x8a\\x02\\x00\\x00\\x89\\xdaX\\x00\\x00\\u07d4,\\g\\x94z\\xe3?\\xb0\\x98\\xb4\\x89\\xa5\\xc1k\\xff\\xf9\\xab\\xcdN*\\x89\\n\\u05ce\\xbcZ\\xc6$

\x00\x00\u07d4,#OP\\\xa8\xdc\xc7\\x9b~\x01\xd2W\xc3\x18\xcc\x199m\x89\x05k\xc7^-

\x00\x00\u07d4,]\xf8ffj\x19K&\u03bb@~J\x1f\xd7>

\x8d^\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94,`?\xf0\xfe\x93alCW>\xf2y\xbf\xea@\x88\x8dj\xe7\x 8a\x01\x00\xf4\xb6\xd6gW\x90\x00\x00\xe0\x94,hF\xa1\xaa\x99\x9a\"F\xa2\x87\x05`\x00\xbaM\u0 2e8\xe6=\x8a\x02\x1f/o\x0f\xc3\xc6\x10\x00\x00\u0794,j\xfc\xd4\x03|\x1e\xd1O\xa7O\xf6u\x8e\tE\

\x9e\x89\x01Y\xf2\v\xed\x00\xf0\x00\x00\u07d4,\x83\xae\xb0/\xcf\x06\e\xa4p\x82\xfd\x97x3\xab\x 1c\uc449\b'8#%\x8a\xc0\x00\x00\x00\x00\x94,\x89\xf5\xfd\xca=\x15T\t\xb68\xb9\x8at.U\xebFR\xb7\x8 a\x14\u06f2\x19\\\xa2(\x90\x00\x00\u07d4,\x96HI\xb1\xf6\x9c\xc7\u03a4D\%8\xed\x87\xfd\xf1\\xfc\x8f\x89Ik\x93[\x8b\xbd@\x00\x00\u0794,\x9f\xa7,\x95\xf3}\b\xe9\xa3`\t\u7930\u007f)\xba\xd4\x1a\x88\xdfn\xb0\xb2\xd3\xca\x00\x00\u07d4,\x9f\xa7,\x95\xf3}\b\xe9\xa3`\t\u7930\u007f)\xba\xd4\x1a\x88\xdfn\xb0\xb2\xd3\xca\x00\x00\u07d4,\x9f\xa7,\x95\xf3}\b\xe9\xa3`\t\u7930\u007f)\xba\xd4\x1a\x88\xdfn\xb0\xb2\xd3\xca\x00\x00\u07d4,\x9f\xa7\x95\xf3}\b\xe9\xa3`\t\u7930\u007f)\xba\xd4\x1a\x88\xdfn\xb0\xb0\xb2\xd3\xca\x00\x00\u07d4,\x9f\xa6\x14\xa2\xc2\x19\xc5\xe0\x89z^\xeb\x01\x1d\xce\xceB\x10\x89\xb8\x291\xa1\xa1\xac\x93\x90\xcc\t\x89\xb8\x291\xa1\xa01\x16\x00\x00\u07d4,\xb6\x15\a:@\xdc\u06d9\xfa\xa8HW.\x98\{;\x05n\xfb\x89\x4\xa01\x10\x69\x20\u00709H#\xef}\u006da\xf3\x80\x00\u07d4,\xbb\fs\u07d1\xb9\x17@\xb6\;\wJ}\x05\x17~\x8eX\x89dI\xe8NG\xa8\xa8\x00\x00\u07d4,\xcbfIM\n\xf6\x89\xab\xf9H=6]x\$D\xe7\u07ad\x8965\u026d\xc5\u07a0\x00\x00\u07d4,\xcc\x18k

 $\label{thm:condition} $$ \x 18\x82\x8e \times 2\x8e \times 2\x$

\x03&\xb2?\x04\t\xc0\xc0\xe9#hc\xa13\aZ\x94\xba\x18\x89\vg\x9b\xe7[\xe6\xae\x00\x00\u07d4-\r\xecQ\xa6\xe8s0\xa6\xa8\xfa*\x0fe\u060dJ\xbc\xdfs\x89\n\ad\a\xd3\xf7D\x00\x00\u07d4-\r\x05s}\xad\x80\xa4\x19\xc4\x0e\xdaMw\x10>\x89\xcf\x15&@\xc5\xc80\x00\x00\u07d4-\x03#Y\xb3c\x96O\xc1\x1aQ\x82c\xbf\xd0T1\xe8g\x89\b\x1c\x1d\xf7b\x9ep\x00\x00\u07d4-

4\x80\xbf\be\aJr\xc7u\x9e\xe5\x13{Mp\xc5\x1c\xe9\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4-

 $[B\xfcY\xeb\xda\r\xfdf\xae\x91K\u008c\x1b\nn\xf8:\x8a+\u0235\x9f\xdc\xd86c\x80\x00\u07d4-\\]s5\xac\xb06+G\u07e3\xa8\xa4\xd3\xf5\x94\x95D\u04c0\x89\n\u05ce\xbcZ\xc6\x00\x00\x00\xe0\x94-\\ a\xbf\xc5hs\x92<+\x00\t]\xc3\xea\xa0\xf5\x90\u062e\x0f\x8a\x04ef\xdf\xf8\xceU\x00\x00\u07d4-\\ e\x11\xfdz8\x00\xb2hT\xc7\xec9\xc0\u0735\xf4\xc4\xe8\xe8\x89\x15\xad\u077a\x9ew\x00\x00\u00$

u07d4-

\x8e\x06\x18\x92\xa5\xdc\xce!\x96j\xe1\xbb\a\x88\xfd>\x8b\xa0Y\x89\r\x8e\\\xe6\x17\xf2\xd5\x00\x

00\u07d4-

\x8e[\xb8\xd3R\x16\x95\xc7~|\x83N\x02\x91\xbf\xac\xeet\b\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4-\x90\xb4\x15\xa3\x8e.\x19\xcd\xd0\\U000ed069z\xf7\xcb\xf6r\x89\x05\xf3\xc7\xf6A1\xe4\x00\x00\u07d4-\x9b\xado\x1e\xe0*p\xf1\xf1=\xef\\\u0332z\x9a'@1\x89a\t=|,m8\x00\x00\u07d4-\x9c_\xec\u04b4O\xbbj\x1e\xc72\xea\x05\x9fO\x1f\x9d+\\\x896\xca2f\x1d\x1a\xa7\x00\x00\x00\xe0\x94-\xa6\x17iP\t\xccW\xd2j\u0510\xb3*]\xfb\xeb\x93N^\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4-\xa7k|9\xb4\u323a,\x10\xb0\x85k\x02pd\x8a\x89lk\x93[\x8b\xbd@\x00\x00\u07d4-\u01ddn\u007fU\xbc\xe2\xe2\xd0\xc0*\xd0|\uca3bR\x93T\x89U\xa6\xe7\x9c\xcd\x1d0\x00\x00\xe0\x94-\x94-

 $gj\x87s\#+V\xf1\x8f\#\x9e/\xad\x8a\x03\xef\xa7\xe7G\xb6\u046d\x00\x00\xe0\x94.\b\x80\xa3E\x96\#\xa0Z\xc8\xf0e\xaf\x86\x81\u0736\u008a\x15-$

 $\x02\xc7\xe1J\xf6\x80\x00\u07d4.\fW\xb4qP\xf9Z\xa6\xa7\xe1j\xb9\xb1\xcb\xf5C(\x97\x9a\x89\x05k\xc7^-$

 $c\x10\x00\x00\u07d4.\x10\x91\v\xa6\xe0\xbc\x17\xe0UUf\x14\u02c7\t\x0fM~[\x89\n\u05ce\xbcZ\xc6\x00\x00\xe0\x94.\$\xb5\x97\x87;\xb1A\xbd\xb27\xea\x8aZ\xb7Gy\x9a\xf0-$

\x00\x00\u07d4.,\xbdz\xd8%G\xb4\xf5\xff\x8b:\xb5o\x94*dE\xa3\xb0\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4.-

~\xa6k\x9fG\xd8\xccR\xc0\x1cR\xb6\u147c}G\x86\x89\xd8\xd4`,&\xbfl\x00\x00\u07d4.C\x93H\u07caBw\xb2*v\x84W\xd1\x15\x8e\x97\xc4\t\x04\x89*\x1e\x9f\xf2o\xbfA\x00\x00\x00\x00\x94.F\xfc\xeej;\xb1E\xb5\x94\xa2C\xa3\x91?\xce]\xado\xba\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u0794.G\xf2\x87\xf4\x98#7\x13\x85\r1&\x82<\xc6}\xce\xe2U\x88\u029d\x9e\xa5X\xb4\x00\x00\u07d4.N\u1b99\xa0\xa1\xd9\$(\xd0fR\xa6\xbe\xa6\xd2\xd1]\x89lk\x93[\x8b\xbd@\x00\x00\u07d4.R\x91+\xc1\x0e\xa3\x9dT\xe2\x93\xf7\xae\u05b9\x9a\x0fLs\xbe\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4.a\x9f\W\xab\xc1\u91ea\x93j\xe3\xa2&lb\xe7\xeb-

\x86\xac5\x10R`\x00\x00\u07d4.\xf8i\xf05\vW\xd54x\xd7\x01\xe3\xfe\xe5)\xbc\x91\x1cu\x89\x02\x b5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4.\xf9\xe4eqj\xca\u03f8\xc8%/\xa8\xe7\xbcyi\xeb\xf6\u4255\x 9e\xb1\xc0\xe4\xae

 $MK\xac\xbd\x04\x8a\x8965\u026d\xc5\u07a0\x00\x00\u07d4/\}2\x90\x85\x1b\xe5\u01b4\xb4?\}Et2\x9fa\xa7\x92\u00c9\x05k\xc7^-$

 $c\x10\x00\x00\u07d4/x858\x17\xaf\u04f8\xf3\xb8n\x9f`\xeew\xb5\xd9ws\xc0\xe3\x89N\xae\xeaD\xe3h\xb9\x00\x00\u07d4/xa4\x91\xfbY \xa6WN\xbd(\x9f9\xc1\xb2C\r-$

\x86\xac5\x10R`\x00\x00\u07d4/\xe1:\x8d\a\x85\u0787X\xa5\xe4\x18v\xc3n\x91I\xf7Pt\x89\xd8\xd

 $7\&\xb7\x17z\x80\x00\u07d4/\xea\x1b/\x83O\x02\xfcT3?\x8a\x80\x9f\x048\xe5\x87\n\xa9\x89\x01\x18T\xd0\xf9\xce\xe4\x00\x00\u07d4/\xee6\xa4\x9e\xe5\x0e\xcfqo\x10G\x91\VFw\x9f\x8b\xa0?\x899B\"\xc4\u0686\xd7\x00\x00\u07d4/\xef\x81G\x8aK.\x80\x98\xdb_\xf3\x87\xba!S\xf4\xe2+y\x896\xe5\xec-$

 $\label{thm:colored} $$ \xbe\v\xbe\x89lh\xcc\u041b\x02,\x00\x00\u07d40t,\xcd\xf4\xab\xbc\xd0\x05h\x1f\x81Y4\\x9e\x05K\x1a\x89$=M\x18\''\x9c\xa2\x00\x00\x940\x83\xef\x0e\xd4\xc4@\x11\x96wJ\x95\xcfN\u0703\xed\xc1HO\x8a\#\xff\xb7\xedee\xd6@\x00\x00\u07d40\x8d\xd2\x1c\xeb\xe7U\x12g\x04\xb4\x8c\x0f\r\xc24\xc6\v\xa9\xb1\x89\n\u05ce\xbcZ\xc6$

\x00\x00\u07d40\x90\xf8\x13\x0e\xc4Df\xaf\xad\xb3n\xd3\xc9&\x139cg{\x89\xd8\xd7&\xb7\x17z\x 80\x00\x00\u07d40\x95D\xb6#,=\xd77\xf9E\xa01\x93\u045b_?e\xb9\x89:\xf3B\xf6~\xf6\xc8\x00\x00\u07d40\x96\u0723A\b\b[\xcf\x04\xaer\xb9Et\xa1>\x1a>\x1d\x89\n\u05ce\xbcZ\xc6

\x83\x17\x9bnBS\x00\x00\u07d40\xe33X\xfc!\xc8P\x06\xe4\x0f25}\u0209Y@\xaa\xf0\x89g\x8a\x93

b\xe4\x18\x00\x00\u07d40\xe6\t\x00\xca\xccr\x03\xf3\x14\xdc`CG%Qg\xfc*\x0f\x89lk\x93[\x8b\xbd @\x00\x00\u07d40\u7273\xd2F^\x94nb\x10\xfa[5\xdeN\x8c\x93\b_\x89lk\x93[\x8b\xbd@\x00\x00\ xe0\x940\xe9i\x8c\xf1\xe0\x8a\x9d\x04\x8b\xd8\xd8\x04\x8f(\xbe~\xd9@\x9f\x8a\x01je\x02\xf1Z\x 1eT\x00\x00\u07d40\xe9\u0560\b\x8f\x1d\xdb/u04c0\xe2\xa0I\x19\"f\xc5\x1c\xbf\x89\n\xac\xac\u0 679\xe2+\x00\x00\u07d40\xea\xc7@\xe4\xf0,\xb5n\xef\x05&\xe5\xd3\x002&\x00\xd0>\x89j\xcb=\xf $2\sim x1fx88x00x00u07d40uc4d2$J!\bu0247\xbc\\xdd\xe0ud7c3zx81{x89Tx99\%xf6xc9xc5}$ %\x00\x00\xe0\x940\xed\x11\xb7{\xc1~^f\x94\u023c[nG\x98\xf6\x8d\x9c\xa7\x8a\x1eo\xb3B\x1f\x e0)\x9e\x00\x00\u07d40\xf7\xd0%\xd1o{\xee\x10U\x80Ho\x9fV\x1c{\xae?\xef\x89\x1b\x1a\xe4\xd6 \xe2\xefP\x00\x00\xe0\x940\xfb\xe5\x88 \x9f\xcc\xe9\xea^\u06c2\xedJ\x11\x96\xdd%\x9a\xed\x8a $\x01\x19\xe4\u007f!8\x1f@\x00\x00\u07d41\x04\p?c\xb94\xfb\xbdn/\x1f\x9et\xde\x13\xe7\t\x89\x$ 9a\x81f\xf7\u6ca7\x80\x00\u07d411?\xfdc[\xf2\xf32HA\xa8\x8c\a\xed\x14aD\xce\xeb\x89j\xcb=\xf2 ~\x1f\x88\x00\x00\u07d41Y\xe9\fH\xa9\x15\x90J\xdf\u24b2/\xa5\xfd^ryk\x896\xaf\xe9\x8f&\x06\x1 0\x00\x00\u07d41]\xb7C\x9f\xa1\u0574#\xaf\xa7\xddq\x98\xc1\xcft\xc9\x18\xbc\x89 \x86\xac5\x10R`\x00\x00\u07d41^\xf2\xdab\x0f\xd30\xd1.\xe5]\xe5\xf3)\xa6\x96\xe0\xa9h\x89\b!\x ab\rD\x14\x98\x00\x00\u07d41n\x92\xa9\x1b\xbd\xa6\x8b\x9e\x98\xb3\xc0H\x93N<\xc0\xb4\x16\ x89lk\x93[\x8b\xbd@\x00\x00\u07d41n\xb4\xe4}\xf7\x1bB\xe1mo\xe4h%\xb72{\xaf1\$\x89\xd8\xd7 &\xb7\x17z\x80\x00\u07d41q\x87~\x9d\x82\f\xc6\x18\xfc\t\x19\xb2\x9e\xfd3?\xdaI4\x8965\u02 6d\xc5\u07a0\x00\x00\u07d41|\xf4\xa2<\xb1\x91\xcd\xc5c\x12\u009d\x15\xe2\x10\xb3\xb9\xb7\x8 4\x89\a\xcef\xc5\x0e(@\x00\x00\u07d41\x8b.\xa5\xf0\xaa\xa8y\xc4\xd5\xe5H\xac\x9d\x92\xa0\xc6

\x00\x00\u07d41\x8cv\xec\xfd\x8a\xf6\x8dpUSR\xe1\xf6\x01\xe3Y\x88\x04-

\x89\x1b1\x19.h\xc7\xf0\x00\x00\u07d41\x8f\x1f\x8b\xd2

 $t\x87\xb7\xb9\n\u05ce\xbcZ\xc6$

\xcd\x18\xe8\x00\x00\u07d41\xcc\xc6\x16\xb3\x11\x82h\xe7]\x9a\xb8\x99I\x88X\xeb\xd7\xf3\u00c 9\x15\xae\x0fw\x1c\xa1R\x00\x00\u07d41\xd8\x1dRI\x19^?\x10\xb5\xc6\xdbR\xb5\xe5\x9a\xfb\u0 a55\x89\x0eO\xbciD\x9f \x00\x00\u07d41\xe9\xc0\x0f\f

jNN~\x05\"\x17\r\xc8\x1e\x88\xf3\xebp\x89\x91\x8d\xdc:B\xa3\xd4\x00\x00\u07d41\xea\x12\u051a 5\xa7@x\r\xde\xea\xec\xe8L\b5\xb2bp\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convolu07d41} $$ \onum{19\xd0\ad\xe9\xa9^\x18?} + \x1b\"\xfc}\xc4\x0f\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d41\xeb\x12<\x95\xc8+\xf6\x85\xac\xe7\xa7Z\x18\x81\xa2\x89\xef\xca\x10\x891\xe0\t\x90\x00\x00\x00\u07d41\ud147\x88\xbd\xa4\xd5'\t\x92\"\x1c\xc0B\x06\xecba\r\x89?\xc0GIH\xf3'\x00\x00\u07d41\xf0\x06\xf3IN\xd6\xc1n\xb9^*\xaf\x90D\xfa\x8a\xbb_\u0563\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\x00\xe0\x942\x01\%\x9c\xafsJ\xd7X\x1cV\x10Q\xba\v\xca\u007f\u0594k\x8a&\x1d\xd1\xce/$

\x88\x80\x00\x00\u07d42\x03N\x85\x81\xd9HN\x8a\xf4*(\xdf\x19\x012\xec)\xc4f\x89\xbb\x91%T\" c\x90\x00\x00\u07d42 !\x02&x\xa0\x16m

K:\xaaz\xd4\xecK\x88\xb7\u0409\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d42%\xc1\xca_*\x9c\x88\x15\xb7\xd9\xcd\xc4J2fS\xc2\x14\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d42'\x88\xb5\xe2\x9b\xf4\xf5\xf5Z\xe1\u0773\x85\xfd\xa9\x1b\x8e\xbe\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d42-o\x9a\x14\r!?L\x80\xcd\x05\x1a\xfe%\xc6

 $\label{thm:colored} $$ \operatorname{xca} xf9\cdot x00\cdot x00\cdot u07d42: \xadA\cdot xdfKo\cdot xc8\cdot xfe\cdot u038c\cdot x93\cdot x95\cdot x8a\cdot xa9\cdot x01\cdot xfah\cdot bC\cdot x894\cdot x95tD\cdot xb8@\cdot xe8\cdot x00\cdot x00\cdot xe0\cdot x942; <xfe>\times xe6+\xbd\cdot xe2\cdot xa2a\cdot xe5<\times xb3\cdot xec\cdot xc0X\cdot x10\cdot xf2\cdot u018a\cdot x02\cdot ub3b1\cdot xa1r\cdot u0738\cdot x00\cdot x00\cdot u07d42? \xca^\cdot xd7\cdot u007fi\cdot x9f\cdot x9d\cdot x90\cdot xf5\cdot xce\cdot xef\cdot xf8\cdot xe5oY\cdot xf0< x89Hz\cdot x9a0E9D\cdot x00\cdot x00\cdot u07d42H\cdot x81\cdot x87(\xc1\cdot x97\cdot xfe\cdot xa4\cdot x87\cdot xfb\cdot xb6\cdot xe8)\cdot x15\cdot x9e\cdot x83p\cdot x899! \xb4\cdot x13\cdot xbcN\cdot xc0\cdot x80\cdot x00\cdot x942P\cdot xe3\cdot xe8X\cdot xc2j\cdot xde\cdot u032d\cdot xf3j\cdot Vc\cdot xc2^* \xa8LAp\cdot x8a\cdot x01\cdot x0f\cdot x5d\cdot xb2$

~L\xfd\xa08\x00\x00\u07d42{\xb4\x9euOo\xb4\xf73\xc6\xe0o9\x89\xb4\xf6]K\xee\x89\x01\x15\x8e F\t\x13\xd0\x00\x00\u07d42\x82\x1do\xd7\x13\xf1\xe9OK\xfdV^\xaax\xb3\xa0Y\x9d\x89Hz\x9a0 E9D\x00\x00\u07d42\x83\xeb\u007f\x917\xdd9\xbe\xd5_\xfek\x8d\xc8E\xf3\xe1\xa0y\x89\x03\x97\ n\xe9!Ux\x00\x00\u07d42\x86\t\x97\xd70\xb2\xd8;s\$\x1a%\xd3f}Q\xc9\b\xef\x89\x1b\x1a\b\x927\a =\x00\x00\x00\xe0\x942\x86\u047cez1,\x88G\xd9<\xb3\xcbyP\xf2\xb0\xc6\xe3\x8a\x04<3\xc1\x93ud\x 80\x00\x00\xe0\x942\xa2\r\x02\x8e,b\x18\xb9\xd9[D\\w\x15\$cj\"\xef\x8a\x02\x02\xfe\xfb\xf2\xd7\xc 2\xf0\x00\x00\u07d42\xa7\x06\x91%\\\x9f\xc9y\x1aOu\u0238\x1f8\x8e\n%\x03\x895e\x9e\xf9?\x0f\ xc4\x00\x00\u07d42\xb7\xfe\xeb\xc5\u015b\xf6^\x86\x1cL\v\xe4*v\x11\xa5T\x1a\x89w\u9aa8R\\\x 10\x00\x00\xe0\x942\xba\x9a}\x04#\xe0:R_\xe2\xeb\xebf\x1d

7\x80\x00\u07d42\xd9P\xd5\xe9>\xa1\u0574\x8d\xb4qO\x86{\x03

 $\label{thm:condition} $$ \xb3\x1c\x0f\x897\b\xba\xed=h\x90\x00\x00\u07d42\u06f6qlT\xe81e\x82\x9aJ\xbb6uxl\xb6\xe4}\x8965\u026d\xc5\u07a0\x00\u07d42\xebd\xbe\x1b]\xed\xe4\b\u01bd\xef\xben@\(\x16\xb7\xed\x02\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d42\xef\(\xdcg\x1d\xf5\V^*\x90\x1a\xee]\xb7\x16\xb9\xbev\xdc\xf6\x89lk\x93[\x8b\xbd@\x00\x00\u07d42\xf2\x9e\x87'\xa7LkC\x01\xe3\xff\xff\x06\x87\xc1\xb8p\xda\xe9\x8965\u026d\xc5\u07a0\x00\x00\u07d42\xfa\x0e\x86\xcd\b\u058di1\x90\xf3-$

\x931\t\t\xedS\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d42\xfb\xee\xd6\xf6&\xfc\xdf\xd5\x1a\xca\xfb\x9e\xef\xf6\x12\xf5d\x89\k\x93[\x8b\xbd@\x00\x00\u07943\x00\xfb\x14\x9a\xde\xd6[\u02e6\xc0N\x9c\u05b7\xa0;\x89;\xb1\x88\xfc\x93c\x92\x80\x1c\x00\x00\x00\xe0\x943\x01\xd9\xca/;\xfe\x02by\xcdh\x19\xf7\x9a)=\x98\x15n\x8a\n\x96\x81c\xf0\xa5{@\x00\x00\x00\xe0\x943\b\xb04f\xc2z\x17\xdf\xe1\xaa\xfc\xeb\x81\xe1m)4Vo\x8a\x03\x99\x92d\x8a#\u0220\x00\x00\x00\u07943\x1a\x1c&\xcci\x94\xcd\xd3\xc1K\xec\xe2v\xff\xffK\x9d\xf7|\x88\xfaz\xed\xdfO\x06\x80\x00\xe0\x943\xb8\x8d\xe8\x06\x18DT\xc4\v'\xf3\t\xd9\xddm\u03f9x\x8a\x03\xca\\f\u067cD0\x00\x00\x00\xe0\x943\x0f+\xaa\x11\r\xd34\x87*\x99\x8f\x14\x84&E<\x8965f3\xeb\xd8\xea\x00\x00\x00\u07d436\xc3\xefn\x8bP\xee\x90\xe0

 $\label{twod} $$ 7\xb1d\xb7\xa8\xea_\xaa\xc6]\x89\x0e\u0223\xa7\x1c\T\x00\x00\xe0\x9438\fo\xffZ\xcd&Q0\x96)\ u06daq\xbf? \u017a\x8a\x03h\xc8b:\x8bM\x10\x00\x00\u07d43:\xd1Yd\x01\xe0Z\xea-$

 $6\xcaG1\x8e\xf4\xcd,\xb3\u07c9\x9d\xc0\\\xce(\u00b8\x00\x00\u07d43C@\xeeK\x9c\u0701\xf8P\xa7Q\x16\xd5\x0e\u9d98\%\xbf\x89Ik\x93[\x8b\xbd@\x00\x00\u07d43H\x1e\x85n\xbe\u050e\xa7\b\\\xa2t\&\xef(\xe8g\xf5]\u0449\n\u05ce\xbcZ\xc6$

 $$ \tiles $$ \t$

\xb1\x16vP\xac\xd8\x00\x00\u07d44\x856\x1e\xe6\xbf\x06\xefe\b\xcc\xd2=\x94d\x1f\x81M>/\x89lk\x93[\x8b\xbd@\x00\x00\u07d44\x85\xf6!%d3\xb9\x8aB\x00\xda\xd8W\xef\xe5Y7\uc609lk\x93[\x8b\xbd@\x00\x00\u07d44\x95\x8aF\xd3\x0e0\xb2s\xec\xc6\xe5\xd3X\xa2\x12\xe50~\x8c\x89lk\x93[\x8b\xbd@\x00\x00\u07d44\x97\xddf\xfd\x11\x80q\xa7\x8c,\xb3n@\xb6e\x1c\xc8%\x98\x89\x05\xf1\x01kPv\xd0\x00\x00\x00\xe0\x944\x9a\x81k\x17\xab='\xbb\xc0\xae\x00Q\xf6\xa0p\xbe\x1f\xf2\x9d\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d44\x9d,\x91\x8f\u041e(\a1\x8ef\xceC)\t\x17k\xd5\v\x89<\xb7\x1fQ\xfcU\x80\x00\x00\u07d44\xa0C\x1f\xff^\xad\x92\u007f<\id\x96\x16\xdcn\x97\x94_o\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\x00\xe0\x944\xa8]m\$?\xb1\u07f7\xd1\xd2\xd4OSn\x94zL\ue78a\

 $x04 < 3 \times 1 \times 93 \times 10 \times 100 \times 100$

N6\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x944\u211b\xeaX:\xb0\xcc7\x97Q\x90\xf3\"\xb3\x95\x05U\x82\x8a\x01\xa5\xc5\xe8W\xfd\xf2\xb2\x00\x00\u07d44\xfaw\x92\xba\u063b\xd7\xffd\x05b\x14\xa3 >\xb6`\f\x1e\xa8\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d44\xff&\xeb`\xa8\u0469ZH\x9f\xae \x13n\xe9\x1dNX\bL\x89

\x86\xac5\x10R`\x00\x00\u07d44\xffX)R\xff\$E\x8f{\x13\xd5\x1f\vO\x98p\"\xc1\xfe\x89\x98\x06\xde =\xa6\xe9x\x00\x00\u07d45\x10k\xa9N\x85c\u0533\xcb<\\i,\x10\xe6\x04\xb7\xce\u0609lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x945\x14_b\x03\x97\u019c\xb8\xe0\tb\x96\x1f\x0fH\x86d9\x89\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d45\x14t0\xc3\x10e\x00\u77e2\xf5\x02F.\x94p<#\xb1\x89lj\xccg\u05f1\xd4\x00\x00\x00\xe0\x945\x17\x87\x845\x05\xf8\xe4\xef\xf4ef\xcc\u695fM\x1c_\xe7\x8a\x01\xf5q\x89\x87fKH\x00\x00\x00\xe0\x945\x1f\x16\xe5\xe0sZ\xf5gQ\xb0\xe2%\xb2B\x11q9@\x90\x8a\x02\xd4\xca\x05\xe2\xb4<\xa8\x00\x00\x00\xe0\x945\x16\x20\x00#N\xba\xaf\a\x89\xa14\xa2\xa4\x178<\xe5(*\x8a\x011yU\x94\x8e,\x00\x00\u07d45\xee\xce\x1ak\xdc>\xe7\xb4\x00\xfe\x93[HF?1\xbe\u05c9\x04w\x87\x9bm\x140\x00\x00\u07d45*x_J\x92\x162PL\xe5\xd0\x15\xf8<|\xaa\x83\x8dm\x89\xe9\xe7\xe0\xfb5\xb7x\x00\x00\x00\xe0\x945-

 $\label{thm:convolu07d45u} $$ \x9e\x16\x00\x00\u07d45u\xc7pf\x8a\x9d\x17\x9f\x1e\xf7h\u0093\xf8\x01f\xe2\xaa=\x89\x19\xb2\x12H\xa3\xef(\x00\x00\u07d45\x02\xc0\xa9\xdf\xe2\x87\xdeD\u007f\xb6zp\xec[b6fG\x89\x01s\x17\x90\x89\x01s\x12\x00\x00\u07d45\x85^\xc6A\xab\x9e\b\x1e\xd0\u00a6\xdc\xd8\x13T\xd0\x3T\x89A'\xab\u94e7\xaa\x80\x00\u07d45\x88\x89Z\xc9\xfb\xaf\xec\x01$$

 $\label{thm:colar_colar$

07d45\xb0>\xa4\$W6\xf5{\x85\xd2\xebyb\x8f\x03m\xdc\xd7\x05\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\x00\u07d45\xbd\$he\xfa\xb4\x90\xac\bz\xc1\xf1\xd4\xf2\xc1\r\f\xda\x03\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\xe0\x945\xbff\x88R/5Fz\u007fu0#\x14\xc0+\xa1v\x80\x0e\x8a\x03\xafA\x82\x02\xd9T\xe0\x00\x00\u07d45\u022d\xc1\x11%C+;w\xac\xd6F%\xfeX\xeb\xee\x9df\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d45\u0497\x0fl\xdc\xc8\x1e\xa9\xeep~\x9c\x8a\n\xb2\xa8\xbbtc\x89N\x10\x03\xb2\x8d\x92\x80\x00\x00\u07d45\xe0\x96\x12\r\xea\xa5\xc1\xec\xb1d^,\u02cbN\xdb\xd9)\x9a\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d45\xea!c\xa3\x8c\u07da\x12\x82\xa5\xec\x00%\x8d\xae\v\xc7g\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d45\xf1\xda\x12\x837o\x1b\x88\xc8*3Y\xf6z^g\xddP\x89g\x8a\x93

\x93\xa9\x01\t\x88\x01\x8f\x9f1]\x03.\u0448\x0f\xa1\x89\x1b\x1b\xcfQ\x89j}\x00\x00\u07d46\x16\x d4H\x98_]2\xae\xfa\x8b\x93\xa9\x93\xe0\x94\xbd\x85I\x86\x89\v\"\u007fc\xbe\x81<\x00\x00\u07d46\x16\x16\xfbF\xc8\x15x\xc9\xc8\xebM;\xf8\x80E\x1a\x887\x9d}\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d460\xc5\xe5e\u03aa\x8a\x0f\x0f\xfe2\x87^\xae*I\xe6<\x19\x89\t7r+7t\xd0\x00\x00\u07d463\x9f\x84\xa5\u00b4L\xe5=\xfd\xb6\xd4\xf9}\xf7\x82\x12\xa7\u07c9\x11o\x18\xb8\x17\x15\x\a0\x00\u07d463\x9f\x84\xa5\u00b4L\xe5=\xfd\xb6\xd4\xf9}\xf7\x82\x12\xa7\u07c9\x11o\x18\xb8\x17\x15\x\a0\x00\u07d464:\xec\xa0{n\u054a\x0eb\xfaN\xcbl\x8a\x12O\xc9q\x89\x10CV\x1a\x88)0\x00\x00\u07d46au@4\x81\xe0\xab\x15\xbbQF\x15\u02f9\x89\xeb\u018f\x82\x89lk\x93[\x8b\xbd@\x00\x00\u07d46ro;\x88Z\$\xf9)\x96\u0681b^\u022d\x16\xd8\xcb\xe6\x89S\xafu\u0441HW\x80\x00\xe0\x946s\x95C\x99\xf6\u07feg\x18\x18%\x9b\xb2x\xe2\xe9.\xe3\x15\x8a*Z\x05\x8f\u0095\xed\x00\x00\u07d46u\x8e\x04\x9c\u064b\u03a1\"w\xa6v\xf9)\sb\x89\x00#\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d46\u007fY\u0302yS)8NA\xe1(1\x15\xe7\x91\xf2j\x01\x89lk\x93[\x8b\xbd@\x00\x00\u07d46\x85T\x14\xb5k\x84U\x17\x1f\xbf\ab

\xfa;\{p\xc1r\xeb\x04\h\x19\xa8\x97%\x95A>\x8965\u026d\xc5\u07a0\x00\x00\x946\xc5\x10\xbfx8dn\V\x9b\xf2\xf3\}G&]\xbc\xb5\x02\xff+\u038a\x06ZM\xa2]0\x16\xc0\x00\x00\x00\x946\xd8]\xc3 h1\V\xe6;\xf8\x80\xa9\xfa\xb7x\x8c\xf8\x14:'\x8a\x04<3\xc1\x93\ud\x80\x00\x00\x00\u07d46\u07cf\x88<\x12\xec\x8a\x17\x1fz3\xcf\xd6l\xb1\xfe`\u\x89\fRHJ\xc4\x16\x89\x00\x00\x00\x00\u07d46\u07cf\x88\x12\xec\x8a\x17\x1fz3\xcf\xd6l\xb1\xfe`\u\x89\fRHJ\xc4\x16\x89\x00\x00\x00\u07d46\xe1Va\f\xd8\xff\d\xe7\x80\u061d\x00T8\\\xa7gU\xaa\x8a\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d47\x00\xe3\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d47\x00\xe3\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d47\x00\xe3\x02\xf6\xf1\a\x89\x02\x6\x12\xa0\x00\x00\u07d47\x00\x20\xe3\x00\x00\u07d47\x035\fM\o\xe374,\xdd\xc6[\xf1\xe28\xf3\xf9\xb2\x89m\x81!\xa1\x94\xd1\x10\x00\x00\x00\x00\u07d47\x19Zc]\x\c6\x04\x05P\x88x)\x02\xe0W\x9cr\x01\xa8\xbfP\x8a*Z\x05\x8f\u0095\xed\x00\x00\x00\u07d47\x19Zc]\x\ccb\xf5jq\x80\xd4\x8f\x9f\x96\x83(\x91\x89j\xcb=\xf2\x1f\x88\x00\x00\x00\u07d47'4\x1f&\xc1\x01\xe3x@^\xe3\x8b-

\xb7\xe9\x93\x1dr\xf5\xa8\xae\x86\x9d\xaf\u076d;m\\\x89\n\u05ce\xbcZ\xc6

b\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d47\x9a\u007fuZ\x81\xa1~\xdb}\xaa\xa2\x8a\xfcf]\xfak\xe6:\x89\x01Z\xf1\u05cbX\xc4 \x00\x00\u07d47\x9cqf\x84\x9b\xc2J\x02\xd6S^-\xef\x13\xda\xee\xf8\xaa\x8d\x89\x05k\xc7^-c\x10\x00\x00\x00\x00\x947\xa0Z\u03b99\\\x865\xa3\x9a|]&j\xe6\x10\xd1\v\xf2\x8a\x06ZM\xa2]0\x16\x c0\x00\x00\u07d47\xa1\x04Q\xf3af\xcfd=\xd2\xdel\x1c\xbb\xa8\xa0\x11\u03e3\x89\x14\x99\x8f2\x acxp\x00\x00\u07d47\xa7\xa6\xffN\xa3\xd6\x0e\xc3\a\xcaQjH\xd3\x05;\xb7\x9c\xbb\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d47\xabf\b:O\xa28H\xb8\x86\xf9\xe6my\xcd\xc1P\xccp\x8a\x12\xbe\"\xff\xb5\xec\x008\x00\x00\u07d47\xac)\xbd\xa9?!\u012e\xaa\xb95E,C\x15\x104\x1e\x895e\x9e\xf9?\x0f\x c4\x00\x00\u07d47\xb8\xbe\xac\{\x1c\xa3\x88}\xd6\x1a\xb5R\xc7f\xf4\x8a\x10\xc3\x89\x15\xaf\x1 dx\xb5\x8e@\x00\x00\u07d47\xbb\xc4r\x12\xd8\xcb^\xe0\x8fR%\xec\xc2\x04\x1a\xd2\xda}\x89\xb1\xcf\xxd4\u0431@\x00\x00\u07d47\u02c6\x8d,?\x95\xb2Wa\x1e\xb3JA\x88\u054bt\x98\x02\x89! k\x93[\x8b\xbd@\x00\x00\u07d47\xe1i\xa98\b\xd8\x03\x\x98\xf8\x15\xc7#\\x13\xc1\xe6Y\xf2\x8965\u026 d\xc5\u07a0\x00\x00\u07d47\xea\u0693\xc4\uxde\xd2\xf7\xe1^\wx87\xd4\x00G\x0f\xa5

 $\label{thm:linear_control_label} $$ \xd7\x15\xee\x01\x82\xd9\x89\x1500\x00\x00\x00\x00\x00\x00\x00\x948\x1d\xb4\xc8F]\xf4F\xa4\xce\x15\xbf\x81\xd4~/x17\u0240\xbf\x8a\x06\u01b95\xb8\xbb\xd4\x00\x00\x00\u07d48 $$,\xd7\a\x8dO\x88\xs\xab\a\x10\x9a\u062d\xa8\x97 $$$

 $\label{thm:convention} $$ \x8965\u026d\xc5\u07a0\x00\x00\u07d48!\x86$\x93$,\n\ub139\r\xe0]\%\f\x1eP\xc0t\x89\x11wIX\xe9F\xdc\x00\x00\x00\xe0\x948\%\x91\xe7!{C^\x8e\x88L\xdb\xf4\x15\xfe7zo\u278a\x01\xb2\u07dd!\x9fW\x98\x00\x00\u07d48+\xa7m\xb4\x1bu\m\u050aH\xf0\x13~\x91t\xe01\xb6\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d481u\x0euW\u02ca7\xa4\xb1\x06D\xb6>M;<u\x89\n\u05ce\xbcZ\xc6\x00\x00\xe0\x9483\x04\xddxW$$

 $\label{thm:convention} $$ \x00\x00\u07d48i_\xc7\xe16|\xeb\x16>\xbb\x057Q\xf9\xf6\x8d\xd0\x89|\k\x93[\x8b\xbd@\x00\x00\u07d48r\xf4\x8d\xc5\xe3\xf8\x17\xbck*\xd2\xd00\xfc^\x04q\x19=\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d48~\xea\xfdk@\t\u07af\x8b\u0578Zr\x98:\x8d\xcc4\x87\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d48\x81\xde\xfa\xe1\xc0{<\xe0Lx\xab\xe2k\f\u070ds\xf0\x10\x89\n\u05ce} $$ \xbcZ\xc6\x00\x00\u07d48\x83\xbe\xcc\b\xb9\xbe\xb2\xb6\xaa\u00f6$$

\xdc\x00\x17\xef\x89lk\x93[\x8b\xbd@\x00\x00\u07d48\x85\xfe\xe6q\a\xdc:<t\x1e\xe2\x90\u0249\x 18\u0279\x93\x97\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d48\x87\x19,\u007fpP\x06\xb60\t\x12v\ xb3\x9a\u0180D\x8dk\x89\x03@\xaa\xd2\x1b;p\x00\x00\u07d48\x89\x8b\xbbES\xe0\v\xbf\xd0\xcf &\x8b\xc4d\xd1T\xad\u0549\x11X\xe4`\x91=\x00\x00\x00\u07d48\x8b\xdc\xda\xe7\x94\xfcD\b.fu\ x014A\x18\xea\x96\u0356\x89Z\x87\xe7\xd7\xf5\xf6X\x00\x00\u07d48\x8c\x85\xa9\xb9 \\\x81F\x03?\xe3\x81C\xf6\xd3KY\\G\x89\n\u05ce\xbcZ\xc6

 $\label{thm:condition} $$ \xd9\xd8\x12\x04\xfd\x01k\xa0\x16\x8a\x02&\x8e\xd0\x1f4\xb30\x00\x00\u07d48\xdf\fJ\xbe\xed_\xe0h\xe0\x0191\wC\xa4\x89a\t=|,m8\x00\x00\u07d48\xe2\xafs9>\xa9\x8a\x1d\x99:t\xdf\xd7\xb9\x8dR\x9a\x89a\t=|,m8\x00\x00\u07d48\xe4m\xe4E<8\xe9A\xe7\x93\x0fC0O\x94\xbb\t+\xe8\x89l\xb7\xe7Hg\xd5\xe6\x00\x00\u07d48\xe7\u06e8\xfdO\x1f\x85\r\xbc&l\xd8\xe8O\tR\xe3\xe}$$$

c\x10\x00\x00\u07d49ck%\x81\x1b\x17j\xbf\xcf\xee\xcad\xbc\x87E/\x1f\xdf\xf4\x89\x15\xaf\x1dx\x b5\x8c@\x00\x00\u07d49i\xb4\xf7\x1b\xb8u\x1e\xdeC\xc0\x166:zaOv\x11\x8e\x89lk\x93[\x8b\xbd @\x00\x00\x00\x949x/\xfe\x06\xacx\x82*<:\x8a\xfe0^P\xa5a\x88\u038a\x02\x1e\x19\xe0\u027a\xb 2@\x00\x00\u07d49zn\xf8v:\x18\xf0\x0f\xac!~\x05\\\r0\x94\x10\x10\x11\x89lk\x93[\x8b\xbd@\x00\x00\u07d49|\u06cc\x80\xc6yP\xb1\x8deB)a\x0e\x93\xbf\xa6\xee\x1a\x89?\x95\xc8\xe0\x82\x15!\x 00\x00\u07d49\x82O\x8b\xce\xd1v\xfd>\xa2.\u01a4\x93\xd0\xcc\xc3?\xc1G\x89\xd8\xd7&\xb7\x17 z\x80\x00\u07d49\x93|"\x19E\v\x94

\xcc%\"\u03d1\xdb\x01\xf2'\xc1\xc1\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d49\x95\xe0\x96\x b0\x8aZrh\x00\xfc\xd1}\x9cd\xc6N\b\x8d+\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d49\x9a\xa6\xf5\xd0x\xcb\tp\x88+\u0259

\x00\x00\u07d49\xba\u018d\x94xY\xf5\x9e\x92&\b\x9c\x96\xd6.\x9f\xbe<\u0789\x02+\x1c\x8c\x12' \xa0\x00\x00\x00\x949\xbf\xd9xh\x9b\xec\x04\x8f\xc7v\xaa\x15\$\u007f^\x1d|9\xa2\x8a\x04<3\xc1\ x93ud\x80\x00\x00\u07d49\xc7s6|\x88%\xd3YlhoB\xbf\r\x141\x9e?\x84\x89\a?u\u0460\x85\xba\x0 0\x00\u07d49\u05291@,\fy\xc4W\x18o\$\u07c7)\u03d5p1\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d49\u05291@,\fy\xc4W\x18o\$\u07c7)\u03d5p1\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d49\xd6\xca\xca\"\xbc\xcdjr\xf8~\xe7\u05b5\x9e\v\xde!\xd7\x19\x89|\x87T\xc8\xf3\f\b\x00\x00\u07d49\xd6\xc5\u07a0\x00\x00\x00\u07d49\xd6\xc5\u07a0\x00\x00\x00\x00\x00\x00\u07d49\xf5\x80\x01\xcb\"\xa8\v\xcc\u044a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d49\xf1\x983\x1eK!\xc1\xb7`\xa3\x15_J\xb2\xfe\x00\xa7F\x19\x89|k\x93[\x8b\xbd@\x00\x00\u07d49\xf4Fc\xd9\%a\t\x1b\x82\xa7\r\xcfY=u@\x05\x97:\x89\n\u05cb.\xdc!Y\x80\x00\u07d4:\x03U\x94\xc7GGmB\xd1\xee\x96|6\"L\xdd\"|\x93\x89\x13J\xf7ei\xf9\xc5\x00\x00\u07d4:\x04W(G\xd3\x1e\x81\xf7v\\\xa5\xbf\xc9\xd5W\x15\x9f6\x83\x89\a6-

\r\xab\xea\xfd\x80\x00\xe0\x94:\x06\xe3\xbb\x1e\xdc\xfd\fD\xc3\aM\xe0\xbb`k\x04\x98\x94\xa2\x8 a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u0794:\x10\x88\x8b~\x14\x9c\xae',\x010,2\n\xf0\x1a\v\$\ x88\xeb\xec!\xee\x1d\xa4\x00\x00\u07d4:1\b\xc1\u6023;3!!\x13\x134@\x9d\x97\xe5\xad\xec\x89\x 01\x15\x8eF\t\x13\xd0\x00\x00\u07d4:6\x8e\xfeJ\u05c6\xe2c\x95\xec\x9f\u01adi\x8c\xae)\xfe\x01\ x89\"E\x89\x96u\xf9\xf4\x00\x00\u07d4:=\xd1\x04\xcd~\xb0O!\x93\\xd43\xeaz\xff\u04d3i\xf5\x89\x 13aO#\xe2B&\x00\x00\u07d4:B\x97\xda<U^F\xc0sf\x9d\x04x\xfc\xe7_\y\x0e\x89j\xc5\xc6-\x94\x86\a\x00\x00\u07d4:Gk\xd2\xc9\xe6d\xc6:\xb2f\xaaLnJH%\xf5\x16\u00c9\n\u05ce\xbcZ\xc6\x00\x00\u07d4:H\xe0\xa7\t\x8b\x06\xa9\x05\x80+\x87TW1\x11\x8e\x89\xf49\x89lk\x93[\x8b\xbd

 $o\x8dX\xf7\v\xb1\xf0\xd3\\(\xcq\xbd\x89\n\ad\a\xd3\xf7D\x00\x00\xe0\x94:r\xd65\xaa\xde\xeeC\x824\x9d\xb9\x8a\x18\x13\xa4\xcf\xeb=\xf1\x8a*Z\x05\x8f\u0095\xed\x00\x00\x00\xe0\x94:}\xb2\xac\xae\x17\xdew\x98y\x82\xcd\xf8\%0\x17\u07e8\x8a\x01\x0f\f\xdd\Y$

@\x00\x00\u07d4:M\xa7\x8d\xce\x05\xae\xb8}\u9bad\x91\x85rm\xa1\x92g\x98\x89\n\u05ce\xbcZ\

xc6 \x00\x00\u07d4:Y\xa0\x82F\xa8

cS\x8a\x99\xf4\x87\xc9P\xa3\xa5\uc78a\x05\x15\n\xe8J\x8c\xdf\x00\x00\x00\u07d4:\x9b\x11\x10)\xce\x1f

 $\label{thm:color$

\x00\x00\u07d4:\xd7\x02C\u060b\xf0@\x0fW\xc8\xc1\xfdW\x81\x18H\xaf\x16*\x89.\x9e\xe5\u00c6 S\xf0\x00\x00\u07d4:\xd9\x15\xd5P\xb7#AV

\xf5\xa9\xb5\xb8\x8a\x85\xf3\x82\xf05\x8965\u026d\xc5\u07a0\x00\x00\u07d4:\xe1`\xe3\xcd`\xae1 \xb9\xd6t-

1d`\x91\\\xdc\xc4

 $[\x89]k\x93[\x8b\xbd@\x00\x00\u07d4;\x15\x90\x99\aR\a\u0180\vc\xb1\xf0\xf7\xed\xa5J\xc8\xcc\xe3\x89]\xc4\xe6[i\xf9-$

 $\label{thm:linear_continuous} $$ \x 00\u 07d4; \x 197\x d5\u 74f8\x 9bc\x fb\x 8e\x b5\x f1\x b1\x c9\x cak\x a0\x fa\x 8e\x 89lk\x 93[\x 8b\x b] $$ d@\x 00\x 00\u 07d4; \x 02q\x c8\x ef\x e1\x 02S\s cji\x b1\x c1~\t\x 89\x 1b6\x a6DJ>\x 18\x 00\x 00\u 07d4; \u 07a3\x c2 \x 1bY\u 01fd'\x bb\x 91\u 04e3\x ea\x ec\x ef 9\x 84\x 89\x 05k\x c7^-$

c\x10\x00\x00\xe0\x94;{\x8e'\xde3\xd3\xceya\xb9\x8d\x19\xa5/\xe7\x9fl%\xbe\x8a\x15-

 $\label{thm:colored} $$ \end{align} $$ \end{align}$

j\x0e\xda\x00\x00\xe0\x94;\xf8n\u0623\x15>\xc93xj\x02\xac\t\x03\x01\x85^Wk\x8a_J\x8c\x83u\xd 1U@\x00\x00\u07d4;\xfb\u04c4|\x17\xa6\x1c\xf3\xf1{R\xf8\ub879`\xb3\U000df262\xa1]\tQ\x9b\xe0 \x00\x00\u07d4<\x03\xbb\xc0#\xe1\xe9?\xa3\xa3\xa6\xe4(\xcf\f\xd8\xf9^\x1e\u0189Rf<\u02b1\xe1 \xc0\x00\x00\u07d4<\f=\ufb1c\xeaz\xcc1\x9a\x96\xc3\v\x8e\x1f\xed\xabEt\x89i*\xe8\x89p\x81\xd0\ x00\x00\u07d4<\x15\xb3Q\x1d\xf6\xf04.sH\u0309\xaf9\xa1h\xb7s\x0f\x8965\u026d\xc5\u07a0\x00 \x00\u07d4<\x15\xb3Q\x1d\xf6\xf04.sH\u0309\xaf9\xa1h\xb7s\x0f\x8965\u026d\xc5\u07a0\x00 \x00\u07d4<\x1f\x91\xf3\x01\xf4\xb5e\xbc\xa2GQ\xaa\x1fv\x13\"p\x9d\u0749a\t=|,m8\x00\x00\u07d4 <\x1f\x91\xf3\x01\xf4\xb5e\xbc\xa2GQ\xaa\x1fv\x13\"p\x9d\u0749a\t=|,m8\x00\x00\u07d4 <\z.a\x1f\u06c2\rc6\xf8\xfcd\xb6\xfa\xd7L\xa9_^\x89\r%\x8e\xce\x1b\x13\x15\x00\x00\u07d4 <\z.xx14Y\u01ab\xbfc\x029\u024a0\xd2\v\x8b:\xc5a\x89\b\x8b#\xac\xff\u0650\x00\x00\u07d4 <\x86\x0e\f7\x08\xc1p\x1d\xb08\x8bh!\r\x00\xf9pB\xd7\x06\x89\t\x8a\x06ZM\xa2]0\x16\xc0\x00\x00\u07d4 <\x86\x0e\f7\x\d8\xa0\pAF\x05\xbb\w#\x1f\xf2\x8965\u026d\xc5\u07a0\x00\x00\u07d4 <\x86\x9c\tie#\xce\xd8\xa0\pAF\x05\xbb\w#\x1f\xf2\x8965\u026d\xc5\u07a0\x00\x00\u07d4 <\x92\x\x19\u02731DF?\x057\u061

65\x87\x06\xc5

\xb0\x89|k\x93[\x8b\xbd@\x00\x00\u07d4<\x98YK\xf6\x8bW5\x1e\x88\x14\xae\x9em\xfd-\%J\xa0o\x89\x10CV\x1a\x88)0\x00\u07d4<\xad\xeb=>\xed?b1\x1dRU>p\xdfJ\xfc\xe5o#\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\x00\x94<\xae\xdbS\x19\xfe\x80eC\xc5nP!\xd3r\xf7\x1b\xe9\x06.\x8a\xg\x83&\xea\xc9\x00\x00\x00\u07d4<\xaf\xaf\bPV\x15\x06\x8a\xf8\xeb\\"\xa1:\u0629\xe5Pp\x89\f\x06E\xaaG\x18\x00\x00\u07d4<\xb1y\xcbH\x01\xa9\x9b\x95\u00f0\xc3\$\xa2\xbd\xc1\x01\xa6S\\x89\x01h\u048e?\x00(\x00\x00\u07d4<\xb5a\u0386BK5\x98\x91\xe3d\xec\x92_\xfe\xff'}\xf7\x89\\n\u05ce\xbcZ\xc6\x00\x00\u07d4<\xcbq\xaah\x80\xcb\v\x84\x01-

\x90\xe6\a@\xec\x06\xac\u05cf\x89lk\x93[\x8b\xbd@\x00\x00\u07d4<\xce\xf8\x86yW9G\xe9l\x97y \x8a\x1e2~\b`:e\x89+\xc9\x16\u059f;\x02\x00\x00\x00\xe0\x94<\xd1\xd9s\x1b\xd5H\xc1\xddo\u03a6\x 1b\xebu\xd9\x17T\xf7\u04ca\x01\x16\x1d\x01\xb2\x15\xca\xe4\x80\x00\u07d4<\u04e6\xe95y\xc5 mIAq\xfcS>z\x90\xe6\xf5\x94d\x89lk\x93[\x8b\xbd@\x00\x00\u07d4<\u05b7Y<\xbe\xe7x0\xa8\xb1 \x9d\b\x01\x95\x8f\xcdK\xc5z\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4<\xd7\xf7\xc7\xc257\x 80\xcd\xe0\x81\xee\xecE\x82+%\xf2\x86\f\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4<\xea0*G*\x94\x03y\xdd9\x8a\$\xea\xfd\xba\u07c8\xady\x89\xa2\xa1]\tQ\x9b\xe0\x 6M\u0552\x00\x00\x00\u07d4<\xf4\x84RO\xbd\xfa\xda\xe2m\xc1\x85\xe3++c\x0f\xd2\xe7&\x89\x1 8TR\xcb*\x91\xc3\x00\x00\u07d4<\xf9\xa1\xd4e\xe7\x8bp9\xe3iDx\xe2b\{6\xfc\xd1A\x89J`S*\xd5\x 1b\xf0\x00\x00\u07d4<\xfb\xf0fVYpc\x9e\x13\r\xf2\xa7\xd1k\x0e\x14\xd6\t\x1c\x89\\(=A\x03\x94\x1 0\x00\x00\x94=\th\x8d\x93\xad\a\xf3\xab\xe6\x8cr'#\xcdh\t\x90C^\x8a\x06ZL\xe9\x9fv\x9en\x0 0\x00\u07d4=1X{\u0546\x98Ex\x87%\xa6c)\nI\xd3q\x8c\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u 07d4=?\xadI\xc9\xe5\xd2u\x9c\x8e\x8eZzM`\xa0\xdd\x13V\x92\x89\x01\x15\x8eF\t\x13\xd0\x00\x0 $0\u07d4=WO\xcf\x00\xfa\xe1\u064c\u023f\x9d\u07e1\xb3\x95;\x97A\xbc\x89j\xcb=\xf2~\x1f\x88\x$ 00\x00\u07d4=Z\x8b+\x80\xbe\x8b5\xd8\xec\xf7\x89\xb5\xedz\au\xc5\al\x89\x01\x15\x8eF\t\x13\x $d0\x00\x00\u07d4 = f\xcdK\xd6M\\x8c\x1b^\xea(\x1e\x10m\x1cZ\xad\#s\x89i\xc4\xf3\xa8\xa1\x10\xa8)$ 6\x00\x00\u0794=j\xe0S\xfc\xbc1\x8do\xd0\xfb\xc3S\xb8\xbfT.h\r'\x88\xc6s\xce<@\x16\x00\x00\u 07d4=o\xf8,\x93w\x05\x9f\xb3\r\x92\x15r?`\xc7u\u0211\xfe\x89\r\x8e\\\xe6\x17\xf2\xd5\x00\x00\u0 $7d4=y\xa8S\xd7\x1b\xe0b\x1bD\xe2\x97Yel\xa0u\xfd\xf4\t\x89lk\x93[\x8b\xbd@\x00\x00\u07d4=~\x80]$ xa5\xbf\x03R\x81\x00\xed\x8a\xf8\xae\xd2e>\x92\x1bng%\x8965\u026d\xc5\u07a0\x00\x00\u07d4 =\x81?\xf2\xb6\xedW\xb97\u06bf+8\x1d\x14\x8aA\x1f\xa0\x85\x89\x05k\xc7^-

c\x10\x00\x00\u07d4=\x88\x143\xf0J}\r'\xf8ID\xe0\x8aQ-\xa3UR\x87\x89A\rXj

 $c\x0\x05)YA\xf2\x10\u0723\xabS\x1e\xec\x88\t\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4>,\xa0\xd24\xba\xf6\a\xadFj\x1b\x85\xf4\xa6H\x8e\xf0\n\xe7\x89\x04\xda!\xa3H=V\x80\x00\u07d4>/&#^\x13 zs\xe4\xdc\x15K]\xf5\xafF\xea\x1al\x89\x017\xaa\xd8\x03-$

 $\xb9\x00\x00\x00\x94>1a\xf1\xea/\xbf\x12ny\xda\x18\x01\u0695\x12\xb3y\x88\u024a\nm\xd9\f\xae$ Q\x14H\x00\x00\xe0\x94>6\xc1rS\xc1\x1c\xf3\x89t\xed\r\xb1\xb7Y\x16\r\xa67\x83\x8a\x01{x\x83\x c0i\x16`\x00\x00\u07d4><\u04fe\xc0e\x91\xd64o%Kb\x1e\xb4\x1c\x89\x00\x8d1\x895\u07fe\u069f 74\x00\x00\u07d4>E\xbdU\u06d0`\xec\xed\x92;\xb9\xcbs<\xb3W?\xb51\x89X\xe7\x92n\xe8X\xa0\ x00\x00\u07d4>M\x13\xc5Z\x84\xe4n\xd7\xe9\u02d0\xfd5^\x8a\u0651\u33c965\u026d\xc5\u07a0\ x00\x00\u07d4>N\x92e\"<\x9782L\xf2\v\xd0`\x06\xd0\a>\u06cc\x89\a?u\u0460\x85\xba\x00\x00\x e0\x94>O\xbdf\x10\x15\xf6F\x1e\xd6s\\\xef\xef\x01\xf3\x14E\xde:\x8a\x03n4)\x98\xb8 \x00\x00\xe0\x94>S\xff!\a\xa8\u07be3(I:\x92\xa5\x86\xa7\xe1\xf4\x97X\x8a\x04\xe6\x9c*q\xa4\x05 \xab\x00\x00\u07d4>Z9\xfd\xdap\xdf\x11&\xab\r\u011asx1\x1aSz\x1f\x89\x82\x1a\xb0\xd4AI\x80\x 00\x00\xe0\x94>Z\xbd\t\xceZ\xf7\xba\x84\x87\xc3Y\xe0\xf2\xa9:\x98k\v\x18\x8a\x02\x1e\x19\xe0\ u027a\xb2@\x00\x00\u07d4>\\\xb8\x92\x8cAx%\xc0:;\xfc\xc5!\x83\xe5\xc9\x1eB\u05c9\xe71\xd9\ xc5,\x96/\x00\x00\u07d4>^\x93\xfbL\x9c\x9d\x12F\xf8\xf2G5\x8e\"\xc3\xc5\xd1{j\x89\b!\xab\rD\x14 \x98\x00\x00\u07d4>a\x83P\xfa\x01ez\xb0\xef>\xba\xc8\xe3p\x12\xf8\xfc+o\x89\x98\x06\xde=\xa6 \xe9x\x00\x00\u07d4>c\xce;\$\xca(e\xb4\u0166\x87\xb7\xae\xa3Y~\xf6\xe5H\x89lk\x93[\x8b\xbd@\ x00\x00\u07d4>f\xb8GiVj\xb6yE\xd5\xfa\x8175V\xbc\u00e1\xfa\x89\b=Iz\xabc`\x00\x00\xe0\x94>v \xa6-

`\xdf\xf1\x96\x00\x00\xe0\x94>\x81w!u#~\xb4\xcb\xe0\xfe-

 $\label{thm:caxfd} $$ \x_01\times d_f(x88_x9a)r(x80)x00\\ \x_00\\ \x_00$

 $11d\xa7\x1d\x04\xdf\xee\xedb!\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4>\x94\x10\u04f9\xa8~\xd5\xe4Q\xa6\xb9\x1b\xb8\x92?\xe9\x0f\xb2\xb5\x89\n\u05ce\xbcZ\xc6$

\x00\x00\u07d4>\x94\xdfS\x13\xfaR\x05p\xef#+\xc31\x1d_b/\xf1\x83\x89lk\x93[\x8b\xbd@\x00\x00\u0794>\x9b4\xa5\u007f3u\xaeY\xc0\xa7^\x19\u0136A\"\x8d\x97\x00\x88\xf8i\x93)g~\x00\x00\u0794>\xad\xa8\xc9/\v\x06~\x1b\xb7<\xe3x\xda\v\xdc,\xdf\xd3e\x89w\xcd\xe9:\xeb\rH\x00\x00\x00\u074>\xaf\by\xb5\xb6\xdb\x15\x9bX\x9f\x84W\x8bjt\xf6\xc1\x03W\x8a\x01\x898\xb6q\xfae\xa2\x80\x00\u07d4>\xaf1k\x87a]\x88\xf7\xad\xc7|X\xe7\x12\xedMw\x96k\x89\x05m\xbcL\xee\$d\x80\x00\u07d4>\xb8\xb3;!\xd2<\u0686\xd8\\x88\x84\xabG\x0e\x16F\x91\xb5\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4>\xb9\xef\x06\xd0\xc2Y\x04\x03\x19\x94~\x8czh\x12\xaa\x02S\u0609\t\r\x97/22<\x00\x00\u07d4>\u030e\x16h\xdd\xe9\x95\xdcW\x0f\xe4\x14\xf4B\x11\xc54\xa6\x15\x89lk\x93[\x8b\xbd\&\w0\x00\x00\u07d4>\u03752\xe3\x97W\x96b\xb2\xa4aA\u73c25\x93j_\x89\x03\x9f\xba\xe8\xd0B\xd\\d\x00\x00\x00\u07d4>\xeeo\x1e\x966\vv\x89\xb3\x06\x9a\xda\xf9\xaf\x8e\xb6\f\u404965\u026d\xc5\u07a0\x00\x00\x00\x00\x00\xe0\x94?\b\u066d\x89O\x81>\x8e!H\xc1`\xd2K5:\x8et\xb0\x8a\f\xb4\x9bD\xba`-

\x820\aN\x1b\xf6\xae\xae\x8a\x01\n\xfc\x1a\xde;N\xd4\x00\x00\u07d4?\x123qO

\x89+\x95\xbd\xcc9\xb6\x10\x00\x00\u07d4?0\u04fc\x9f`\"2\xbcrB\x88\xcaF\xcd\v\a\x88\xf7\x15\x8 9\xd8\xd7&\x17\x80\x00\u07d4?<\x8ea\xe5`L\xef\x06\x05\xd46\xdd\\"\xac\u0346\\"\x17\xf c\x89Hz\x9a0E9D\x00\x00\u07d4??F\xb7\\\xab\xe3{\xfa\u0307`(\x1fCA\xca\u007fF=\x89 \xacD\x825\xfa\xe8\x80\x00\u07d4?G)c\x19x\x83\xbb\xdaZ\x9b}\xfc\xb2-

 $\xb1\x14@\xad1\x89\x1a\x19d<\xb1\xef\xf0\x80\x00\u07d4?L\xd19\x9f\x8a4\xed\u06da\x17\xa4q\xfc\x92+Xp\xaa\xfc\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:convoluo7d4} $$ \x00\x00\u07d4?U\x1b\xa9<\xd5F\x93\xc1\x83\xfb\x9a\xd6\re\xe1`\x96s\u0249lk\x93[\x8b\xbd@\x00\x00\x00\x94?bzv\x9ej\x95\x0e\xb8p\x17\xa7\u035c\xa2\bq\x13h1\x8a\x02\ub3b1\xa1r\u0738\x00\x00\u07d4?m\xd3e\x0e\xe4(\u0737u\x95S\xb0\x17\xa9j\x94(j\u0249Hz\x9a0E9D\x00\x00\u07d4?u\x890\x82\x8ahR\xeb\bg\xf7\x90'\xaf\x89\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4?u\xaea\xcc\x1d\x80Be;[\xae\xc4D>\x05\x1c^z\xbd\x89\x05-$

V\x9c\x9b\x9a\xf9\xaa\x05\xe8>^\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4@s\xfal\xb8q\x17\u02d0\x8c\xf1\xabQ-

\xa7T\xa92\xd4w\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4@\x8ai\xa4\a\x15\xe1\xb3\x13\xe15N`\b\x 00\xa1\xe6\xdc\x02\xa5\x89\x01\u7e11\u0312T\x00\x00\u07d4@\x9b\xd7P\x85\x82\x1c\x1d\xe7\f\ xdc;\x11\xff\xc3\xd9#\xc7@\x10\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4@\x9dZ\x96.\xde\uefa 1x\x01\x8c\x0f8\xb9\u0372\x13\xf2\x89\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4@\xa31\x19[\x 97s%\u00aa(\xfa/B\xcb%\xec<%<\x89lk\x93[\x8b\xbd@\x00\x00\u07d4@\xa7\xf7(g\xa7\u0706w\v \x16+uW\xa44\xedP\xcc\xe9\x8965\u026d\xc5\u07a0\x00\x00\u07d4@\xab\n>\x83\xd0\u022c\x93 f\x91\x05 \xea\xb1w+\xac;\x1a\x894\xf1\f-

\xe1\t\xc6X\x00\x00\u07d4@\u03c9\x05\x91\xea\u484f\x81*)T\xcb)_c3'\xe6\x89\x02\x9b\xf76\xfcY\x1a\x00\x00\u07d4@\u03d0\xef[v\x8c]\xa5\x85\x00,\xcb\xe6avP\xd8\xe87\x8963\x03\"\xd5#\x8c\x00\x00\x00\xe0\x94@\xd4]\x9dv%\xd1QV\xc92\xb7q\xca{\x05'\x13\tX\x8a\x15-

 $\label{temp} $$\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4@\xdb\x1b\xa5\x85\xce4S\x1e\xde\xc5IHI9\x13\x81\xe6\xcc\u04c9a\t=|,m8\x00\x00\x00\x94@\xdfI^\xcf?\x8bL\xef^t|\x18\x99W\x8f\u813c+\x8a\x02\x8a\x85t\% Fo\x80\x00\x00\u07d4@\xe0\xdb\xf3\xef\uf404\xea\x1c\xd7\xe5\x03\xf4\v;\J\x84C\xf6\x89\xd8\xd7 &\x80\x00\x00\u07d4@\xe2D\n\xe1B\u02006j\x12\xc6\xd4\x10\K\x844\xb6^*\x8965\u026 d\xc5\u07a0\x00\x00\u07d4@\xe3\u0083\xf7\xe2M\xe0A\xf2\x1b\xee\xa5\u007f>)\xa6\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94@\xeaPD\xb2\x04\xb20v\xb1\xa5\x80;\xf1\xd3\xf\x0f\x88\x87\x1a\x8a\x02\xf6\xf1\a\x80\xd2\xc0\x00\x00\x00\xe0\x94@\xed\xdbD\x8di\x0e\xd7.\x05\xc2\%\xd3O\xc85\x00\xa1\xe4\u014a\x01\{x\x83\xc0i\x16\x00\x00\xe0\x94@\xf4\xf4\xc0ls,\xd3[\x11\x9b\x89;\x12~\x9\x9]$

 $\label{thm:linear_continuous} $$ \frac{(x_10)x_35(@x_00)x_00(u_07d_4A?K(x_02f)x_9c)x_cf(x_0f)x_80k)x_c8x_fc)x_9 (x_00)x_00(u_07d_4A?K(x_02f)x_90k). $$ 2x_f5(x_00)x_00(u_07d_4AHV)x_12(x_04F)x_65(x_05)x_65 $$ V?(x_1c)x_97(x_894)x_95tD)x_98(x_00)x_00(u_07d_4AHV)x_12(x_04F)x_6(x_05)x_65 $$ V?(x_1c)x_9x_02+(x_1c)x_8c)x_12'(x_00)x_00(x_00)x_00(u_07d_4AH))x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18?<(x_03)x_06)x_93(x_18)x$

 $\label{thm:linear_control_label} $$ \x 3 \x d1 \x 6 \x 90 \x 84 \x 6 \x d2 \x d2 \x d2 \x d2 \x d6 \x 6 \x 90 \x 89 \x 04 \x 65 \x cd \x 00 \x$

\x00\x00\x94A\x9b\xdes\x16\xcc\x1e\u0495\u0205\xac\xe3B\u01db\xf7\xee3\xea\x8a\x01EB\x ba\x12\xa37\xc0\x00\x00\u07d4A\xa2\xf2\xe6\xec\xb8c\x94\xec\x0e3\x8c\x0f\xc9~\x9cU\x83\xde\ u0489|\xee\x06\u077e\x15\xec\x00\x00\u07d4A\xa8\u0083\x00\x81\xb1\x02\xdfn\x011e|\a\xabc[T\ u0389|j\xccg\u05f1\xd4\x00\x00\u07d4A\xa8\xe26\xa3\x0emc\xc1\xffdM\x13*\xa2\\\x89S~\x01\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4A\xa9\xa4\x04\xfc\x9f[\xfe\xe4\x8e\xc2e\xb1\%#3\x8e)\xa8\ xbf\x89\x15\b\x94\xe8|\xb3\x90\x00\x00\u07d4A\xad6\x9fu\x8f\xef8\xa1\x9a\xa3\x14\x93y\x83,\x8 1\x8e\xf2\xa0\x8966\x9e\xd7t]&\x00\x00\u07d4A\xb2\xd3O\xde\v\x10)&+Ar\xc8\x1c\x15\x90@[\x0 3\xae\x8965\u026d\xc5\u07a0\x00\x00\u07d4A\xb2\xdb\u05dd\u069b\x86Ojp0'T\x19\u00dd>\xfd;\ x89\xadx\xeb\u016cb\x00\x00\x00\u07d4A\xc3\xc26u4\xd1;\xa2\xb3?\x18\\\xdb\xe6\xacC\xc2\xfa1 \x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4A\u02d8\x96D_p\xa1\n\x14!R\x96\xda\xf6\x14\xe3,\xf4 \u0549q\x8a\x93

$d4B\x0f\xb8n}+Q@\x1f\xc5\xe8\xc7$

 $\label{thm:linear_control_co$

\x82\x01\x91\x89lk\x93[\x8b\xbd@\x00\x00\u07d4B\x8a\x1e\xe0\xed3\x1dyR\u033e\x1cyt\xb2\x85 +\u0453\x8a\x89w\xb7JN\x8d\xe5e\x00\x00\u0794B\x9c\x06\xb4\x87\xe8Tj\xbd\xfc\x95\x8a%\xa3 \xf0\xfb\xa5?o\x00\x88\xbbdJ\xf5B\x19\x80\x00\xe0\x94B\xa9\x8b\xf1`'\xceX\x9cN\xd2\xc9X1\xe2r B\x05\x06N\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4B\xc6\xed\xc5\x15\xd3UW\x80\x8d\ x13\xcdD\xdc\xc4@\v%\x04\xe4\x89\n\xba\x14\u015b\xa72\x00\x00\u07d4B\xce\xcf\u0492\x10y\x c2\xd7\xdf?\b\xb0z\xa3\xbe\xee^!\x9a\x8965\u026d\xc5\u07a0\x00\u07d4B\u04669\x9b0\x16\ xa8Y\u007f\x8bd\t'\xb8\xaf\xbc\xe4\xb2\x15\x89\xa1\x8b\xce\xc3H\x88\x10\x00\x00\u07d4B\xd3I @\xed\xd2\xe7\x00]F\xe2\x18\x8eL\xfe\u0383\x11\xd7M\x89\b\x90\xb0\xc2\xe1O\xb8\x00\x00\u0 7d4B\u04e5\xa9\x01\xf2\xf6\xbd\x93V\xf1\x12\xa7\x01\x80\xe5\xa1U\v`\x892\$\xf4'#\xd4T\x00\x00\ u07d4B\u05b2c\xd9\xe9\xf4\x11IA\x14\$\xfc\x99Ux<v00\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4B\xdb \v\x90%Y\xe0@\x87\xdd\\D\x1b\xc7a\x194\x18K\x89\x89m3\xb1}%:b\x00\x00\u07d4B\xdd\xd0\x1 4\xdcR\xbf\xbc\xc5U2Z@\xb5\x16\xf4\x86j\x1d\u04c9lk\x93[\x8b\xbd@\x00\x00\u07d4C\x19&?u @,\vS%\xf2c\xbeJP\x80e\x10\x87\xf0\x895K\x0f\x14c\x1b\xab\x00\x00\u07d4C\x1f,\x19\xe3\x16\x b0D\xa4\xb3\xe6\x1a\fo\xf8\xc1\x04\xa1\xa1\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94C\"}e3Ni\x1 c\xf21\xb4\xa4\xe1\xd39\xb9]Y\x8a\xfb\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\xe0\x94C(\t\xa 29\x0f\a\xc6e\x92\x1f\xf3}T}\x12\xf1\u0256j\x8a\x06ZM\xa2]0\x16\xc0\x00\x00\u07d4C)\xfc\t1\xcb\ xeb\x038\x80\xfeL\x93\x98\xcaE\xb0\xe2\xd1\x1a\x89\q qm3h\x00\x00\u07d4C-\x88K\u059d\xb1\xac\xc0\u061cd\xad\xe4\xcbO\u00e8\x8bz\x89\x86\x9a\x8c\x10\x80\x8e\xec\x00

\x00\u07d4C1\xab7G\xd3W

 $\label{thm:column} $$ \x02\xc7\xe1J\xf6\x80\x00\x00\u07d4CI\"Zb\xf7\n\xeaH\n\x02\x99\x15\xa0\x1eSy\xe6O\xa5\x89\x8 c\xd6~\#4\xc0\xd8\x00\x00\u07d4CT\"\x1eb\xdc\t\xe6@d6\x16:\x18^\xf0m\x11J\x81\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94CTC\xb8\x1d\xfd\xb9\xbd\x8cg\x87\xbc\%\x18\xe2\xd4~W\xc1_\x8a\x01C\x8d\x93\x97\x88\x1e\xf2\x00\x00\u07d4Ca\u0504o\xaf\xb3w\xb6\xc0\xeel\xa5\x96\xa7\x8d\xdf5\x16\xa3\x89\xc2\x12z\xf8X\xdap\x00\x00\xe0\x94Cd0\x9a\x9f\xa0p\x95\x0f\xx6Q$

 $9>\x92\x9c\xbd\x92\x84d\xc5h\xaaJ\f\x89K\xe4\xe7\&\{j\xe0\x00\x00\u07d4C\x9d//Q\x10\xa4\u054b\x17W\x93P\x15@\x87@\xfe\xc7\xf8\x89\u03e5\xc5\x15\x0fL\x88\x80\x00\u07d4C\x9d\xee?vy\xff\x100s?\x93@\xc0\x96hkl9\v\x89lk\x93[\x8b\xbd@\x00\x00\u07d4C\xb0y\xba\xf0ry\x99\xe6k\xf7C\u057c\xbfwl;\t\"\x89lk\x93[\x8b\xbd@\x00\x00\u07d4C\xbc-$

 $M\xdc\xd6X;\xe2\u01fc\tK(\xfbr\xe6+\xa8;\x89lk\x93[\x8b\xbd@\x00\x00\u07d4C\xc7\xeb\u0173\xe7\xaf\x16\xf4}\xc5az\xb1\x0e\xof9\xb4\xaf\xbb\x89g\x8a\x93$

b\xe4\x18\x00\x00\u07d4C\u02d6R\x81\x8coMg\x96\xb0\xe8\x94\t0ly\xdbcl\x89lk\x93[\x8b\xbd@\x00\x00\u07d4C\xcc\b\xd0s*\xa5\x8a\xde\xf7a\x9b\xedFU\x8a\xd7wAs\x89\xf0\xe7\u0730\x12*\x8 f\x00\x00\x00\xe0\x94C\u0567\x1c\xe8\xb8\xf8\xae\x02\xb2\xea\xf8\xea\xf2\xca(@\xb9?\xb6\x8a\x01E B\xba\x12\xa37\xc0\x00\x00\u0794C\xdb\u007f\xf9Z\bm(\ubff8\xb8\xfb_#\n^\xbc\u0348\xdfn\xb0\ xb2\xd3\xca\x00\x00\u07d4C\xe7\xec\x84cX\xd7\xd0\xf97\xad\x1c5\v\xa0i\u05ffr\xbf\x89\x06p\xae b\x92\x14h\x00\x00\u07d4C\xf1o\x1eu\xc3\xc0j\x94x\xe8\u0157\xa4\n<\xb0\xbf\x04\u0309\x9d\xf7 \u07e8\xf7`H\x00\x00\u07d4C\xf4p\xede\x9e)\x91\xc3u\x95~]\xde\u017d\x1d8\"1\x89\x05k\xc7\c\x10\x00\x00\u07d4C\xff8t>\xd0\xc5\x1e\u0110m\x14v\u02e9z=\xb5\x84\xe4\x8965\u026d\x c5\u07a0\x00\x00\u07d4C\xff8t>\xd0\xcdC0\x8c\x06e\t\u030e~r\xc8b\xaa\x89i*\xe8\x89p\x81\xd0\ x00\x00\x00\x00\x00\u07d4D\t\x88f\xa6\x9bh\xc0\xb6\xbc\x16\x82)\xb9`5\x87\x05\x89g\x89\n1\x06+\xee e\xedp\x00\x00\u07d4D\x19\xaca\x8d]\xea|\xdc`w

\x00\x00\u07d4D%\rGn\x06\$\x84\xe9\b\n9g\xbf:Js*\xd7?\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07

 $\label{thm:continuous} $$d4D)\times 2\x9f\times e^x19\x84Pg,\f\x1d\a1b\%\v\xecdt\x896^*\x82\x02\xf2P\x00\x00\u07d4D5RS\xb2\wH\xe3\xf3O\xe9\xca\xe1\xfbq\x8c\x8f\x95)\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:colored} $$ \frac{x_00\cdot x_00\cdot x_0$

\x89,s\xc97t,P\x00\x00\u07d4D\u07faP\xb8)\xbe\xcc_O\x14\u0470J\xab3

\xa2\x95\xe5\x8965\u026d\xc5\u07a0\x00\x00\u07d4D\xe2\xfd\xc6\xbe\xe0\x1e\x93\xefJ:\xb 1\xbc\xce\x01*\xbc\x89\x16=\x191\x00\xc5E\x80\x00\xe0\x94D\xf6/*\xaa\xbc)\xad:k\x04\xe1\xffo\x 9c\xe4R\xd1\xc1@\x8a\x03\x99\x92d\x8a#\u0220\x00\x00\u07d4D\xff\xf3{\xe0\x1a8\x88\u04f8\xb 8\u1200\xa7\xdd\xef\xee\xea\u04c9\x0e\f[\xfc]\xae\x9a\x80\x00\u07d4E\x06\xfe\x19\xfaK\x00k\xa a9\x84R\x9d\x85\x16\xdb++P\xab\x89lk\x93[\x8b\xbd@\x00\x00\u07d4E\x1b6\x99G[\xed]\y\x05\xf 8\x90Z\xa3Eo\x1e\u05c8\xfc\x89\x8a\xc7#\x04\x89\xe8\x00\x00\x00\u07d4E\x1bpp%\x9b\u06e2q\x00\xe3n#B\x8aS\xdf\xe3\x04\u9239\x8b\xc8)\xa6\xf9\x00\x00\u07d4E'+\x8fb\xe9\xf9\xfa\x8c\xe0

 $\x00\x00\u07d4E{\xce\xf3}\xd3\xd6\v-$

 $\label{thm:convention} $$ \xd0\x19\xe3\xfea\xd4k?\x1erR\x89\x01\x15\x8eF\tx13\xd0\x00\x00\x00\x00\x94E\x8e<\u025e\x94xD\x31\x8ejB\x91\x8f\xef~\u007f_^\xb3\x8a\a\xb5?y\xe8\x88\xda\xc0\x00\x00\u07d4E\x93\x93\xd6:\x06>\xf3r\x1e\x16\xb4\x9f\xeE\ue77dw\xfb\x89j\xba\u05a3\xc1S\x05\x00\x00\u07d4E\xa5p\xdc\xc2\tf\x86\xa6\xb3\xea)\xa6\bc\xdd\xe4\x1f\x13\xb5\x89\f\x9a\x95\xee)\x86R\x00\x00\u07d4E\xa8\xa0g\x17\xdct\xa0\x81\x12\xbcd?\xd1\x16\w6\u00c9\n\xd6\xc4;(\x15\xed\x80\x00\u07d4E\xb4q\x05\xfeB\xc4q-$

 $\label{thm:condition} $$ \x89l\xb7\xe7Hg\xd5\xe6\x00\x00\xe0\x94F\"O2\xf4\xec\xe5\u0206p\x90\xd4@\x9dU\xe5\v\x18C-\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4F\xc6\x06\x84\&q\xab\u0782\x95\xee]\xd9L\u007fT\x954\xf4\x89\x0f\x89_\x0f\x872\xf4\x00\x00\u07d4F+g\x8bQ\xb5\x84\xf3\xedz\xda\a\v\\u065c\v\xf7\xb8\u007f\x89\x05k\xc7^-$

 $\label{thm:capacity$

\u0708\x89\x8d\x1d\xc8bu\x97\xbd~\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4Fe\xe4s\x96\xc7\u06d7\xeb*\x03\xd9\bc\xd5\u053a1\x9a\x94\x89

xde\x00\x00\u07d4F~\x0e\xd5O;v\xae\x066\x17n\aB\b\x15\xa0!sn\x89lk\x93[\x8b\xbd@\x00\x00\u

07d4F~\xa1\x04E\x82~\xf1\xe5\x02\xda\xf7k\x92\x8a

 $\label{thm:linear} $$ \xbc\xdd\xd0\''\x0f\x8e\u06e7\u040a\x03\xa9\u057a\xa4\xab\xf1\xd0\x00\u07d4F\x97\xba\xaf\x9c\xcb`?\xd3\x040h\x9dCTE\xe9\u024b\xf5\x89\n\xd2\x01\xa6yO\xf8\x00\x00\u07d4F\xa3\v\x8a\x80\x891!tE\xc3\xf5\xa9>\x88,\x03E\xb4&\x89\r\x8d\xb5\xeb\u05f2c\x80\x00\u07d4F\xa40\xa2\u0528\x94\xa0\u062a?\xea\xc6\x156\x14\x15\xc3\xf8\x1f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4F\xaaP\x18pg~\u007f\nPHv\xb4\xe8\x80\x1a\n\xd0\x1cF\x89+^:\xf1k\x18\x80\x00\x00\u07d4F\xbf\u0172\xeb}$

 $\label{thm:cc'v9a} $$ \|v_05\|_x \|_1^2\|v_0\|_x \|_1^2\|v_0\|_$

 $8\x83\x86a\x9cI(\x11\x84\x89Ik\x93[\x8b\xbd@\x00\x00\x94G\xe2]\xf8\x82\%8\x88Yk(\xc67\x89kM\x14<5\x1d\x8a\x11\v\xe9\xeb\xb8\x81P\x00\x00\u07d4G\xf4ik\xd4b\xb2\r\x80\x9f\xb8>\xd2\x03\x98\x18\xd7v\%\xb3\x89\b\x13\xcaV\x90m4\x00\x00\u07d4G\xfe\xf5\x85\x84FRH\x80\x81\r\F>\xe9>Zn\xe8\u04c9\x0fX\xcd>\x12i\x16\x00\x00\u07d4G\xff0\xebC!$

`\xbb\x15\x03\u05e3\x97\xfc\b\xf4\xe7\x03R\x89lk\x93[\x8b\xbd@\x00\x00\u07d4G\xff\xf4,g\x85Q\ xd1A\xebu\xa6\xee9\x81\x17\xdf>J\x8d\x89\x05k\xea\xe5\x1f\xd2\xd1\x00\x00\u07d4H\x01\x0e\xf 3\xb8\xe9^?0\x8f0\xa8\xcb\u007fN\xb4\xbf`\xd9e\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4H\n\xf5 v\x00\x9c\xa77\x81\xb7\x0eC\xb9Y\x16\xa6\"\x03\xab\x892\x19r\xf4\b=\x87\x80\x00\u07d4H\x0f1\ xb9\x891\x1eA\$\u01a7F ZD\tM6\xf9\u04097\x90\xbb\x85Q7d\x00\x00\xe0\x94H\x11\x15)i\xb7\xd 4(\xa0\x11\x9d\x03\xa4\x16\x01A~\x1c\x8965\u026d\xc5\u07a0\x00\u07d4H(\xe4\xcb\xe3N\x 15\x10\xaf\xb7,+\ueb0aE\x13\xea\xeb\u0649\u0556{\xe4\xfc?\x10\x00\x00\xe0\x94H)\x82\xac\x1f\ x1cm\x17!\xfe\xec\u0679\xc9I\xd9I\x80PU\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4H0,1\ cb/r4\xa8\x8d\u019ah\x0eS\x9c\xf0F\x89\x05l\xf1\u02fbt2\x00\x00\u07d4Hc\x84\x979&Zc\xb0\xa 2\xbf#jY\x13\xe6\xf9Y\xce\x15\x89Rf<\u02b1\xe1\xc0\x00\x00\u07d4He\x9d\x8f\x8c\x9a\xd4Oh\u 06a5]#\xa6\b\xfb\xe5\x00\u0709lk\x93[\x8b\xbd@\x00\x00\x00\x94Hf\x9e\xb5\xa8\x01\u0637 \xb6 \xaaX\xc3E\x1bpX\xc2C\xbf\x8a\x06\x8dB\xc18\u06b9\xf0\x00\x00\u07d4Hjl\x85\x83\xa8D\x84\xe 3\xdfC\xa1#\x83\u007f\x8c~#\x17\u0409\x11\x87\xc5q\xab\x80E\x00\x00\u07d4Hz\xdf}p\xa6t\x0f\ x8dQ\xcb\xddh\xbb?\x91\u0125\xceh\x89\x03\x9f\xba\xe8\xd0B\xdd\x00\x00\u07d4H~\x10\x85\x0 2\xb0\xb1\x89\uf70cm\xa4\xd0\xdbba\xee\xc6\xc0\x89g\x8a\x93

\x89\x02b\x9ff\xe0\xc50\x00\x00\u07d4H\xbf\x14\u05f1\xfc\x84\xeb\xf3\xc9k\xe1/{\xce\x01\xaai\xb 0>\x89\x06\x81U\xa46v\xe0\x00\x00\u07d4H\xc2\ue465\aV\xd8\u039a\xbe\xebu\x89\xd2,o\xee]\xf b\x89\xae\x8ez\v\xb5u\xd0\x00\x00\u07d4H\xc5\u0197\v\x91a\xbb\x1c{z\xdf\xed\x9c\xde\u078a\x 1b\xa8d\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\xe0\x94H\xd2CKz}\xbb\xff\b\";c\x87\xb0]\xa2\xe5\t1& \x8a\x03\xcf\xc8.7\xe9\xa7@\x00\x00\u07d4H\xd4\xf2F\x8f\x96?\u05da\x00a\x98\xbbg\x89]-\trs\u007f\x89\x05k\xe0<\xa3\xe4}\x80\x00\u07d4H\xf6\n5HO\xe7y+\u030a{c\x93\xd0\u0761\xf6\x b7\x17\x89\xc3(\t>a\xee@\x00\x00\u07d4H\xf8\x83\xe5g\xb46\xa2{\xb5\xa3\x12M\xbc\x84\xde\xc 7u\xa8\x00\x89\\xd7n\x86\x9d\u0340\x00\x00\xe0\x94I\x01E\xaf\xa8\xb5E\"\xbb!\xf3R\xf0m\xa5\x a7\x88\xfa\x8f\x1d\x8a\x01\xf4lb\x90\x1a\x03\xfb\x00\u07d4l\t\xb3\x19\x98\xea\xd4\x14\xb8\xf b\x0e\x84k\xd5\xcb\xde995\xbe\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4I\x12\xd9\x02\x93\x16v \xff9\xfc4\xfe<<\xc8\xfb!\x82\xfaz\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4I\x13o\xe6\xe2\x8btS\ xfc\xb1kk\xbb\u9aac\xba\x837\xfd\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94l\x15a\u06cbo\xaf\xb9\x0 0~b\xd0P\u0082\xe9,Kk\u020a\x06ZM\xa2]0\x16\xc0\x00\x00\u07d4I\x18]\xd7\xc262\xf4Iu\x94s\u bb96`\b\xcd5\x98\x89\r\xc5_\xdb\x17d{\x00\x00\u07d4I,\xb5\xf8a\xb1\x87\xf9\xdf!\xcdD\x85\xbe\x d9\vP\xff\xe2-\x89\x1b\x19\xe5\vD\x97|\x00\x00\u07d4I-

\xe4j\xaf\x8f\x1dp\x8dY\u05da\xf1\xd0:\xd2\xcb`\x90/\x89lk\x93[\x8b\xbd@\x00\x00\u07d4I.p\xf0M \x18@\x8c\xb4\x1e%`70Pk5\xa2\x87k\x89\x02\"\xc8\xeb?\xf6d\x00\x00\u07d4I:g\xfe#\xde\xcc\xb $1\r\dau\xf3(v\x95\xa8\x1b\u056b\x89\xb4t\t\x8fq\xc0\x00\x00\u07d4l=H\xbd\xa0\x15\xa9\xbf\xcf\$ x16\x03\x93n\xabh\x02L\xe5Q\xe0\x89\x018\xa3\x88\xa4<\x00\x00\x00\xe0\x94IBV\xe9\x9b\x0f\x 9c\xd6\xe5\xeb\xca8\x99\x862R\x90\x01e\u020a\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d4IM\xec M^\xe8\x8a'q\xa8\x15\xf1\xeerd\x94\\xb5\x8b(\x89lk\x93[\x8b\xbd@\x00\x00\u07d4l[d\x1b\x1c\u07 a3b\u00f4\u02fd\x0f\\\xc5\v\x1e\x17k\x9c\x8965\u026d\xc5\u07a0\x00\x00\x00\x94Ih\xa2\xce\xdb $EuU\xa19)Z\xea(wnT\x00<\x87\x8a\x02\#\x1a\xef\u0266b\x8f\x00\x00\u07d4Im6U4S\n\ \xc1W\nR$ A\u02c8\xc4\xdapr\x89a\t=|,m8\x00\x00\xe0\x94In1\x95\x92\xb3A\xea\xcc\xd7x\u0767\xc8\x19mT \xca\xc7u\x8a\x01\xf5q\x89\x87fKH\x00\x00\u07d4IoXC\xf6\xd2L\u064d%^L#\xd1\xe1\xf0#\"uE\x8 9 \x17\x9f\u0526\xee\t\x80\x00\xe0\x94Ip\u04ec\xf7+[\x1f2\xa7\x00<\xf1\x02\xc6N\xe0TyA\x8a\x1 d\xa5jK\b5\xbf\x80\x00\x00\u07d4Iw\xa7\x93\x9d\t9h\x94U\xce&9\xd0\xeeZL\xd9\x10\xed\x89b\xa 9\x92\xe5:\n\xf0\x00\x00\u07d4Iy\x19N\xc9\xe9}\xb9\xbe\xe84;|w\xd9\xd7\xf3\xf1\u071f\x89\x01\x 15\x8eF\t\x13\xd0\x00\x00\u07d4Iy4c\xe1h\x10\x83\u05ab\xd6\xe7%\u057b\xa7E\xdc\xcd\xe8\x8 9\x1d\x98\xe9LNG\x1f\x00\x00\u07d4I\x81\xc5\xfff\xccN\x96\x80%\x1f\xc4\xcd/\xf9\a\xcb2xe\x89(\ xa8WBTf\xf8\x00\x00\u07d4I\x89\u007f\xe92\xbb\xb3\x15L\x95\u04fc\xe6\xd9;ms)\x04\u0749\xd8 \xd7&\xb7\x17z\x80\x00\u07d4I\x89\xe1\xab^|\xd0\aF\xb3\x93\x8e\xf0\xf0\xd0d\xa2\x02[\xa5\ x89lk\x93[\x8b\xbd@\x00\x00\u07d4l\x8a\xbd\xeb\x14\xc2k{r4\xd7\x0f\u03ae\xf3a\xa7m\xffr\x89\x a2\xa1]\tQ\x9b\xe0\x00\x00\u07d4I\xa6E\xe0f}\xfd{2\xd0u\xcc\$g\u074ch\t\a\u0109\a\x06\x01\x95\ x8f\u02dc\x00\x00\xe0\x94I\xb7N\x16\x92e\xf0\x1a\x89\xecL\x90r\u0164\xcdr\xe4\xe85\x8a\x03h\ xc8b:\x8bM\x10\x00\x00\u07d4I\xbd\xbc{\xa5\xab\xeb\xb68\x9e\x91\xa3(R

\v\xa4o\bg\x98\x9a\x89\x0e\x87?D\x13<\xb0\x00\x00\u07d4I\xd2\u008e\xe9\xbcT^\xaa\xf7\xfd\x14 \xc2\\@s\xb4\xbb_\x1a\x89O\xe9\xb8\x06\xb4\r\xaf\x00\x00\u07d4I\xdd\xee\x90.\x1d\f\x99\u0471\x1a\xf3\u030a\x96\xf7\x8eM\xcf\x1a\x89\n\u03a5\xe4\xc1\x8cS\x00\x00\u07d4I\xf0(9\Z\x86\xc9\xe0\u007fwxc\x0eL.=7:\w\x89\x06\xa7JP8\u06d1\x80\x00\xe0\x94J\x19

 $5\xe2a\x9b\xb0p\x9d\Y\x0e\x91\x83\xcc\xf2\xc1\u064a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u007d4J@S\xb3\x1d\x0e\xe5\u06ef\xb1\xd0k\u05ec\u007f\xf3\",G\u0589K\xe4\xe7\&{j\xe0\x00\x00\u007d4JC\x01p\x15-}$

\xe5\x17&3\u0742b\xd1\a\xa0\xaf\xd9j\x0f\x89\xabM\xcf9\x9a:`\x00\x00\u07d4JG\xfc>\x17\u007fV\ z\x1e8\x93\xe0\x00\x00\xe3k\xba#R\n\xb8\x89lk\x93[\x8b\xbd@\x00\x00\u07d4JR\xba\xd2\x03W\"\x8f\ \xaa\x1e\x99k\xedy\f\x93gK\xa7\u0409Hz\x9a0E9D\x00\x00\u07d4JS\xdc\xdbV\xceL\xdc\xe9\xf8.\ \xc0\xeb\x13\xd6sR\xe7\u020b\x89\u3bb5sr@\xa0\x00\x00\u07d4J_\xae;\x03r\xc20\xc1%\xd6\xd4 p\x14\x037\xab\x91VV\x89V\xbcu\xe2\xd61\x00\x00\x00\u07d4Jq\x90a\xf5(T\x95\xb3{\x9d~\xf8\x a5\x1b\a\xd6\u6b2c\x89\n\xd4\xc81j\v\f\x00\x00\u07d4Js]\"G\x927m3\x13g\xc0\x93\xd3\x1c\x87\x 944\x15\x82\x89f\xff\xcb\xfd^Z0\x00\x00\u07d4Ju\xc3\xd4\xfao\u033d]\u0567\x03\xc1Sy\xa1\xe7\x83\u 9dc9b\xa9\x92\xe5:\n\xf0\x00\x00\x00\x00\x00\x00\x00\x00\x94J\x81\xab\xe4\x98L|k\xefc\u0598\xe5WC\xc6\x1f

 $\label{thm:condition} $$ \86\xe5\xaa+4\xe09\x89\|k\x93[\x8b\xbd@\x00\x00\u07d4J\u016c\xad\x00\v\x88w]L\xb1\xae\x00\xea\u0263\}Y\xa0\xfd\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4J\u0250ZL\xb6\xab\x1c\xfdbTn\xe5\x91s\x00\xb8|O\u07897\b\xba\xed=h\x90\x00\x00\u07d4J\u03e9\xd9N\xdaf\%\xc9\u07e5\xf9\xf4\xf5\xd1\a\xc4\x03\x1f\u07c9\x02\"\xc8\xeb?\xf6d\x00\x00\u07d4J\xd0G\xfa\xe6~\xf1b\xfeh\xfe\xdb\xc2\;e\xca\xf1\f6\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4J\xd9]\x18\x8dddp\x9a\xdd\%U\xfbM\x97\xfe\x1e\xbf1\x1f\x89\x12\xc1\xb6\xee\xd0=(\x00\x00\u07d4J\xdb\xf4\xaa\xe0\xe3\xefD\xf7\xddM\x89\x85\u03ef\tn\u010e\x98\x89\b!\xab\rD\x14\x98\x00\x00\u07d4J\xe2\xa0M9\t\xefENTL\xcf\xd6\x14\xbf\xef\xa7\x10\x89\xae\x89\x18\x01\x15\x9d\xf1\xee\xf8\x00\x00\x00\xe0\x94J\xe90\x82\xe4Q\x87\xc2a\xe6g\x92\xf5\u007f\xad5Q\xc7:\x8a\x04\x96\x15$

\xda\xff\x82(\x00\x00\u07d4J\xf0\xdb\a{\xb9\xba^D>!\xe1H\xe5\x9f7\x91\x05\u0152\x89 \x86\xac5\x10R`\x00\x00\u07d4K\x06\x19\xd9\u062a1:\x951\xac}\xbe\x04\xca\rjZ\u0476\x89lk\x93

[\x8b\xbd@\x00\x00\u07d4K\v\u062c\xfc\xbcS\xa6\x01\v@\xd4\u040d\xdd-\x9dib-

 $\label{thm:linear} $$ \X89\=M\x18\"\x9c\x32\x00\x00\u07d4K\x19\xeb\f5K\xc199\\xeb\x06\x06;\x83\x92o\rg\xb2\x89\x01\x92t\xb2Y\xf6T\x00\x00\u07d4K)C\x97\xb4\xa8D\xbeq\u0323\xb6H\xd4\xca\x0f\u075b\xa4\x89\b $$ \qx984\u03ec\x00\x00\u07d4K1\xbfA\xab\xc7\\x9a\xe2\u034f\u007f5\x16;n+tPT\x89\x14\xb5P\xa0\x13\xc78\x00\x00\u07d4K:\u00e7\u05f0\x0e\xd5(\"!\xa6\x02Y\xf2[\xf6S\x8a\x8965\u026d\xc5\u07a0\x00\x00\x00\x00\x94K:\xab3^\xbb\xfa\xa8p\xccM^\$.t\xc6h6\x9f\x8a\f\xb4\x9bD\xba^--$

\xa4\xc0\x00\x00\u07d4KX\x10\x1fD\xf7\xe3\x89\xe1-

 $G\x1d\x165\xb7\x16\x14\xfd\xd6\x05\x89\b\xacr0H\x9e\x80\x00\x00\u07d4K\\xdb\x1eB\x8c\x91\xd|\xb5Jj\xedEq\xda\x05K\xfeR\x89\x04\xc5>\xcd\xc1\x8a\\x00\x00\u07d4K\\xa3\xe2S\xbf8\xc8\xd5f$

 $\label{thm:convention} $$ \x010\x03\x04\x02\x04\x010\x00\x00\u07d4Kt\xf5\xe5\x8e.\xdfv\xda\xf7 $$ \x010\x96J\v\x8f\x1d\xe0f<\x89\x11\x90\xaeID\xba\x12\x00\x00\u07d4Kv!f\xdd\x11\x18\xe8Ci\xf8\x04\xc7_\x9c\xd6W\xbfs\f\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4Ky.)h>\xb5\x86\u353b3RI\x01\xb3\x97\x99\x9e\x89 \x86\xac5\x10R\x00\x00\u07d4K\x90N\x93K\xd0\u030b$

 $p_x87\\x9e\\x90[\\x93\\xea\\f\\xc0\\x89\\k\\x93[\\x8b\\xbd@\\x00\\x00\\xe0\\x94\\K\\x92\\x06\\xba\\x1a\\u007f\\x96\\x9e\\x1d]\\xba\\x86u9\\xd1\\xfag\\x8a\\x01\\xab,\\xf7\\xc9\\xf8\sim$

 $00\u07d4K\xa0\xd9\xe8\x96\x01w+IhG\xa2\xbbC@\x18g\x87\xd2e\x8965\u026d\xc5\u07a0\x00\x00\x00\u07d4K\xa5:\xb5I\xe2\x01m\xfa\"<\x9e\u0563\x8f\xad\x91(\x8d\a\x89K\xe4\xe7\&\{j\xe0\x00\x00\x00\xe0\x94K\xa8\xe0\x11\u007f\xc0\xb6\xa3\xe5k\xa3\xa5\x8f\xe6\xce\xf4B\xff\x98\x8a\x011\xbe\xb9\%\xff\xd3$

\x00\x00\u07d4K\xac\x84j\xf4\x16\x9f\x1d\x95C\x1b4\x1d\x88\x00\xb2!\x80\xaf\x1a\x89\x01\x15\x 8eF\t\x13\xd0\x00\x00\u07d4K\xb6\xd8k\x83\x14\xc2-\x8d7\xeaQm\x00\x19\xf1V\xaa\xe1-\x8965\u026d\xc5\u07a0\x00\x00\x00\xe0\x94K\xb9e\\\xfb*6\xea|cz{\x85\x9bJ1T\xe2n\xbe\x8a\x03c\\\x9a\xdc]\xea\x00\x00\x00\x00\xe0\x94K\xbc\xbf8\xb3\xc9\x01c\xa8K\x1c\u04a9;X\xb2\xa34\x8d\x87\x 8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\xe0\x94K\xd6\xdd\f\xff#@\x0e\x170\xba{\x89E\x04W}\x14\xe7 J\x8a+\xa0\xcc\xdd\xd0\xdfs\xb0\x00\x00\x00\u07d4K\xe8b\x8a\x81T\x87N\x04\x8d\x80\xc1B\x18\x10 \"\xb1\x80\xbc\xc1\x89\x03@\xaa\xd2\x1b;p\x00\x00\u07d4K\xe9\rA!)\u0564\xd0BCa\xd6d\x9dNG \xa6#\x16\x897\b\xba\xed=h\x90\x00\x00\x00\x00\xe0\x94K\xea(\x8e\xeaB\u0115^\xb9\xfa\xad*\x9f\xafG\x

 $xa1\xbfT\x00\x1e^{x89\u0556}\xe4\xfc?\x10\x00\x00\u07d4K\xf8\xbf\x1d5\xa211Wd\xfc\x80\x01\xe4}$

83\xcb\u076c\x8a\x06\x18\xbe\x16c\u012fI\x00\x00\u07d4K\xf4G\x97\x99\xef\x82\xee\xa2\tC7OV\

80\x9a\x94\x92\x94\xfcl\x89\x03\x9f\xba\xe8\xd0B\xdd\x00\x00\u07d4K\xf8\xe2oL'\x90\xdae3\xa2\xac\x9a\xba\xc3\u019a\x19\x943\x89\n\u05ce\xbcZ\xc6

u07d4L\x99\xda\xe9d\x81\xe8\a\xc1\xf9\x9f\x8b\u007f\xbd\xe2\x9buG\u017f\x89\b!\xab\rD\x14\x9 8\x00\x00\u07d4L\x9a\x86*\xd1\x15\xd6\xc8'N\u0439D\xbd\u05a5P\x05\x10\xa7\x89\x05k\xc7^-c\x10\x00\x00\x00\xe0\x94L\xa7\x83\xb5V\xe5\xbfS\xaa\x13\xc8\x11f\x13\xd6W\x82\u0276B\x8a\x05V\x18@\xb4\xad\x83\xc0\x00\x00\u07d4L\xa7\xb7\x17\u067c\x87\x93\xb0N\x05\x1a\x8d#\xe1d\x0f[\xa5\xe3\x89C\xb5\x14T\x9e\xcfb\x00\x00\u07d4L\xa8\xdbJ^\xfe\xfc\x80\xf4\u035b\xbc\u03302e\x93\x132\xb6\x89\n\u05ce\xbcZ\xc6

 $c\x10\x00\x00\u0794M)\xfcR:,\x16)S!!\u0699\x98\u9d6b\x9d\x1bE\x88\xdbD\xe0l\xbb,\x00\x00\u07d4M8\xd9\x0f\x83\xf4Q\(\x03\xccx2j\x15M5\x8b\u0602\xb7\x89\n\ad\a\xd3\xf7D\x00\x00\u07d4M L\xf5\x80t)a^0\xcd\xfa\xce\x1eZ\xaeM\xad0U\xe6\x89$

\x86\xac5\x10R`\x00\x00\u07d4MW\xe7\x16\x87\|f\x95\xef^\xae\xbd5\xc8\xf4\x1b\x06\x9bk\xfe\x8 9\lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94Mg\U000ab159\xfe\xf5\xfcA9\x99\xaa\x01\xfd\u007f\xcep\xb4= \x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4Mn\x8f\xe1\t\xcc\xd2\x15\x8eM\xb1\x14\x13/xe 7_\xec\u023e[\x89\x01[5W\xf1\x93\u007f\x80\x00\xe0\x94Mq\xa6\xeb=\u007f2~\x184\x8e(\v\x03\x9e\xdd\xd3\x1c/\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4M|\xfa\xa8L\xb31\x06\x80\n\x8c\x80 \xxb8\xaaF8\x96\u0159\x89a\t=|,m8\x00\x00\u07d4M\x80\x10\x93\xc1\x9c\xa9\xb8\xf3B\xe3<\xc9\xc7{\xbdL\x83\x12\u03c9\x12\xb3\xe7\xfb\x95\u0364\x80\x00\u07d4M\x82\xd7p\f\x12;\xb9\x19A\x9b\xba\x f0Fy\x9ck\x0e,f\x8a\x04<3\xc1\x93ud\x80\x00\u07d4M\x83m\x9d;\x0e,\xbdM\xe0PYo\xaal\f\xf\x6\r]\x89\x10CV\x1a\x88)0\x00\x00\u07d4M\x86\x97\xaf\x0f\xbf,\xa3n\x87h\xf4\xaf\\"\x135phZ`\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4M\x92y\x96

)\xa8\xbdEc\x977\xe9\x8bQ\x1e\xff\aL!\x89Hz\x9a0E9D\x00\x00\u07d4M\x93io\xa2HY\xf5\u0493\x9a\xeb\xfaT\xb4\xb5\x1a\xe1\xdc\u0309\x01\t\x10\xd4\xcd\xc9\xf6\x00\x00\u07d4M\x9cw\xd0u\f^o\xbc\$\u007f/\u05d2thl\xb3S\u0589\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4M\xa5\xed\u0188\xb0\xcbb\xe1@=\x17\x00\xd9\u0739\x9f\xfe?\u04c9lk\x93[\x8b\xbd@\x00\x00\x00\x00\xe0\x94M\xa8\x03\ai\x84 K\xc3A\x86\xb8\\\xd4\xc74\x88l\xffl\xe9\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4M\xb1\xc4:\x0f\x83M}\x04x\xb8\x96\ag\xec\x1a\xc4L\x9a\xeb\x89/Q\x810V'7\x00\x00\u07d4M\xb2\x12\x8 4\xbc\xd4\xf7\x87\xa7Ue\x00\xd6\xd7\xd8\xf3f#\xcf5\x89i(7Ow\xa3c\x00\x00\u07d4M\xc3\xda\x13\xb2\xb4\xaf\xd4O]\r1\x89\xf4D\xd4\xdd\xf9\x1b\x1b\x89lk\x93[\x8b\xbd@\x00\x00\u07d4M\xc9\u057b

K\x19\xce\u0354\xf1\x9e\xc2]

\x0e\xa7\%\xd7\xed\x89|k\x93[\x8b\xbd@\x00\x00\x00\x94M\xcd\x11\x81X\x18\xae)\xb8]\x016sl\x a8\xa7\xfb\x12\xd0k\x8a\x01\xacB\x86\x10\x01\x91\xf0\x00\x00\u07d4M\xcfb\xa3\xde?\x06\x1d\xb 9\x14\x98\xfda\x06\x0f\x1fc\x98\xffs\x89|j\xccg\u05f1\xd4\x00\x00\u07d4M\xd11\xc7J\x06\x8a7\xc 9\n\xde\xd4\xf3\t\xc2@\x9fdx\u04c9\x15\xaf9\u4ab2t\x00\x00\x00\u07d4M\u0767Xk\"7\xb0S\xa7\xf3(\x9c\xf4`\xdcW\xd3z\t\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4M\xe3\xfe4\xa6\xfb\xf64\x c0Q\x99\u007fG\xcc\u007fHy\x1fX\$\x89|]\xb2\xa4\xd8\x15\xdc\x00\x00\u07d4M\xf1@\xbaye\x85\xddT\x891[\xcaK\xbah\n\u06f8\x18\x89\x90\xf54`\x8ar\x88\x00\x00\u07d4N\x02\ay\xb5\xdd\xd3\xd f\"\x8a\x00\xcbH\xc2\xfc\x97\x9d\xa6\xae8\x89|k\x93[\x8b\xbd@\x00\x00\u07d4N\\\xd3\$\s\xc4\xc5\x1b\xf2VT\xde\xf6\x9fy|k)\xa22\x89V\xc9]\xe8\xe8\xca\x1d\x00\x00\u07d4N\\\"%\xa1\xbbY\xbc\x88\xa21ft\xd33\xb9\xb0\xaf\xcafU\x89\bg\x0e\x9e\xc6Y\x8c\x00\x00\u07d4N\\\\x10\x19\x1e\xad\x8d;\x c6H\x98\xa5\xf0\xc2\xeck\x87\u1f8965\u026d\xc5\u07a0\x00\x00\u07d4N\\\\-

 $S\xb3\u6f8f\x89Sa\xd3\x1c4\xd4v+\x12\xc8.\x89_h\xe8\x13\x1e\u03c0\x00\x00\u07d4N+\xfaJFo\x82g\x1b\x80\x0e\xeeBj\xd0\fa\x1b\xa1p\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4N>\xda\u0506\\M\xabd\xca\xe4\xc5Azvw@S\xdcd2\x89$

\xdatw\xfaNG\xd6H\x89\n\u05ce\xbcZ\xc6

\xab(\xdd\u07ca\x04<0\xfb\b\x84\xa9I\x00\x00\u07d4N\xb1EKW8\x05\u022c\xa3~\xde\xc7\x14\x9 aA\xf6\x12\x02\xf4\x89\x10CV\x1a\x88)0\x00\x00\u07d4N\xb8{\xa8x\x8e\xba\r\xf8~[\x9b\xd5\n\x8 eE6\x80\x91\xc1\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4N\xbcV)\xf9\xa6\xa6k,\xf36:\u0109\\\x 03H\u8fc7\x8967\tlK\xcci\x00\x00\u07d4N\xc7h)^\xea\xba\xfcB\x95\x84\x15\xe2+\xe2\x16\xcd\xe7 v\x18\x89\x03;\x1d\xbc9\xc5H\x00\x00\u07d4N\xcc\x19\x94\x8d\xd9\u0347\xb4\xc7

\x1a\xb4\x8eu\x8f(\xe7\xccv\x89\x1b\x1d\xaba\u04ead\x00\x00\u07d4N\xd1M\x81\xb6\v#\xfb%\x05M\x89%\u07e5s\u072eah\x89\x12nr\xa6\x9aP\xd0\x00\x00\xe0\x94N\xe1<\rA

 $\label{thm:colored} $$ \F\u045d\xee\K\xce\xc7\x1d\x82\xbb\x8e8\x8a\x01\xab\xee\x13\u033e\ufbc0\x00\u07d4N\xea\xd4\n\xad\x8cs\xef\b\xfc\x84\xbc\n\x92\xc9\t/j6\xbf\x89\x01s\x17\x90SM\xf2\x00\x00\u07d4N\xeb\xe8\x89\xo0\xo0\xo0\u07d4N\xeb\xe9\xo0\xo0\xo0\u07f\x90q\x89\xfc\xab\x89\j\xccg\u05f1\xd4\x00\x00\u07d4N\xeb\xf1$$

]\f\xc2\f\xeel\u007f\x8f\xf3\x11_V\u050f\xba&\x89\x01\r:\xa56\xe2\x94\x00\x00\u07d4N\xf1\xc2\x14 c:\xd9\xc0p;\N#t\xa2\xe3>>B\x92\x91\x89Hz\x9a0E9D\x00\x00\u07d4N\xfc\xd9\u01df\xb43L\xa6\${

\n3\xbd\x9c\xc32\b\xe2r\x89Hz\x9a0E9D\x00\x00\xe0\x94O\x06\$k\x8dK\u0496a\xf4>\x93v\"\x01\u 0486\x93Z\xb1\x8a\x01\x059O\xfcF6\x11\x00\x00\u07d4O\x15+/\xb8e\x9dCwn\xbb\x1e\x81g:\xa8 Ai\xbe\x96\x89lk\x93[\x8b\xbd@\x00\x00\u07d4O\x17\u007f\x9dV\x95=\xedq\xa5a\x1f93\"\xc3\x02 y\x89\\\x89\rU\uf422\xda\x18\x00\x00\u07d4O\x1a-

\xa5JLm\xa1\x9d\x14\\x12\xe5n\x81WA\xdb#%\x89\x05k\xc7^-

\x00\x00\u07d4O:HT\x91\x11E\xea\x01\xc6D\x04K\xdb.Z\x96\n\x98\x89\xd8\xd7&\xb7\x17z\x80\x 00\x00\u07d4O?,g0i\xac\x97\xc2\x026\a\x15)\x81\xf5\xcd`c\xa0\x89

 $p\tx8966;] \x9awp\x00\x00\u07d4O\xc4l9ngHi\xad\x94\x81c\x8f\x00\x13c\f\x87\u02ac\x8965\u026d\xc5\u07a0\x00\x00\x94O\xcc\x19\xea\x9fLW\u073c\xe8\x93\x19<\xfb\x16j\xa9\x14\xed\u014\x01{\x8b\xaa\u007f\x19Tj\x00\x00\x00\x94O\u0384}\xbal\u02a06\x9d\x1eIM\xb5~\x89\uacad9\x8a*Z\x05\x8f\u0095\xed\x00\x00\x00\u07d4O\xda\xc1\xaaQp\a\xe0\b\x940\xb31j\x1b\xad\xd1,\x01\x01c9\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4O\xe5j\xb3\xba\u1c24D3E\x833\u0130Z\x8f\x82\x89v-\x93\xd1\xddo\x90\x00\x00\u07d4O\xeb\x84k\xe40A\xfdk4$

 $\label{thm:condition} $$ (x97\x94>?!\xcb\u007f\x04\x89\x04\x82\xfe&f\xbc\xa9\x00\u07d4O\xeeP\xc5\xf9\x88 k\t\xa5sF\x9f\xb1\u0434.\xbbm\u0389I\xee\x06\u077e\x15\xec\x00\x00\u07d4O\xf6v\xe2\u007fh\x13\x98-$

 $\label{thm:linear_control_label} $$ \x8f\xd9\xd2\x0ed\x8b=\xee\x05\xe9E\x89\x97\xc9\xceL\xf6\xd5\xc0\x00\x00\u07d4O\xf6\u007f\xb8\u007fn\xfb\xa9'\x990\u03fd\x1bz4<y\xfa\u0789\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4P\x06\xfeL\''\x179\x80\xf0\ft4+9\xcd\#\x1ce1)\x89lk\x93[\x8b\xbd@\x00\x00\u07d4P\fx165.\x90\x1dH\xba\x8]$

 $c\x10\x00\x00\u07d4P7\x8a\xf7\xefT\x04?\x89*\xb7\u0397\xd6Gy5\x11\xb1\b\x89\x01\x11du\x9f\xefb2\x00\x00\u07d4P;\xdb\u063cB\x1c2\xa4C\x03-$

\xeb.>L\u057a\x8bN\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94PFf\u03891\x17^\x11\xa5\xed\x11\xc1\\u072a\x06\xe5\u007fNf\x8a\x02\u007f>\u07f3Nn@\x00\x00\u0794PXM\x92\x06\xa4l\xe1\\0\x11\x\17\xee(\xf1\\0\xe6\x0eu\x88\xb9\xf6]\x00\xf6<\x00\x00\x00\u0794PXM\x92\x06\xa4l\xe1\\0\x11\x\17\xee(\xf1\\0\xe6\x0eu\x88\xb9\xf6]\x00\xf6<\x00\x00\x00\xe0\x94PZ3\xa1\x864\xddH\x00i<g\xf4\x8a\x1di=H3\xf8\x8a\x01\x89!\xb7\x99A\xdc\xd0\x00\x00\u0794P^O|'U\x88\xc53\xa2\x0e\xbd*\xc1;@\x9b\xbd\xea<\x88\xf4?\xc2\xc0N\xe0\x00\x00\u07d4Pb\xe5\x13La\x12iM\xbd\x0e\x13\x1dL\xe1\x\97\u0476\xa4\x8965\u026d\xc5\u07a0\x00\x00\u07d4Pd\x11\xfdy\x004\x80\xf6\xf2\xb6\xaa\xc2k\\xa7\x92\U00014c89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4Pg\xf4T\x9a\xfb\xfe\x88LY\xcb\xc1+\x96\x93l#\xd4]\xb0\x8965\u026d\xc5\u07a0\x00\x00\u07d4P\x8c\xf1\x91\x19\xdbp\xaa\x86EBS\xdavJ,\xb1\xb2\xbe\x1a\x8965\u026d\xc5\u07a0\x00\x00\x00\x00\x94P\x99\x82\xf5b7\xeeE\x89Q\x04~\n\"0\xf8\x\04\xe2\u854a\x03\xb4\xadla\x06\xb7\xf0\x00\x00\u07d4P\x9a

\xbcH\xe7+\xe1\u036f\x95i\xc7\x11\xe8d\x8d\x95s4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4P\x9c\x8 6h\x03m\x14?\xb8\xaep\xb1\x19\x95c\x1f=\xfc\xad\x87\x8965\u026d\xc5\u07a0\x00\x00\u07d4P\x ad\x18z\xb2\x11g\u00b6\xe7\x8b\xe0\x15?DPJ\a\x94^\x89\x05l\xd5_\xc6M\xfe\x00\x00\u07d4P\x b9\xfe\xf0\xa12\x9b\x02\xd1e\x06% Z-\xb7\x1e\xc9-

 $\label{thm:convenient} $$ \frac{\lambda 16}{\lambda 00} \n 00^{d4} \n$

%\xd70\x8a\x02g\u04ebd#\xf5\x80\x00\x00\u07d4Q\x1e\x0e\xfb\x04\xacN?\xf2\xe6U\x0el\x82\x95

 $\label{thm:convolu07d4QiT} $$ \and $$

 $\label{thm:linear} $$ \x86\xac5\x10R^\x00\x00\u07d4Q\xa6\xd6'\xf6j\x89\#\u060d^\x94\xc4qS\x80\xd3\x05|\xb6\x89>s\xd225\x94\x1e\x00\x00\u07d4Q\xa8\xc2\x166\x02\xa3.\xe2L\xf4\xaa\x97\xfd\x9e\xa4\x14QiA\x89\x03h\xf7\xe6\xb8g,\x00\x00\u07d4Q\xb4u\x8e\x9e\x14P\xe7\xafBh\xc3\u01f1\xe7\xbdo\uP\x8965\u026d\xc5\u07a0\x00\x00\u07d4Q\u028b\xd4\xdcdO\xacG\xafgUc\u0540J\r\xa2\x1e\xeb\x89*\xb7\xb2\xb2\xff?\xd0\x00\x00\u07d4Q\xd2K\xc3so\x88\xddc\xb7\"$

 $\& x88f0 \times b6 \setminus x93[\times 8b \times 2 (x00 \times 00 \times 00 \times 00 \times 07) \\ & x88f0 \times b6 \setminus x93[\times 8b \times 2 (x00 \times 00 \times 07) \\ & x88f0 \times b6 \times 17 \times 8dp - 9n \times 87 \times 10 \times 96 \setminus OA \times b1 \\ & x88f0 \times b6 \times 17 \times 8dp - 9n \times 87 \times 10 \times 96 \setminus OA \times b1 \\ & x89f0 \times b1 \times 10 \times 10 \times 10 \times 10 \\ & x89f0 \times b1 \times 10 \times 10 \times 10 \times 10 \\ & x89f0 \times b1 \times 10 \times 10 \times 10 \times 10 \\ & x89f0 \times b1 \times 10 \times 10 \times 10 \times 10 \\ & x89f0 \times b1 \times b1 \times b1 \times b1 \times b1 \\ & x89f0 \times b1 \times b1 \times b1 \times b1 \times b1 \\ & x89f0 \times b1 \times b1 \times b1 \times b1 \times b1 \\ & x89f0 \times b1 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \times b1 \times b1 \\ & x80f0 \times b1 \\ & x80f0 \times b1 \times b1 \\ & x80f0 \times b1 \\ & x80f0 \times b1 \times b1 \\ & x80f0 \times$

\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94R!Cx\xb5@\x04\x05j|\xc0\x8c\x89\x13'y\x8a\u01b2H\x8a\x037\xfe_\xea\xf2\u0440\x00\x00\x94R##\xaa\xd7\x1d\xbc\x96\xd8Z\xf9\x0f\bK\x99\xc3\xf0\

 $x9d\ucdca\x01EB\xba\x12\xa37\xc0\x00\u07d4R>\x14\r\xc8\x11\xb1\x86\xde\xe5\xd6\u020b\x f6\x8e\x90\xb8\xe0\x96\xfd\x89lk\x93[\x8b\xbd@\x00\x00\u07d4R?mdi\x0f\xda\u0354(SY\x1b\xb0\xff ff)$

[\xe8\x9aKV>\x89\x85\xcaa[\xf9\xc0\x10\x00\x00\u07d4Rs\x8c\x90\xd8`\xe0L\xb1/I\x8d\x96\xfd\xb5\xbf6\xfc4\x0e\x89\x01\xa0Ui\r\x9d\xb8\x00\x00\u07d4Rz\x8c\xa1&\x863\xa6\xc99\xc5\xde\x1b\x92\x9a\ue4ae\xac\x8d\x890\xca\x02O\x98{\x90\x00\u07d4R\x81\x01\xceF\xb7

\x00\x00\u07d4R\x98\xab\x18*\x195\x9f\xfc\xec\xaf\xd7\u0475\xfa!-

@;\xa7\xed\xa6\xbc0z=c\xb5\x91\x1b\x81|\x12c\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u0794R\u04 c0Q\x1d\xf1\x9d^\u0080{\xbc\xb6vX\x1bg\xfd7\xa3\x88\xb9\xf6]\x00\xf6<\x00\x00\xe0\x94R\xe1s\ x13P\xf9\x83\xcc,A\x89\x84\xde\x06\x13\xfa\xd5\f\xe1\x8a\x02w\x01s8\xa3\n\xe0\x00\x00\u07d4 R\xe4g\x832\x9av\x93\x01\xb1u\x00\x9d4gh\xf4\xc8~\xe4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4R\x $f0X\xd4aG\xe9\x00m)\xbf,\t0J\xd1\xcd\xddn\x15\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4R\xf1T$ #2<\$\xf1\x9a\xe2\xabg7\x17\"\x9d?t\\x9b\x897\xa04\xcb\xe8\xe3\xf3\x80\x00\u07d4R\xf8\xb5\t\xfe \xe1\xa8t\xabo\x9d\x876\u007f\xbe\xaf\x15\xac\x13\u007f\x8965\u026d\xc5\u07a0\x00\x00\u07d4 R\xfbF\xac]\x00\xc3Q\x8b,:\x1c\x17}D\x81eU_\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4S\x00w \xc9\xf7\xb9\a\xff\x9c\xec\fw\xa4\x1ap\xe9\x02\x9a\xddJ\x89lk\x93[\x8b\xbd@\x00\x00\u07d4S\x0 3\x19\xdb\n\x8f\x93\xe5\xbb}M\xbfH\x161O\xbe\xd86\x1b\x89lk\x93[\x8b\xbd@\x00\x00\u07d4S\x $04}\u022c\x90\x83\xd9\x06r\xe8\xb3G<\x10\f\xcd'\x83\#\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4$ u00fc4\x12\xe2\xec\x0e\xa4{y\x81\xc7p\xf5\xbb/5\x89\a?u\u0460\x85\xba\x00\x00\u07d4S\x17\xe c\xb0#\x05,\xa7\xf5e+\xe2\xfa\x85L\xfeEc\xdfM\x89\x1b\x1a\xb3\x19\xf5\xecu\x00\x00\u07d4S\x1 9M\x8a\xfa>\x885\x02v~\xdb\xc3\x05\x86\xaf3\xb1\x14\u04c9lk\x93[\x8b\xbd@\x00\x00\u07d4S*}\ $xa0\xa5\xadt\aF\x8d;\xe8\xe0\sim i\xc7\xddd\xe8a\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4S-xe2\xefP\x00\x00\x00\xeq0$ 2\xb0\x0f0[\xcc\$\xdc\xefV\x81}b/4\xfb,\$\x89a\x94\x04\x9f0\xf7

\x00\x00\u07d4S4DX@\x82\xeb\xa6T\xe1\xad0\xe1Is\\o{\xa9\"\x89]\u0212\xaa\x111\xc8\x00\x00\x00\u07d4S8\xefp\xea\xc9\u075a\xf5\xa0P;^\xfa\xd1\x03\x9eg\xe7%\x89\x90\xf54`\x8ar\x88\x00\x00\x

e0\x94S9oJ&\u00b4`D\x960ITB\xe7\xfc\xba'.6\x8a\x04?\b\xd4\x0eZ\xfc\x00\x00\xe0\x94S:s\xa4\x a2\"\x8e\xee\x05\xc4\xff\xd7\x18\xbb\xf3\xf9\xc1\xb1)\xa7\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u007d4S<\x06\x92\x8f\x19\u0429V\xcc(\x86k\xf6\xc8\xd8\xf4\x19\x1a\x94\x89\x0f\xd8\xc1C8\xe60\x 00\x00\u07d4S@e6\x1c\xb8T\xfa\xc4+\xfb\\\x9f\xcd\xe0`J\xc9\x19\u0689lk\x93[\x8b\xbd@\x00\x00\u07d4SC\u007f\xec\xf3J\xb9\xd45\xf4\u07b8\xca\x18\x15\x19\xe2Y

 $\label{loop} I2\x89\a\xa2\x8c1\xc6\x04\x00\x00\u07d4S\xce\xc6\u0200\x92\xf7V\xef\xe5o\xb1\x12(\xa2\xdbE\xb1)\"\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4S\xe3[\x12\#\x1f\x19\xc3\xfdwL\x88\xfe\xc8\xcb\xee\xdf\x14\b\xb2\x89\x1b\xc1mgN\xc8\x00\x00\x00\x00\u07d4S\xe4\xd9im\xcb?M{?p\u072aN\xec\xb7}\x17\x82\xff\\x89\n\u05ce\xbcZ\xc6$

\x00\x00\u07d4S\xfa\xf1e\xbe\x03\x1e\xc1\x830\xd9\xfc\xe5\xbd\x12\x81\xa1\xaf\b\u06c9\a\x96\x e3\xea?\x8a\xb0\x00\u07d4T\n\x18\x19\xbd|5\x86\x1ey\x18\x04\xe5\xfb\xb3\xbc\x97\u026b\x b1\x89N\xd7\xda\xc6B0

\x00\x00\xe0\x94T\f\a(\x02\x01N\xf0\xd5a4Z\xecH\x1e\x8e\x11\xcb5p\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\x00\xe0\x94T\f\af(2=\xd9\\MU\x8a'\x9dw\x8d+75\xb3\x16A\x91\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4T\x10`\xfcX\xc7P\xc4\x05\x12\xf83i\xc0\xa63@\xc1\"\xb6\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4T\x13\xc9\u007f\xfaJn*{\xba\x89a\u071f\u03850\xa7\x87\u05c965\u026d\xc5\u07a0\x00\u07d4T\x1d\xb2\n\x80\xcf;\x17\xf1b\x1f\x1b?\xf7\x9b\x88/P\xde\xf3\x8965\u026d\xc5\u07a0\x00\x00\u07d4T\x1d\xb2\n\x80\xcf;\x17\xf1b\x1f\x1b?\xf7\x9b\x88/P\xde\xf3\x8965\u026d\xc5\u07a0\x00\x00\u07d4T\x1d\xb2\n\x80\xp6\xba\xfb\x88\x16&\x06\x00\.\x8c\x8a>\u0458\x14\xae\xac\x89lk\x93[\x8b\xbd@\xx00\x00\u07d4T1\v:\xa8\x87\x03\xa7\\u07e5}\xe6\xe6F\x93Qd\x80,\x89g\x8a\x93\xb4\x18\x00\x00\u07d4T1\xb1\u0447Q\xb9\x8f\xc9\u220a\xc7u\x9f\x155\xa2\xdbG\x89lk\x93[\x8b\xbd@\x00\x00\u07d4T1\xcaB~ae\xa6D\xba\xe3&\xbd\tu\n\x17\x8c\x16\x98[\x89\xbd\xbd\\x00\x00\x00\u07d4T5\xc6\xc1y3\x17\xd3,\xe1;\xbaLO\xfe\xb9s\xb7\x8a\u0709\r\x8e\x1c\x12\x85\xef\x00\x00\x00\u07d4T9\x1bM\x17\xd3,\xe1;\xbaLO\xfe\xb9s\xa9\xf9\r\x00\xac\x8a\r(\x96R\x9b\xad\u0708\x00\x00\u07d4T9\x1bM\x17\xd3,\xe1;\xb55\u0197\x00\xcb\%5\x89\x05\\xd5_\xc6M\xfe\x00\x00\x00\\xe0\x94T:\x8c\x0e\xfb\x8b\xcd\x15\xc5C\u29a4\xf8\ayv1\xad\xef\x8a\x01?\x80\xe7\xe1O-

\x00\x00\u07d4T\xecs\x00\xb8\x1a\xc8C3\xed\x1b\x03<\xd5\u05e39r\xe24\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4T\xfe\xbc\xce

c\x10\x00\x00\u0794UC\xddm\x16\x9e\xec\x8a!;\xbfz\x8a\xf9\xff\xd1]O\xf7Y\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4UG\xfd\xb4\xae\x11\x95>\x01)+x\a\xfa\x92#\xd0\xe4`j\x89\x05]\x11}\xcb\x1d&\x00\x00\u07d4UR\xf4\xb3\xed>\x1d\xa7\x9a/x\xbb\x13\xe8\xaeZh\xa9\xdf;\x8965\u026d\xc5\u07a\0\x00\x00\u07d4U\\\xa9\xf0\\\xc1\x\x8b\x2\x\x8b\x2\x\x8Q\x98\u0289\x05k\xc7^-

\x00\x00\u07d4U^\xbe\x84\u06a4+\xa2\V\xeax\x91\x05\xce\u0136\x93\xf1/\x18\x89\x05k\xc7^-c\x10\x00\x00\x94U\u007f^e\xe0\xda3\x99\x82\x19\xadN\x99W\x05E\xb2\xa9\xd5\x11\x8a\x0

2U\x9c\xbb\x98XB@\x00\x00\u07d4U\x83`

 $\label{thm:condition} $$ \operatorname{t=x1f}_x89_i \times b=xf2-x1f_x88_x00_x00_u07d4U_xa6_x1b_x10_x94_x80_xb5_xb2_xc4_xfc_xfd_xef_x92_xd9_x05_x84_x16_f_r5_x89_x02_IVM+S_xf6_x00_x00_u07d4U_xaa]1>xbb_b $$ M_xa0_xe7_x80_x10_x91_u2792_xc5_xde_u00ea_x89_kx93_x8b_xbd@_x00_x00_u07d4U_xab_x99_xb0_xe0_xe5]_{xb8t_xb7_xcf_xe84_xdec_x1c_x97_xec_x897_xe9_x8c_xe3_hx99_xe4_x00_x00_u07d4U_xaf_t_x94_xbaj_yx91_x8b_f_xf99_xea_xb3_xf0_x1b_2Q_u01c9_b$

 $\label{thm:condition} $$ \xd5\xe3\x95v\x12\x00\x00\u07d4U\xc5dfAf\xa1\xed\xf3\x91>\x01i\xf1\xcdE\x1f\xdb]\f\x89\x82\x17 $$ \xeaIP\x8el\x00\x00\xe0\x94U\xcaj\xbey\xea$\x97\xf4o\u06f804\x10\xfeF\x9c\xbe\x8a\x016\x9f\xb9a(\xacH\x00\x00\u07d4U\xca\xffK\xba\x04\xd2$$$

,\x0e\xc3\xd2\xcc\xe0\xce\v\x9d\x16\x9cM\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4V\x00s\nU\xf6\xb2\x0e\xbd\$\x81\x1f\xaa=\xe9m\x16b\xab\x89e\xea=\xb7UF`\x00\x00\u07d4V\x03\$\x1e\xb8\xf0\x8fr\x1e4\x8c\x9d\x9a\xd9/H\u342a\$\x89\n\u05ce\xbcZ\xc6

/x185\xfe_UA}Q\x11F\fj\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4V

byK^\xb9B\xf9\x16\x17\x1d\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4V:\x03\xab\x9cV\xb6\x00\xf6\xd2[f\f!\xe1c5Qzu\x8965\u026d\xc5\u07a0\x00\x00\u07d4V<\xb8\x80<\x1d2\xa2['\xb6A\x14\x85+\xd0M\x9c

 $\label{thm:converse} $$ \u0349\vx14\x9e\xad\n\xd9\xd8\x00\x00\u07d4VXc\x91\x04\fW\xee\xc6\xf5\xaf\xfd\x8c\u052b\xde\x10\xb5\n\u0309\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4VI\x10\xd68\u8e0bG\xd6\xe6\xa4\x14\Iz\xfd\xd0\x00\u0509\x05\x9bc\xa4\fx00\x00\u07d4VI\(\xe3L8\b\xd9\vo\xe8B\x1e\xbfO+\x1cO\)w\x89\xb2=\xf2-\x1f\x88\x00\x00\u07d4V\x8d\xf3\x18\Vi\x9b\xb5\xac\xfc\x1f\xe1\u0580\u07d9\xcaCY\x89J\xcfUR\xf3\xb2I\x80\x00\u07d4V\x91\xdd\gE\xf2\x0e\"\xd2\xe1\u0479U\xaa)\x03\xd6VV\x89j\xc5\xc6-$

 $\x 94\x 86\a\x 00\x 00\u 07d 4V\x a 1\x d 6\r @\x f 5\u 007f 0\x 8e\x e b\x f 0\x 87\x d e\x e 3\x b 3\u 007f\x 1e\x , \x b a\x 89\x u 072e\x c 8-\x 06\x f 8\x 00\x 00\u 07d 4V\x a c$

\xd6:\xd8\x03Y\\xec\x03m\xa7\xed\x1d\xc6n\n\x9e\a\x89\x03w*S\xcc\xdce\x80\x00\u07d4V\xb6\x c2=\xd2\uc434r\x8f;\xb2\xe7d\xc3\xc5\f\x85\xf1D\x8965\u026d\xc5\u07a0\x00\x00\u07d4V\xdf\x05 \xba\xd4I?\x00\xaeGn\xcf\x01{\xb8\xc8w8?\xf1\x89\n\xb1]\xaa\xefp@\x00\x00\u07d4V\xee\x19\u0 07fK\xbf\x9f\x1b\x06b\xe4\x1c+\xbd\x9a\xa1\xf7\x99\xe8F\x8965\u026d\xc5\u07a0\x00\x00\u07d4 V\xf4\x93\xa3\xd1\b\xaa\xa2\u044d\x98\x92\x8e\xfe\x16b\u03f7=\x89m\x81!\xa1\x94\xd1\x10\x00 \x00\u07d4V\xfc\x1a{\xad@G#|\xe1\x16\x14b\x96#\x8e\a\x8f\x93\xad\x89\t\xa6?\b\xeac\x88\x00\x $00\u07d4V\xfe\xbf\x9e\x10\x03\xaf\x15\xb1\xbd\a\xec\b\x9aJ\x1b\x91\xd2h\x89\n\u05ce\xbcZ\xc6$ \x00\x00\u07d4W\x17\u0313\x01Q\x1dJ\x81\xb9\xf5\x83\x14\x8b\xee\xd3\xd3\u0303\t\x89\x8c\xf2 ?\x90\x9c\x0f\xa0\x00\u07d4W\x17\xf2\xd8\xf1\x8f\xfc\xc0\xe5\xfe\$}:B\x19\x03|:d\x9c\x89\u06 3bel\xb0+\xb8\x00\x00\u07d4W\x19P\xea,\x90\xc1B}\x93\x9da\xb4\xf2\xdeL\xf1\u03ff\xb0\x89\x0 1\x15\x8eF\t\x13\xd0\x00\x00\u07d4W\x19\xf4\x9br\r\xa6\x88V\xf4\xb9\xe7\b\xf2VE\xbd\xbcKA\x8 9\"\xb1\xc8\xc1\"z\x00\x00\x00\u07d4W*\xc1\xab\xa0\xde#\xaeA\xa7\xca\xe1\xdc\bB\u062b\xfc\x1 0;\x89g\x8a\x93 b\xe4\x18\x00\x00\xe0\x94W-\xd8\xcd?\xe3\x99\xd1\xd0\xec(\x121\xb7\xce\xfc \xb9\u4eca\x023\xc8\xfeBp>\x80\x00\x00\xe0\x94WI!\x83\x8c\xc7\l\x98\xb1\\x90::\xe0\xee\r\xa9[\ u040a\v\$(\x17\x8a\xd0\xf2\xa0\x00\x00\u07d4WJ\xd95\$\x90\u421e\xf4*\xcd\x13\x8b*'\xe7\x8c\x0 0\xae\x89Tg\xb72\xa9\x134\x00\x00\u07d4WM\xe1\xb3\xf3\x8d\x91XF\xae7\x18VJZ\xda \xc2\xf3\xed\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\xe0\x94W\\\x00\u0081\x82\x10\u0085U\xa0\xff)\ x01\x02\x89\xd3\xf8#\t\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\xe0\x94Ws\xb6\x02q!\xa1\xdd\ x04\xb7\x82\x8c\xd6+Y\x1b\xfb4SL\x8a\x05\xb7\xacES\xdez\xe0\x00\x00\xe0\x94WwD\x1c\x83\x e0?\v\xe8\xdd4\v\xdechP\x84|b\v\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4Wx\xff\u071b\x 94\u0165\x9e\"N\xb9e\xb6\u0790\xf2\"\xd1p\x89\x12-

c\x10\x00\x00\u07d4W\x880\x10\xb4\xac\x85\u007f\xed\xac\x03\xea\xb2U\x17#\xa8D\u007f\xfb\x 8965\u026d\xc5\u07a0\x00\x00\u07d4W\x89\xd0\x1d\xb1,\x81j\xc2h\xe9\xaf\x19\xdc\r\xd6\u065f\x

15\u07c9\n\u05ce\xbcZ\xc6

\x00\x00\u07d4W\x92\x81OY\xa3:\x18C\xfa\xa0\x1b\xaa\b\x9e\xb0/\xfb\\\xf1\x89\x1b\x1a\xb3\x19\\xf5\xecu\x00\x00\u07d4W\x93\xab\xe6\xf1S3\x11\xfdQSh\x91x;?\x96%\xef\x1c\x89,\u0626V\xf2?\\xda\x00\x00\xe0\x94W\x97\xb6\x0f\u0489J\xb3\xc2\xf4\xae\u0786\xda\xf2\xe7\x88\xd7E\xad\x8a\\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4W\xa8R\xfd\xb9\xb1@[\xf5<\u03d5\b\xf82\x99\xd3

 $IR\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4W\xb2=j\x1a\xdc\x06\xc6R\xa7y\u01a7\xfbk\x95\xb9\xfe\xadf\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4W\xbc$

 $\xe2\xd6+=\x19f<\xdbL0\x9d[O/\xc2\u06cf\x89\x05k\xc7^-]$

 $c\x10\x00\x00\u07d4W\xbd\xdf\a\x884\x00\x9c\x89\u060eb\x82u\x9d\xc4S5\xb4p\x89tq\x89t\x83\x10\x00\x00\u07d4W\xbe\xeq\x81p\ns\xd6\u007f\x9f\x9c-$

\x90%\x89\n\u05ce\xbcZ\xc6

 $Ei \times 17e \{ \times 2 \setminus 0689k \times f2 \times 01 \times 95 \times f5T \times d4 \times 00 \times 00 \setminus 07d4W \setminus 0754q \times cb \times fa\&' \t \times f5 \setminus 09106f37t \times c5 \times f5' \times 8k \times 89 \setminus 089k \times f8 \times 89 \times 09106f37t \times 0$

\x84\x15\xa8\xea,\x90\xe0\xc5\u02c9\n\u05ce\xbcZ\xc6

 $\label{thm:cond} Y\xa4\x1f\xa0Y\xe3\xa4\x06\x8a\x1cO\xe4:\xdb\n^\x90\x00\x00\u07d4X\x1a:\xf2\x97\xef\xa4Cj)\xaf\x00r\x92\x9a\xbf\x98\&\xf5\x8b\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94X\x1b\x9f\xd6\xea\xe3r\xf3P\x1fB\xeb\x96\x19\xee\xc8$

\xb7\x8a\x84\x8a\x04+\xe2\xc0\f\xa5;\x8d\x80\x00\u07d4X\x1b\xdf\x1b\xb2v\xdb\u0746\xae\xdc\x db9z\x01\xef\xc0\xe0\f[\x8965\u026d\xc5\u07a0\x00\x00\u07d4X\x1f4\xb5#\xe5\xb4\x1c\t\xc8|)\x8 e)\x9c\xbc\x0e)\xd0f\x89=X3\xaa\xfd9u\x80\x00\xe0\x94X\$\xa7\xe2(8'q40\x8c_KP\u06b6^C\xbb1\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4X+pf\x9c\x97\xaa\xb7\u0581H\xd8\xd4\xe9\x04\x11\x e2\x81\rV\x8965f3\xeb\xd8\xea\x00\x00\u07d4X+pf\x9c\x97\xaa\xb7\u0581H\xd8\xd4\xe9\x04\x11\x e2\x81\rV\x8965f3\xeb\xd8\xea\x00\x00\u07d4X-\x83\xbaU\xe6~\x13\xe0\xe7o\x83\x92\xd8s\xcd!\xfb\xf7\x98\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4X\x\x83\xbaU\xe6~\x13\xe0\xe7\xeb\B\xc3\u007fH\xbf\x89\xb4\t\t\x8g\xc0\x00\x00\u07d4X\x\x87\xdcj3\xdf\xedZ\xc1\xed\xef\xe3^\xf9\x1a!b1\xac\x96\x89\r\x8drkqw\xa8\x00\x00\x00\x00\u07d4X\x8e\u0650\xa2\xaf\xf4J\x94\x10]X\xc3\x05%w5\xc8h\xac\x8a\x03 h\xc8b:\x8bM\x10\x00\x00\u07d4X\x\x8e-

@\x00\x00\xe0\x94X\xe2\xf1\x12#\xfc\x827\xf6\x9d\x99\xc6(\x9c\x14\x8c\x06\x04\xf7B\x8a\x05\x15\n\xe8J\x8c\xdf\x00\x00\x00\x00\x00\x00\x05\x1

 $\label{thm:condition} $$ \ada\xd58\xc7\xf5\xb4\xb5LJ\xfe\x89FP\x9diE4r\x80\x00\u07d4X\xe5\xc9\xe3D\xc8\x06e\r\xac\xfc\x90M3\xed\xb0\u0789\x01\t\x10\xd4\xc9\xf6\x00\x00\u07d4X\xe6a\u043as\xd6\xcf\t\x9aUb\xb8\b\xf7\xb3g;h\x89lk\x93[\x8b\xbd@\x00\x00\x00\x00\x00\x00\x94X\xf0[&%`P<\xa7a\xc6\x18\x90\xa4\x03_Lsr\x80\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\x00\u07d4X\xfb\x94sd\xe7iWe6\x1e\xbb\x1e\x80\x1e\x80\x1e\x80\x80\x8b\x95\xe6\u0409\n\u05ce\xbcZ\xc6$$

 $\label{thm:convoluo7d4Y} $$ \x00\x00\u07d4Y\x01\x81\xd4E\x00{\u0407Z\xaf\x06\x1c\x8dQ\x159\x00\x83j\x89lk\x93[\x8b\xbd @\x00\x00\u07d4Y\x02\xe4J\xf7i\xa8rF\xa2\x1e\a\x9c\b\xbf6\xbf6\xb0n\xfe\xb3\x8965\u026d\xc5\u07a 0\x00\x00\u07d4Y\n\xcb\xda7)\fr>\xc8O\xc2\x00\rv\x97\xf9\xa4\xb1]\x89\x1b\x1a\xe4\xd6\xe2\xef P\x00\x00\x00\x94Y\f\xcbY\x11\xcfx\xf6\xf6\"\xf55\xc4t7_J\x12\xcf\u03ca\x04<3\xc1\x93ud\x80\x00\x00\u07d4Y\x10\x10m\xeb\u0491\xa1\u0340\xb0\xfb\xbb\x8d\x8d\x9e\x93\xa7\xcc\x1e\x89lk\x93[\x8b\xbd\@\x00\x00\u07d4Y\x16\x17l\xfe\xdc\xf1\xc7!\xf2 -$

B,\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4Y0Dg\x0f\xae\xff\x00\xa5[Z\xe0Q\xeb{\xe8p\xb1\x16\x 94\x89\a?u\u0460\x85\xba\x00\x00\x00\x00\x94Y;E\xa1\x86J\xc5\xc7\xe8\xf0\u02ae\xba\r\x87<\xd5\x d1\x13\xb2\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4Y<H\x93[\xea\xff\x0f\xde\x19\xb0M0\x9c\x d50\xa2\x8eR\u0389\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4YG<\xd3\x00\xff\xfa\xe2@\xf5xV&\xc6]\xfe\u01d2\xb9\xaf\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4YH\xbc6P\xedQ\x9b\xf8\x91\xa5r g\x9f\u0652\xf8x\fW\x89\n\xad\xec\x98?\xcf\xf4\x00\x00\u07d4YJv\xf0i58\x8d\xde^#F\x96\xa0f\x8 b\xc2\r-

 $\label{thm:convoluo7d4} $$ \onum{1} \onum{1} wo $$ \onum{1} \onum{1} wo $$ \onum{1} \onum{1} wo $$ \onum{1} \onum{1} wo $$ \onum{1} \onum{1} \onum{1} wo $$ \onum{1} \onum{1$

 $c\x10\x00\x00\u07d4Y\x8a\xaa\xba\xe9\xed\x83={\xc2\"\xe9\x1f\u02a0d\xwX\v\x89a\x94\x04\x9f0\xeq} f7$

 $\label{thm:colored} $$ \x00\x00\u07d4Y\x92bLT\xcd\xec`\xa5\xae\x93\x803\xaf\x8b\xe0\xc5\f\xbb\n\x89\xc4T\xe0\xf8\x87\x00\x00\x00\xe0\x94Y\x97\x86\x18\u0461{x9e4\xe0\xfe\xd8\xe8}W\xd5\xc4\x06\"\x8a\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d4Y\x97\xff\xef\xb3\xc1\xd9\xd1\x0f\x1a\u2b0a\xc3\xc8\xe2\xd2)'\x83\x8965\u026d\xc5\u07a0\x00\x00\u07d4Y\xa0\x87\xb95\x1c\xa4/X\xf3n\x02\x19'\xa2)\x88(O8\x89\x01\x00\xbd3\xfb\x98\xba\x00\x00\u07d4Y\xa1-$

\xf2\xe3\xef\x85z\xce\xff\x93\x06\xb3\t\xf6\xa5\x00\xf7\x014\x8965\u026d\xc5\u07a0\x00\x00\u07d4Y\xb9m\ub1c4\x88]\x8d;J\x16aC\xccC]%U\xa1\x89Hz\x9a0E9D\x00\x00\u07d4Y\xb9\xe73\u02e 4\xbe\x00B\x9bK\xd9\u07e6G2\x05:}U\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\x00\x00\xe0\x94Y\xc5\xd0k\x1 7\x0e\xe4\xd2n\xb0\xa0\xebF\xcb}\x90\xc1\xc9\x10\x19\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x0 0\u07d4Y\xc7\xf7\x85\xc91`\xe5\x80~\xd3N^SK\xc6\x18\x86G\xa7\x89\"\xb1\xc8\xc1\"z\x00\x00\x 00\u07d4Y\xd19\xe2\xe4\f{\x97#\x9d#\u07ec\xa38X\xf6\x02\xd2+\x89lk\x93[\x8b\xbd@\x00\x00\u07d4Y\xf6\\$\tx8\xb7\x97k)\xd1\x15\x88B\xa2\xe1y\x14\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4Z\x19+\x96J\xfd\x80w>_^\xdajV\xf1N%\xe0\xc6\xf3\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4Z\x1a3ib\xd6\xe0\xc601\u0303\u01a5\u01a6\xf4G\x8e\u02c965\u026d\xc5\u07a0\x00\x00\u07d4Z\x1d-\x1dR\x03\x04\xb6

 $b\xe4\x18\x00\x00\u07d4ZVR\x857JI\xee\xddPL\x95\Q\bt\xd0\x04U\xbc\x89\x05k\xc7^-c\x10\x00\x00\u07d4Z^\xe8\xe9\xbb\x0e\x8a\xb2\xfe\xcbK3\u0494x\xbeP\xbb\xd4K\x89*\x11)\u0413g$

\x00\x00\u07d4Z\xd1,^\xd4\xfa\x82~!P\u03e0\u058c\n\xa3{\x17i\xb8\x89+^:\xf1k\x18\x80\x00\x00\

$xe0\x94Z\xd5\xe4$

 $\x 89\v''' u 007 f c x b e x 81 < x 00 u 07 d 4 [\% x ca x e 8 m x ca x f a *` x e 7 f 61 x f c_ x a 4 x 9 c x 1 a x d 8 \} x 87 f XQ x 0 e x 85 e x 87 f XQ x 0 e x 8$

 $2\x90\x0e\xbd8\xa3\u01c9lk\x93[\x8b\xbd@\x00\x00\u07d4[\xa2\xc6\xc3]\xfa\xec)h&Y\x19\x04\xd5DFJ\xea\xbd^\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\xe0\x94[\xafmt\x96$

 $\x 80 > \x 83 H \x a f 7 \x 10 \x e 5 \x c 4 \x f b \x f 2 \x 0 f \u 0 2 1 4 \x 8 a \x 0 1 \x 0 f @ \x 0 2 a] \x f e \x 0 0 \x 0 0 \x 0 0 \u 0 7 d 4 [\x c 1 \x f 9 U \a \x b 1 \x 0 1 \x 8 6 B \x e 4 \x 0 9 \x 0 0 \x e 2 \x b 9 \x b 1 \x a 3 \& \x 8 9 \x 0 5 k \x c 7^-$

2\x8e5!\u024f\x05\u0309\x1c\x9fx\u0489>@\x00\x00\u07d4\\a6\xe2\x18\xde\na\xa17\xb2\xb3\x96

 $c\x10\x00\x00\u0794\\x8d\x8d\x8d\x67\x04\xcd\xd0\xd9\t\x89\xb86\xedO7\xb2\x88\xb9\xf6{\x00\x00\x00\xe0\x94\\xc4\u02e6!\xf2}$

 $cwB\x05\u007f`U\xb8\r\xff\xd7~\x13\x8a\bxG{}\%;f\x00\x00\xe0\x94\l\xc7\xd3\x06mE\xd2v!\xf7\x8b\xb4\xb39G>D*\x86\x00\x8a\x02\x1e\x18\x99\xf07z\xea\x00\x00\u07d4\l\xcc\xf1P\x8b\xfd5\xc2\x05\n\x00\xc1\r\xee\xea\xed\x89.\x14\x1e\xa0\x81\xca\b\x00\x00\u07d4\l\xcer\xd0h\xc7\xc3\xf5[\x1d(\x19T^w1|\xae\x82@\x89i*\xe8\x89p\x81\xd0\x00\x00\u07d4\l\xd0\xe4u\xb5D!\xbd\xfc\f\x12\xea\x8e\b+\u05e5\xaf\nj\x89\x032\xca\x1bg\x94\f\x00\x00\u07d4\l\u0548\xa1N\xc6H\xcc\xf6G)\xf9\x16z\xa7\xbf\x8b\xe6\xeb=\x8965\u026d\xc5\u07a0\x00\x00\u07d4\l\u062f`\xdee\xf2M\xc3\xce\w0\xba\x92e0\l\xdc\xc1\xg_\xc8\xcb\v\u007f\xaa\x9en\x89\x1d\x1c_\xda$

 $\label{thm:c4x00x00u07d4}\\\label{thm:c4x00x00u07d4}\\\label{thm:c4x00x00u07d4}\\\label{thm:c4x00x00u07d4}\\\label{thm:c4x00x00x00u07d4}\\\label{thm:c4x00x00x00u07d4}\\\label{thm:c4x00x00x00u07d4}\\\label{thm:c4x00x00x00u07d4}\\\label{thm:c4x00xc1x93udx80x00x00u07d4}\\\label{thm:c4x00xc1x93udx80x00x00u07d4}\\\label{thm:c4x00xc1x93udx80x00x00u07d4}\\\label{thm:c4x00xc1x93udx80x00x00u07d4}\\\label{thm:c4x00xc1x93udx80x00x00u07d4}\\\label{thm:c4x00xc1x93udx80x00x00u07d4}\\\label{thm:c4x00xc1x93udx80x00x00u07d4}\\\label{thm:c4x00xc1x93udx80xd0}\\\label{t$

 $81\x99\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xf1\x8f\xa7\u0227\xc0\xa2\xb3\xd5\xef\u0459\x00 fd\xdd\xc5i\x,x8965\u026d\xc5\u07a0\x00\x00\x00\x94\xf4N\x10T\reqd\#\xb1\xbc\xb5B\xd2\x1f\xf8\xc0>\xb5\xb5\xd2\x1f\xf8\xc0>\xb3\xe8r\xe5\x0f\xfd\f/\x8d; ?.\xb5\x18:\x89\n\u05ce\xbcZ\xc6$

\x00\x00\u07d4]\x1d\xc38{G\xb8E\x1eU\x10I\f\xc6}m\xc7+\u007f\v\x89Ik\x93[\x8b\xbd@\x00\x00\u 07d4]#\x1ap\xc1\xdf\xeb6\n\xbd\x97\xf6\x16\xe2\xd1\r9\xf3\u02b5\x89\x15\xaf\x1dx\xb5\x8c@\x00 \x00\u07d4]\$\xbd\xbc\x1cG\xf0\xeb\x83\xd1(\xca\xe4\x8a\xc3<H\x17\xe9\x1f\x8965\u026d\xc5\u0 7a0\x00\x00\u07d4](\x19\xe8\xd5x!\x92.\xe4Ee\f\xca\xec}@TJ\x8d\x89\n\u05ce\xbcZ\xc6 \x00\x00\u07d4]\\u007f\v\x04\xbaK\xe1a\u1736\xf1\x12\xcez^}\u007f\xe4\x89\x01\xe8\u007f\x85\x 80\x9d\xc0\x00\x00\u07d4]2\xf6\xf8nx\u007f\xf7\x8ec\u05cb\x0e\xf9_\xe6\a\x18R\xb8\x89\x15\xbe at\xe1\x91.\x00\x00\u07d4]9\uf7a6\xbd\xff\xf1]\x11\xfe\x91\xf5a\xa6\xf9\xe3\x1f]\xa5\x89lk\x93[\x8 b\xbd@\x00\x00\xe0\x94]?;\x1fq0\xb0\xbb!\xa0\xfd29b9\x17\x9a%e\u007f\x8a\r:\xb8\xea^\x8f\xd9\ xe8\x00\x00\u07d4]WQ\x81\x9bO=&\xed\f\x1a\xc5qU'5'\x1d\xbe\xfa\x8965\u026d\xc5\u07a0\x00\ x00\u07d4]\\\xdb\xe2[*\x04K{\x9b\u30fc\xaaX\a\xb0m<k\x89lk\x93[\x8b\xbd@\x00\x00\u07d4]]n\x8 2\x1cn\uf581\f\x83\u0111F\x85`\xefp\xbf\xb5\x89lk\x93[\x8b\xbd@\x00\x00\u07d4]h2K\xcbwm?\xf d\v\xf9\xfe\xa9\x1d\x9f\x03\u007f\u05ab\x0f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4]j\xe8\xcb\u05b39 $<\Tx10\rx028\xe8\b\x14\x89\a\xe5mQ\xa3\f\x00\x00\u07d4\f\xa6\xab\u0283\x97\x14.c$ \xd2h\x18\xea\xabT\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4]I\u03c0g8\t\x10B\xad\x97\xa6\xe0\ $x95\xfe\x8c6\xaay\u0149\n1\x06+\xee\xedp\x00\x00\u07d4\gy\x9c\x8d\xf3\xbc\xcb~\xe4F\xdfP\xb$ 81+\xc4\xebq\u0149\n\u05ce\xbcZ\xc6 \x00\x00\u07d4]\x82-

 $\label{thm:condition} $$\x9b>\xf4\xb5\x02bt\a\xda'/g\x81Jk\xec\u0509\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4]\x83\xb2\x1b\xd2q\#\Ckg\xa5\x97\xee3x\xdb>z\xe4\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94]\x87+\x12.\x99N\xf2\parked\xd7\u07b4W\xbfeB\x9e\xcal\x8a\x01\xb1\xad\xed\x81\u04d4\x10\x80\x00\xe0\x94]\x8d1\xfa\x88\x05\xb6\xb7\xd5g\x10\x00\x00\xe0\x94]\x8d1\xfa\x8a\x05\xb6\xb6\xb7\xd5g\x10\x00\x00\xe0\x94]\x95\x8a\x9b\u0449\u0098_\x86\u014a\x8ci\xa7\x88\x06\xe8\u068a\x02(\xf1o\x86\x15x^\x00\x00\u07d4]\x82\x89\x86\u014a\x8e\x89\xcb\xe0\x85\xb9\xd0\xc6'\x81\u03e0\x89'\xbf8\xc6TM\xf5\x00\x00\u07d4]\x82\x89\x85\u0288\x93\x93\x95\x10\x89\x04\x88\x80\x89\x04\x98\x80\x89\x04\x98\x80\x89\x04\x99\x04\x88\x80\x89\x04\x99\x04\x89\x04\x99\x04\x89\x04\x99\x04\x89\x04\x99\x04\x89\x04\x9$

 $A \x02 \n9\xe1{\x89j\xa2\t\xf0\xb9\x1de\x80\x00\xe0\x94]\xb6\x9f\xe9>o\xb6\xfb\xd4P\x96k\x97\#\x89\x11\n\xd8'\x9a\x8a\bxg\x83\&\xea\xc9\x00\x00\x00\u07d4]\xb7\xbb\xa1\xf9W?\x11]\x8c\x8cb\xe9\u0388\x95\x06\x8e\x9f\x89\x02\xb5\xaa\xd7,e$

5\u07a0\x00\x00\u07d4]\u562b\xa3D7\x8c\xabD1U[Oy\x99-

\u0090\u0189Hz\x9a0E9D\x00\x00\u07d4]\xe9\xe7\xd5\u0476g\u0415\xdd4\t\x9c\x85\xb0B\x1a\v\ u0181\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4]\xf3'|\xa8Y6\u01e0\xd2\xc0yV\x05\xad%\t^qY\x 89lk\x93[\x8b\xbd@\x00\x00\u07d4]\xff\x81\x1d\xad\x81\x9e\xce;\xa6\x02\u00c3\xfb]\xc6L\n:H\x8 9\n\x15D\xbe\x87\x9e\xa8\x00\x00\u0794^\x03\x1b\nrDq\xd4v\xf3\xbc\xd2\xeb\a\x838\xbfg\xfb\xef \x88\xfc\x93c\x92\x80\x1c\x00\x00\xe0\x94^\a\x85S,w#\xe4\xc0\xaf\x93W\xd5'Ks\xbd\xdd\u07 8a\x05KA\xea\x9b\xdba\xdc\x00\x00\u07d4^\x11\xec\xf6\x9dU\x1d\u007fO\x84\xdf\x12\x80F\xb3\ xa12@\xa3(\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\x00\xe0\x94^\x1f\xbdNX\xe21+<x\u05ea\xaa\xfa\x10 \xbf\x9c1\x89\xe3\x8a\bxg\x83&\xea\xc9\x00\x00\x00\x00\xe0\x94^2\xc7!\x91\xb89,U\xf5\x10\xd8\xe3 2n:`P\x1db\x8a\tQ>\xa9\xde\x02C\x80\x00\x00\u07d4^Q\xb8\xa3\xbb\t\xd3\x03\xea|\x86\x05\x15\ x82\xfd`\x0f\xb3\xdc\x1a\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u0794^X\xe2U\xfc\x19\x87\n\x040 \ xf2\xa0F1\xf2\xff)K\xb1\x88\xf4?\xc2\xc0N\xe0\x00\x00\u07d4^ZD\x19t\xa8=t\u0187\xeb\xdcc?\xb 1\xa4\x9e{\x1a\u05c9\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4^eE\x8b\xe9d\xaeD\x9fqw7\x04\x97\x97 f\xf8\x89\x87a\x89\x1c\xa7\xccs[o]\x00\x00\u07d4^g\u07c9i\x10\x1a\u06bd\x91\xac\xcdk\xb1\x99\ $x12t\xaf\x8d\xf2\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4^n\x97G\xe1b\xf8\xb4\en\x0fI\xaez\xeq$ x84\xba\xc8\x0eN\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4^s\x1bU\xce\xd4R\xbb??\xe8q\xdd\xc3\xed ~\xe6Q\n\x8f\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4^t\xed\x80\xe9eW\x88\xe1\xbb&\x97R1\x96g \xfeuNZ\x89\x03\t"\xf7L\x9d\xe0\x00\x00\u07d4^w.'\xf2\x88\x00\xc5\r\u0697;\xb3>\x10v.n\xea \x89a\t=|,m8\x00\x00\u07d4^{\x8cT\xdcW\xb0@

 $@n\x00\x00\u07d4^\xb3q\xc4\a@IB{;}\xe2q\xad<\x1e\x04\&\x95y\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\x00\x00\x007d4^\u037a\xea\xb9\x10o\xfe]{Q\x96\x96^x96^x9a\x05\xba\ub16d\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\x00\xd63\x85Y\xefD\xdcza\xed\xeb\x89?\xa5\xd8?\xa1\xb5\x89\v\xed\x1d\x02c\xd9\xf0\x00\x00\x00\xe0\x94^\u04fb\xc0R@\xe0\u04d9\xebm\xdf\xe6\x0fb\xdeM\x95\t\xaf\x8a)\x14\xc0\xu\xf9\xd6\xd3\x00\x00\u0594^\xd3\xf1\xeb\xe2\xaegV\xb5\xd8\xdc\x19\xca\xd0,A\x9a\xa5w\x8b\x80\u007d4^\xd5a\x15\xbde\x05\xa8\x82s\xdf\V\x83\x94p\xd2J-$

\xd4`\x91\x1d\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94_6>\n\xb7G\xe0-

 $\label{thm:linear} $$ \int_{xafR:\x8a\x02w\x01s8\xa3\n\xe0\x00\x00\u07d4_7[\x86\f@\u0328\xb2g kz\x1a\x1d\x16D\xc5\xf5,\x89\x04F\x18\xd7Lb?\x00\x00\u07d4_>\x1eg9\xb0\xc6\"\x00\xe0\n\x006\x00\x00\u07d4_H?\xfb\x8fh\n\xed\xf2\xa3\x8fx3\xe1\xdc\xdeY\xb6\x1eK\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94_J\xceL\x1c\xc13\x91\xe0\x1f\x00\xb1\x98\xe1\xf2\v_\x91\xcb\xf5\x8a\x01\x0f\x0f\x08\xb9\u04c1\x1a\x00\x00\xe0\x94_R\x12\x82\xe9\xb2\xb2\xb070c\x03Lr\xafS\xee)\xe5D=x\x8a\x01\as-$

\xbdM\x8c\x1d\xd1R\x8cL\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4_\u0368G\xaa\xf8\xd7\xfa\x8 b\xca\b\x02\x9c\xa2\x84\x91f\xaa\x15\xa3\x89!\u02b8\x12Y\xa3\xbf\x00\x00\u07d4_\xd1\xc3\xe3\x17x'l\xb4.\xa7@\xf5\xea\xe9\xc6A\xdb\xc7\x01\x89\n\x84Jt\$\xd9\xc8\x00\x00\u07d4_\xd3\xd6w~\xc2b\n\xe8:\x05R\x8e\xd4%\a-

 $19C\xe1\x8f\xdb\xc3Ow\x89j\xcb=\xf2-\x1f\x88\x00\x00\u07d4`B\xc6D\xba\xe2\xb9o\%\xf9M1\xf6x$ \xc9\r\xc9f\x90\u06c9lk\x93[\x8b\xbd@\x00\x00\u07d4`L\xdf\x18b\x8d\xbf\xa82\x91\x94\xd4x\xdd R\x01\xee\xccK\xe7\x89\x01?0j\$\t\xfc\x00\x00\u07d4`N\x94w\xeb\xf4r|t[\u02bb\xed\xcbl\xcf)\x99@ \"\x8966\x9e\xd7t}&\x00\x00\u07d4`gm\x1f\xa2\x1f\xca\x05\"\x97\xe2K\xf9c\x89\u0171*p\u05c9\r\x 17|Zzh\xd6\x00\x00\u07d4`gn\x92\u044b\x00\x05\t\xc6\x1d\xe5@\xe6\xc5\u0776v\xd5\t\x89A\rXi \xa4\xc0\x00\x00\u07d4`o\x17q!\xf7\x85\\!\xa5\x06#0\xc8v\"d\xa9{1\x89\xd8\xd7&\xb7\x17z\x80\x0 0\x00\u07d4`\x86B6\x93\r\x04\xd8@+]\xcb\xeb\x80\u007f<\xafa\x1e\xa2\x89\xd8\xd7&\xb7\x17z\x 80\x00\x00\u07d4`\xabq\xcd&\xeamnY\xa7\xa0\xf6'\xee\a\x9c\x88^\xbb\xf6\x89\x01s\x17\x90SM\x f2\x00\x00\u07d4`\xaf\x0e\xe1\x18D<\x9b7\xd2\xfe\xadw\xf5\xe5!\u07be\x15s\x89g\x8a\x93 b\xe4\x18\x00\x00\u07d4`\xb3X\xcb=\xbe\xfa7\xf4\\xf2\xd76X@\u068e;\u024c\x89\x01\x15\x8eF\t\ x13\xd0\x00\x00\u07d4`\xb8\u05b7;ySO\xb0\x8b\xb8\xcb\xce\xfa\xc7\xf3\x93\xc5{\xfe\x89 h\xe8\x 13\x1e\u03c0\x00\x00\u07d4`\xbeo\x95?*M%\xb6%o\xfd\$#\xac\x148%.N\x89\b!\xab\rD\x14\x98\x 00\x00\u0794`\xc3qO\xdd\xdbcFY\u48b1\xeaB\xc4r\x8c\u01f8\xba\x88\xb9\x8b\xc8)\xa6\xf9\x00\x 00\u07d4`\xcc=D^\xbd\xf7j}z\xe5q\u0197\x1d\xffh\u0305\x85\x8965\u026d\xc5\u07a0\x00\x00\xe0 \x94`\xd5fq@\xd1&\x14\xb2\x1c\x8e^\x8a3\b.2\xdf\xcf#\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4`\ xde\"\xa1Pt2\xa4{\x01\xcch\xc5*\v\xf8\xa2\xe0\u0418\x89\x01\t\x10\xd4\xcd\xc9\xf6\x00\x00\u07d 4\xe0\xbd\u0422Y\xbb\x9c\xb0\x9d?7\xe5\u034b\x9d\xac\uafca\x89JD\x91\xbdm\xcd(\x00\x00\u0 7d4`\xe3\xccC\xbc\xdb\x02j\xadu\x9cpf\xf5U\xbb\xf2\xacf\xf5\x89lk\x93[\x8b\xbd@\x00\x00\u07d4 a\x04+\x80\xfd`\x95\u0478{\xe2\xf0\x0f\x10\x9f\xab\xaf\xd1W\xa6\x89\x05k\xc7^c\x10\x00\x00\u07d4a\a\xd7\x1d\xd6\xd0\xee\xfb\x11\xd4\xc9\x16@L\xb9\x8cu>\x11}\x89lk\x93[\x

\\x94v\i\xa4\xb4;8\x96I#\x89Y\xd2\xdb\\x14\u0699\x00\x00\u07d4\B'm\xf2\x98?\xe2\xbcGY\xdc\x

8b\xbd@\x00\x00\u07d4a\x0f\xd6\xeeN\xeb\xab\x10\xa8\xc5]\vK\xd2\xe7\xd6\xef\x81qV\x89\x01\x15\x95a\x06]]\x00\x00\u07d4a\x14\xb0\xea\xe5Wi\x03\xf8\v\xfb\x98\x84-

\$\xed\x92#\u007f\x1e\x89\x05k\xc7^-c\x10\x00\x00\u07d4a!\xaf9\x8a[-

\xa6\x9fe\xc68\x1a\xec\x88\u039c\xc6D\x1f\x89\"\xb1\xc8\xc1\"z\x00\x00\x00\u07d4a&g\xf1r\x13[\x95\v,\xd1\xde\x10\xaf\xde\xcehW\xb8s\x8965\u026d\xc5\u07a0\x00\x00\u07d4a,\xed\x8d\xc0\u071e\x89\x9e\xe4oyb33\x15\xf3\xf5^D\x89\x12^5\xf9\xcd=\x9b\x00\x00\u07d4a4\xd9B\xf07\xf2\xcc=BJ#\f`=g\xab\xd3\xed\xf7\x89lk\x93[\x8b\xbd@\x00\x00\u07d4a:\xc5;\xe5e\xd4e6\xb8q[\x9b\x8d:\xe6\x8aK\x95\x89\xcb\xd4{n\xaa\x8c\xc0\x00\x00\u07d4a?\xabD\xb1k\xbeUMD\xaf\xd1x\xab\x1d\x02\xf3z\ua949lk\x93[\x8b\xbd@\x00\x00\u07d4aN\x8b\xef=\xd2\u015bY\xa4\x14Vt@\x10\x185\x18\x84\xea\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4aQ\x84d\xfd\u0637<\x1b\xb6\xacm\xb6\x00el8\xdb\xf1z\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4aT}7nSi\xbc\xf9x\xfc\x16,<V\xaeE5G\xe8\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convactive} $$ \x00\x00\u07d4aX\xe1\a\xc5\xebT\xcbv\x04\xe0\u034d\xc1\xe0u\x00\xd9\x1c<\x89\x02\xb5\xe3\xe3\xe16\xb1\x88\x00\x00\x00\xe0\x94aZo6w\u007f@\xd6a~\xb5\x81\x98\x96\x18i\x83\xfd71\x8a\x01@a \xb9\xd7z^\x98\x00\x00\u07d4a_\x826\Q\x01\xf0q\xe7\xd2\xcbj\xf1Oz\xad,\x16\u0189\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4ap\xdd\x06\x87\xbdU\u0288\xb8z\xde\xf5\x1c\xfd\xc5\M\xd4X\x89I\xb3/\4\xfeD\x00\x00\u07d4as9G\xfa\xb8 $$$

\xdb\xd3Q\xef\xd6xU\xea\x0e\x88\x13s\xa0\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4ay\x97\x99\a\xfe\u007f\x03~L8\x02\x9d`\xbc\xba\xb82\xb3\u0589WG=\x05\u06ba\xe8\x00\x00\x00\x94a\u007f

\x89O\xa7\x0e\x94\xa8jI\xcdt\xe028\xf6M<\u064a\x01\x0f\r\xba\xe6\x10\tR\x80\x00\u07d4a\u007f\

xf2\u0300>1\xc9\b\"3\xb8%\xd0%\xbe?{\x10V\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4a\x91\xdd\u0276J\x8e\b\x90\xb427\t\u05e0|H\xb9*d\x89*\x03I\x19\u07ff\xbc\x00\x00\u07d4a\x96\xc3\xd3\xc0\x90\x8d%Cf\xb7\xbc\xa5WE\"-

 $\label{thm:condition} $$ \x9dM\xb1\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4a\x9f\x17\x14E\xd4+\x02\xe2\xe0p\x04\xad\x8a\xfeiO\xa5=j\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4a\xad\xf5\x92\x9a^)\x81hN\xa2C\xba\xa0\x1f\x1f^\x14\x8a\x89\x05\xfa\xbfl\x98O\#\x00\x00\u07d4a\xb1\xb8\xc0\x12\xcdLx\xf6\x98\xe4p\xf9\x02V\xe6\xa3\x0fH\u0749\n\u05ce\xbcZ\xc6$$

 $\label{thm:condition} $$ \u007f=U\xb2\xa5\x1a\xa7\xd5\x0f\a\xfa\t\xe8\x89lk\x93[\x8b\xbd@\x00\x00\u07d4a\xff\x8eg\xb3M\x9e\xe6\xf7\x8e\xb3o\xfe\xa1\xb9\xf7\xc1W\x87\xaf\x89X\xe7\x92n\xe8X\xa0\x00\x00\u07d4b\x05\xc2\xd5dtp\x84\x8a8@\xf3\x88^\x9b\x01]4u\x89a\x94\x04\x9f0\xf7}$

 $\label{thm:convention} $$ \x00\x00\u07d4b(\xad\xe9^\x8b\xb1)\x1a\xe2;\xfb\x05\x18AMI~\x0e\xb8\x89\x15\xaf\x1dx\xb5\x8c @\x00\x00\xe0\x94b)\xdc\xc2\x03\xb1\xed\xcc\xfd\xf0n\x87\x91\fE*\x1fMzr\x8a\x06\xe1\xd4\x1a\x8f\x9e\xc3P\x00\x00\u0794b+\xe4\xb4T\x95\xfc\xd91C\xef\xc4\x12\u0599\xd6\xcd\xc2=\u0148\xf0\x15\xf2\W6B\x00\x00\u07d4b3\x1d\xf2\xa3\xcb\xee5$

 $x91: \x901 \x91 \x901 \x91 \x901 \x91 \x901 \x91 \x901 \x$

 $\label{thm:colim} $$ \x02!\x89\x01\x15\x8eF(t)x13\xd0\x00\x00\u07d4c1\x02\x8c\xbbZ!H[\xc5\x1bVQB\x99;\xdb\%\x82\xa9\x89\x1c\xfd\xd7F\x82\x16\xe8\x00\x00\u07d4c3O\xcf\x17E\x84\x0eK\tJ;\xb4\v\xb7o\x96\x04\xc0L\x89\u05e5\xd7\x03\xa7\x17\xe8\x00\x00\u07d4c4\nWqk\xfac\xebl\xd13r\x12\x02W[\xf7\x96\xf0\x89\va\xe0\xa2\fx12\x80\x00\u07d4cn\xfc\x7\x11\a\xb4\xcb\xf0?y\xa9=\xfd\x93\xe41\xd5\xfd\x89\x82\xe0\x8e\xdc\x80\x00\xe0\x94c\x80\x00\xfd\xf05\xbc\xa1_\xa3a\xr\xf38N\x0f\xb7\x90\xb1\x89\x01\xe7\xe4\x17\x1b\xf4\u04e0\x00\x00\u07d4ca.xb\xc2{X|\xfbm\xaf\x99\x12\xcb\x05\x1f\x03\n\x9f\x89\x02[\x19\u053f\xe8\xed\x00\x00\u07d4cfgU\xbdA\xb5\x98i\x97x<\x13\x040\b$+<\xb5\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4c{\xe7\x1b}\xa8\x15\xffE=VB\xf70tE\xd\xc8^x89lk\x93[\x8b\xbd\@\x00\x00\x94c\g\xd8\u007fXo\nZG\x9e$

\xee\x13\xea1\n\x10\xb6G\x8a\n:Y&\xaf\xa1\xe70\x00\x00\u07d4c\u007fXi\xd6\xe4i_\x0e\xb9\xe2 s\x11\u0107\x8a\xff33\x80\x89j\xc0Nh\xaa\xec\x86\x00\x00\u07d4c\x97|\xad}\r\xcd\xc5+\x9a\xc9\ xf2\xff\xa16\xe8d(\x82\xb8\x89\x04\x10\u0546\xa2\nL\x00\x00\u07d4c\xa6\x1d\xc3\n\x8e;0\xa7c\x c4!<\x80\x1c\xbf\x98s\x81x\x8965\u026d\xc5\u07a0\x00\x00\u07d4c\xacT\\x99\x12C\xfa\x18\xae\ xc4\x1dOoY\x8eUP\x15\u0709\x86\xac5\x10R`\x00\x00\u07d4c\xb9uMu\xd1-

\xc7\xd4\u007f\x15`\x00\x00\xe0\x94c\xe4\x14`>\x80\xd4\xe5\xa0\xf5\xc1\x87t

FB%\x82\b\xe4\x8a\x01\x0f\f\xf0d\xddY

\x00\x00\x94c\xe8\x8e.S\x9f\xfbE\x03\x86\xb4\xe4g\x89\xb2#\xf5GIE\x8a\x01U\x17\nw\x8e%\xd0\x00\x00\u07d4c\xef\xbc=\xaf^\xda\xf4\xa2\x95b\x9c\xcf1\xbc\xdf@8\xe5\x89O%\x91\xf8\x96\xa6P\x00\x00\u07d4c\xf0\xe5\xa7R\xf7\x9fg\x12N\xedc:\xd3\xfd'\x05\xa3\x97\u0509\u0556{\xe4\xfc?\x10\x00\x00\x00\x00\xe0\x94c\xf5\xb5=y\xbf.A\x14\x89Re0\"8E\xfa\xc6\xf6\x01\x8a\x06ZM\xa2]0\x16\xc0\x00\x00\x00\u07d4c\xfc\x93\x00\x13\x05\xad\xfb\u0278])\xd9)\x1a\x05\xf8\xf1A\v\x8965\u026d\xc5\u07a0\x00\x00\u0794c\xfek\xccK\x8a\x98P\xab\xbeu\x8070\xc92%\x1f\x14[\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4d\x03\xd0bT\x96\x90\xc8\xe8\xb6>\xaeA\xd6\xc1\tGn%\x88\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4d\x04+\xa6\x8b\x12\xd4\xc1Qe\x1c\xa2\x81:sR\xbd\\xf0\x8e\x89

 $\label{thm:linear} $$ \x86\xac5\x10R^\x00\x00\u0794d\x05\xdd\x13\xe9:\xbc\xff7~p\x0e<\x1a\x00\x86\xec\xa2})\x88\xfc\x93c\x92\x80\x1c\x00\x00\xe0\x94d\n\xbam\xe9\x84\xd9E\x177x\x03p^\xae\xa7\t_J\x11\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4d\v\xf8t\x15\xe0\xcf@s\x01\xe5Y\x9ah6m\xa0\x9b\xba\u0209\x1a\xbc\x9fA^\x98\x15\x80\x00\u07d4d$

\xf8\xbc\xc8\x16JaR\xa9\x9dk\x99i0\x05\xcc\xf7\xe0S\x8965f3\xeb\xd8\xea\x00\x00\u07d4d\$\x1ax

D)\x0e\n\xb8U\xf1\u052au\xb5SE\x03\"\$\x89V\xbcu\xe2\xd61\x00\x00\x00\u07d4d&J\xed\xd5-\xca\xe9\x18\xa0\x12\xfb\xcd\f\x03\x0e\xe6\xf7\x18!\x8965\u026d\xc5\u07a0\x00\x00\u07d4d7\x0e\x87 &E\x12Z5\xb2\a\xaf\x121\xfb`r\xf9\xa7\x89\n\u05ce\xbcZ\xc6

\xa3\xab\x05(!\xa0\$=\x1c\xe4\xb6\xe0\xa3e\x17\xb8\xeb\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convoluo7d4dj} $$ \x00\x00\u07d4dj\xfb\xa7\x1d\x84\x9e\x80\xc0\xedY\xca\xc5\x19\xb2x\xe7\xf7\xab\xe4\x8965\u026d\xc5\u07a0\x00\x00\u07d4dn\x04=\x05\x97\xa6d\x94\x8f\xbb\r\xc1\Tu\xa3\xa4\xf3\xa6\xed\x89\x01\x15\x8eF\t\x13\xa0\x00\u07d4dp\xa4\xf9.\u01b0\xfc\xcd\x01\#O\xa5\x90\#\xe9\xff\x1f:\xac\x89\xa2\xa1]\tQ\x9b\xe0\x00\u07d4d\x85\x04M\xf2\xcf\vN\u0508.\x88\x81\x9f\xe2*\xe5\xf7\x93\x8966;]\x9a\wp\x00\x00\u07d4d\x85G\x0ea\xdb\x11\n\xeb\u06ef\xd56\xy9e<\Y\x9c\xc9\b\x89\x89\x02\xdb7\x84\x1c\xb0\u06d3\x90\xb0bH\x88\x01\xa55\xec\xf0\v\n\x04\x80\x00\xe0\x94d\x9a+\x98y\u034f\xb76\xe6p;\fwG\x84\x97\x96\xf1\x00\x8a\x01\x8e\xe2-$

\v\x18\x99\u00e0\xc0e;P@\x13m\r\xc8B\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4d\xec\x8a[t?4y\xeq\a\xda\xe9\xee\u076aO@\xf1\u0649\n\u05ce\xbcZ\xc6

c\x10\x00\x00\u07d4e\x10\xdfB\xa5\x99\xbc\xb0\xa5\x19\u0329a\xb4\x88u\x9aogw\x89lk\x93[\x8b\xbd@\x00\x00\u07d4e6u\xb8B\xd7\u0634a\xf7\"\xb4\x11|\xb8\x1d\xac\x8ec\x9d\x89\x01\xae6\x1f\xc1E\x1c\x00\x00\u07d4eK~\x80\x87\x99\xa8=r\x87\xc6w\x06\xf2\xab\xf4\x9ald\x04\x89j\xcb=\xf

\x00\x00\u07d4e]\\xd7H\x96)\xe2A<!\x05\xb5\xa1r\xd93\xc2z\xf8\x89\xdb\x03\x18I\xd8@\xa6\x00\x00\u07d4e`\x18XA0\u06c3\xab\x05\x91\xa8\x12\x8d\x93\x81fj\x8d\x0e\x89\x03w\x9f\x91\x19\xfc\x00\x00\u07d4e`\x94\x13(\xffX|\xbcV\u00ccx#\x8a{\xb5\xf4B\xf6\x89(a\x90kY\xc4z\x00\x0

 $0\u07d4eey\xda\xed\u0493p\u06777\xee?\\xd9\xd8K\u00b3B\x89M\x85<\x8f\x89\b\x98\x00\x00\u007d4etswOc\xac=by\xfd\aC\xd5y\fO\x16\x15\x03\x89\n\u05ce\xbcZ\xc6$

\x00\x00\u07d4e\x80\xb1\xbc\x949\x0f\x04\xb3\x97\xbds\xe9]\x96\xef\x11\xea\xf3\xa8\x89\x01\x15\x8eF\t\x13\xd0\x00\u07d4e\x84\x9b\xe1\xaf

 $\label{lem:condition} $$C\xf3\xeb\xfa\xfb,\x00\x00\u0794e\xb4/\xae\xcc\x1e\u07f1B\x83\u0297\x9a\xf5E\xf6;0\xe6\f\x88\xfc\x93c\x92\x80\x1c\x00\x00\u0794e\xd3>\xb3\x9c\xdadS\xb1\x9ea\xc1\xfeM\xb91p\xef\x9d4\x88\xb9\x8b\xc8)\xa6\xf9\x00\x00\u07d4e\xd8\xddN\%\x1c\xbc\x02\x1f\x05\xb0\x10\xf2\xd5\xdcR\f8r\xe0\x89-$

 $\label{thm:condition} $$ \x8968\x02\x1c\xec\u06b0\x00\x00\xe0\x94f\x05W\xbbC\xf4\xbe:\x1b\x8b\x85\xe7\xdf{<[\xcdT\x80W\x8a\x01EB\xba\x12\xa37\xc0\x00\u07d4f\b,u\xa8\xde1\xa59\x13\xbb\xd4M\xe3\xa07O\u007f\xaaA\x89O\%\x91\xf8\x96\xa6P\x00\x00\u07d4f\x11\xceY\xa9\x8b\a*\xe9Y\xdcl\xadQ\x1d\xaa\xaa\xa1\x9dk\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4f$

\x1b\xd2'\xaem\u01bd\xfe\xd5\xfb\u0781\x1f\xec\xfe^\x9d\u0649

 $> \x9e\x84\x92x\x8c\x00\x00\u07d4f\#4\x81G\$\x93[y1\xdd\xcaa\x00\xe0\rFw'\u0349\"\x88\&\x9d\a\x83\xd4\x00\x00\u07d4f'O\xea\x82\xcd0\xb6\u009b\#5\x0eOO=1\nX\x99\x89p7\x05P\xab\x82\x98\x00\x00\u07d4f,\xfa\x03\x8f\xab7\xa0\x17E\xa3d\u1e41'\xc5\x03tm\x89\u0556\{\xe4\xfc?\x10\x00\x00\u07d4f5\xb4oq\x1d-\xa6\xf0\xe1cp\u034e\xe4>\xfb,-$

 $= \xf2-\x1f\x88\x00\x00\u07d4fBK\xd8x[\x8c\xb4a\x10*\x90\x02\x83\xc3]\xfa\a\xefj\x89\x02.- \xb2ff\xfc\x80\x00\u07d4fL\xd6}\xcc\u026c\x82(\xb4\U\u06cdvU\ve\x9c\u0709\x15[\xd90\u007f\x9f\xe8\x00\x00\u07d4fNC\x11\x98p\xaf\x10zD\x8d\xb1'\x8b\x04H8\xff\u036f\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4fQso\xb5\x9b\x91\xfe\xe9\xc9:\xa0\xbdn\xa2\xf7\xb2Pa\x80\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4f[\x00\x0f\vw'P\xcc<!z^\xf4)\xa9+\xf1\u033b\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4ff$

 $\label{thm:colored} $$ \x06\x01\\x1f\x8e<\xcf\xca\xeb\xc8\xeeh\a\xee\x19c\x03\x89\x1b\x1b:\x1a\xc2a\xec\x00\x00\u07ddff\x9g\x10\x2e\x10\x2e\x10\x2e\x10\x15\x8eF\t\x13\xd0\x00\x00\u07ddff\x9e\x10\x2e\x10\x10\x2e\x$

\x86\xac5\x10R`\x00\x00\u07d4f{a\xc0;\xb97\xa9\xf5\xd0\xfcZ\t\xf1\xea3c\xc7p5\x89\xe6d\x99\"\x 88\xf2(\x00\x00\u07d4f\x85\xfd.%Dp,6\v\x8b\xb9\xeex\xf10\xda\xd1m\xa5\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94f\x8bk\xa8\xab\b\xea\xce9\xc5\x02\xefg+\xd5\u0336\xa6z

 $2\xb98h\x8e2A\xd0\xe2O\x8a\x02\t\x80Q\x97\x0e9\xd0\x00\u07d4f\u030a\xb2<\x00\u0478*\xcd\s\xf3\x8c\x99\xe0\xd0ZO\xa6\x89\x05k\xc7^-$

 $\label{lem:class} $c\x10\x00\x00\u07d4f\xdc\xc5\xfbN\xe7\xfe\xe0F\xe1A\x81\x9a\xa9hy\x9ddD\x91\x89Hz\x9a0E9D\x00\x00\u07d4f\xe0\x94'\xc1\xe6=\xee\xd7\xe1+\x8cU\xa6\xa1\x93$

 $\label{thm:color$

 $x00\u07d4gB\xa2\xcf\u038dy\xa2\u0125\x1bwtt\x98\x91\"E\xcdj\x89\r\xfd[\x80\xb7\xe4h\x00\x00\u07d4gJ\x00]\x00\x00\u07d4gQ\x8e]\x007d4gJ\xdb!\xdf\x98\u01e3G\xacL<$&gW\xddp9\x89lk\x93[\x8b\xbd@\x00\x00\u07d4gQ\x8e]\x002\xb2\x05\x18\x0f\x04c\xa3$

c\x10\x00\u07d4gv\xe13\xd9\xdc5L\x12\xa9Q\b{c\x96P\xf59\xa43\x89\x06\x81U\xa46v\xe0\x0 0\x00\u07d4g\x85Q<\xf72\xe4~\x87g\ap\xb5A\x9b\xe1\f\xd1\xfct\x89lk\x93[\x8b\xbd@\x00\x00\u0 7d4g\x947\xea\xcfCxx\xdc)=H\xa3\x9c\x87xb7B\x1a!I\x89\x03\u007f\x81\x82\x1d\xb2h\x00\x00\u0 07d4g\x9b\x9a\x10\x990Q~\x89\x99\t\x9c\xcf*\x91LL\x8d\xd94\x89\x03@\xaa\xd2\x1b\;p\x00\x00\u0 07d4g\xa8\x0e\x01\x90r\x1f\x949\rh\x02r\x9d\xd1,1\xa8\x95\xad\x89lk\x13u\xbc\x91V\x00\x00\u0 07d4g\xb8\xa6\xe9\x0f\xdf\n\x1c\xacD\x17\x930\x1e\x87P\xa9\xfayW\x890\x89\x91V\x00\x00\u0 07d4g\xb8\xa6\xe9\x0f\xdf\n\x1c\xacD\x17\x930\x1e\x87P\xa9\xfayW\x890\x89\x89\x15\xd1\xcfAv\xae\xba\x00\x00\u07d4g\xc9&\t>\x9b\x89'\x938\x10\u0642\"\xd6.+\x82\x06\xbb\x89g\x8a\x93 b\xe4\x18\x00\x00\u07d4g\xcf\xdanp\xbfvW\u04d0Y\xb5\x97\x90\xe5\x14Z\xfd\xbea\x89\x05\r\tX fX\x00\x00\u07d4g\u0582\xa2\x82\xefs\xfb\x8dn\x90q\xe2aOG\xab\x1d\x0f\n\xf6\x8aa\x89\n\xbc\xbbW\x18\x97K\x80\x00\u07d4g\u05a8\xaa\x1b\xf8\xd6\xea\xf78N\x99=\xfd\xf1\x0f\n\xf6\x8aa\x89\x01\x15\x8eF\t\x13\xd0\x00\u07d4q\xdf\$-

 $\label{thm:condition} $$ \x04<3\xc1\x93ud\x80\x00\x00\u07d4h\x11\xb5L\u0456c\xb1\x1b\x94\xda\x1d\xe2D\x82\x85\u035fh\u0649;\xa1\x91\v\xf3A\xb0\x00\x00\u07d4h\x19\f\xa8\x85\xdaB1\x87L\x1c\xfbB\xb1X\n!s\u007f8\x89\xcf\x15\&@\xc5\xc80\x00\x00\x94h(\x97\xbcO\x8e\x89\x02\x91$

 $\label{thm:colored} $$ vz\x03\x114(\xca\f\xe2\xf3\x89\x89\x01\r:\xa56\xe2\x94\x00\x00\u07d4\hy'\xe3\x04\x8b\xb5\x16*\xe7\xc1\xf7\k\xd1$\xf9I{\x9e\x89lk\x93[\x8b\xbd@\x00\x00\x00\x94\h\x80\x9a\xf5\xd52\xa1\x1c\x1a Mn2\xaa\xc7\LR\xb0\x8e\xad\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\h\x86\xad\xa7\xbb \xb0a{\u0684!\x91\u018c\x92.\xa3\xa8\xac\x82\x89>\xe2;\xde\x0e} $$$

 $\label{label} $$ \frac{xb1\cdot xac\cdot xa9\cdot x3\cdot x12\cdot xc0\cdot x06\cdot x89\cdot xd8\cdot xd7\&\cdot xb7\cdot x17z\cdot x80\cdot x00\cdot x00\cdot u07d4h\cdot xc7\cdot xd1q\cdot x1b\cdot x01\cdot x1f0\cdot x1f0\cdot x1f0\cdot x02\cdot xcc\cdot xe9p\cdot xbd\cdot u05c9\cdot b=|z\cdot xabc\cdot x00\cdot x00\cdot u07d4h\cdot xc8y\cdot x1d\cdot xc3b\cdot xc3sv\cdot x9e\cdot xa6\cdot x1f\cdot xb7\cdot xb5\cdot x10\cdot xf2Q\cdot xd3$$

\xc0\x00\x00\x94iy{\xfb\x12\u027e\u0582\xb9\x1f\xbcY5\x91\xd5\xe4\x027(\x8a\x02\x1e\x19\x e0\u027a\xb2@\x00\x00\x94i\u007fUSk\xf8Z\xdaQ\x84\x1f\x02\x87b:\x9f\x0e\u041a\x17\x8a\ x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4i\x82\xfe\x8a\x86~\x93\xebJ\v\xd0QX\x93\x99\xf2\xe c\x9aR\x92\x89lk\x93[\x8b\xbd@\x00\x00\u07d4i\x8a\x8ao\x01\xf9\xabh/c|yi\xbe\x88 |S\x02\xbf\x 89\x01\r:\xa56\xe2\x94\x00\x00\u07d4i\x8a\xb9\xa2\xf33\x81\xe0|\fGC=\r!\xd6\xf36\xb1'\x89\x01\x 15\x8eF\t\x13\xd0\x00\u07d4i\x94\xfb21\xd7\xe4\x1dI\x1a\x9dh\xd1\xfaL\xae,\xc1Y`\x89\xd8\x d7&\xb7\x17z\x80\x00\x00\u07d4i\x9c\x9e\xe4q\x95Q\x1f5\xf8b\xcaL\"\xfd5\xae\x8f\xfb\xf4\x89\x0 4V9\x18\$O@\x00\x00\u07d4i\x9f\xc6\u058aGuW<\x1d\u036e\xc80\xfe\xfdP9|N\x89\x03@\xaa\xd 2\x1b;p\x00\x00\u07d4i\xaf(\xb0tl\xac\r\xa1p\x84\xb99\x8c^6\xbb:\r\xf2\x896w\x03n\xdf\n\xf6\x00\x 00\u07d4i\xb8\x0e\xd9\x0f\x84\x83J\xfa?\xf8.\xb9dp;V\tw\u0589\x01s\x17\x90SM\xf2\x00\x00\xe0\ x94i\xb8\x1dY\x81\x14\x1e\u01e7\x14\x10`\xdf\u03cf5\x99\xff\xc6>\x8a\x01\x0f\f\xfd\xddY \x00\x00\u07d4i\xbc\xfc\x1dC\xb4\xba\x19\xde{'K\xdf\xfb5\x13\x94\x12\xd3\u05c95e\x9e\xf9?\x0f\ xc4\x00\x00\u07d4i\xbd%\xad\xe1\xa34IY\xc4\xe90\xdb*\x9dq^\xf0\xa2z\x89\xd8\xd7&\xb7\x17z\x 80\x00\x00\u07d4i\xc0\x8dtGT\xdep\x9c\xe9n\x15\xae\r\x1d9[:\"c\x8965\u026d\xc5\u07a0\x00\x00 \u07d4i\xc2\xd85\xf1>\xe9\x05\x80@\x8ej2\x83\xc8\u0326\xa44\xa2\x89#\x8f\xd4,\\\xf0@\x00\x00 \u07d4i\xc9N\a\u0129\xbe3\x84\xd9]\xfa<\xb9)\x00Q\x87;{\x89\x03\xcbq\xf5\x1f\xc5X\x00\x00\u07 d4i\xcb>!S\x99\x8d\x86\xe5\xee

\xc1\xfc\u0466\xba\uec86?\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4i\u04ddQ\b\x89\xe5R\xa3\x\96\x13[\xfc\xdb\x06\xe3~8v3\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\x00\xe0\x94i\u064f8\xa3\xba=\xbc\x\01\xfa\\,\x14'\xd8b\x83//p\x8a\x15-

 $\label{thm:converse} $$ \x1c\x89\x00\x00\x00\u07d4j\x04\xf5\xd5?\xc0\xf5\x15\xbe\x94+\x8f\x12\xa9\xcbz\xb0\xf3\x97 x\x89\xa9\xaa\xb3E\x9b\xe1\x94\x00\x00\u07d4j\x05\xb2\x1cO\x17\xf9\xd7?_\xb2\xb0\u02c9\xffS $$ \xa6\xcc-\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\xe0\x94j\x0f\x05`f\xc2\xd5f(\x85\x02s\xd7\xec\xb7\xf8\xe6\xe9\x12\x9e\x8a\x01\x0f\r)<\u01e5\x88\x00\x00\u07d4j\x13\xd5\xe3,\x1f\xd2m-\x91\xffn\x051`\xa8\x9b,\x8a\xad\x89\x02\xe6/$

\xa6\x9b\xe4\x00\x00\u07d4j.\x86F\x9a[\xf3|\xee\x82\xe8\x8bL8c\x89](\xfc\xaf\x89\x1c\"\x92f8[\xbc\x00\x00\u07d4j6\x94BL|\u01b8\xbc\u067c\u02baT\f\xc1\xf5\xdf\x18\u05c9lk\x93[\x8b\xbd@\x00\x00\x00\x00\u07d4j6\x94BL|\u01b8\xbc\u067c\u02baT\f\xc1\xf5\xdf\x18\u05c9lk\x93[\x8b\xbd@\x00\x00\x00\x00\x00\u07d4jB\u0297\x1cex\u056d\xe2\x95\xc3\xe7\xf4\xad3\x1d\xd3BN\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4jD\xaf\x96\xb3\xf02\xaed\x1b\xebg\xf4\xb6\xc83B\xd3|]\x89\x01\x92t\xb2Y\xf6T\x00\x00\u07d4jL\x89\a\xb6\x00\\$x80\W\xb1\xe4cT\xb1\x9b\u0705\x9c\x99\x1a\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4jQNbB\xf6\xb6\x8c\x13~\x97\xfe\xa1\u73b5U\xa7\xe5\xf7\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4jS\xd4\x1a\xe4\xa7R\xb2\x1a\xbe\xd57FI\x95:Q=\xe5\xe5\x89lk\x93[\x8b\xbd@\x00\x00\u07d4jaY\aJ\xb5s\xe0\xeeX\x1f\x0f=\xf2\u05a5\x94b\x9bt\x89\x10\xce\x1d=\x8c\xb3\x18\x00\x00\u07d4jc7\x83?\x8fjk\xf1\f\xa7\xec!\xaa\x81\x0e\xd4D\xf4\u02c97\xbd\$4\\\xe8\xa4\x00\x00\u07d4jc\xf6\x89\xab\xc7\xf3n(-

 $\x80x{{\x04\xaf\xd6U>q\x89\b\xacr0H\x9e\x80\x00\x00\u07d4jg\x9e7\x8f\xdc\xe6\xbf\xd9\u007f\xe}$

6/\x04<od\x05\u05de\x99\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4jhk\xf2

\xc0\x80`jy\xc7;\xd8\xe7[\x11qzN\x8d\xb3\xf1\u00c9\x10?sX\x03\xf0\x14\x00\x00\u07d4k\"\x84D\x02!\xce\x16\xa88-

\x00\x00\xe0\x94k\x94a]\xb7Pej\u00cc~\x1c\xf2\x9a\x9d\x13g\u007fN\x15\x8a\x02\x8a\x85t%Fo\x 80\x00\x00\u07d4k\x95\x1aC'N\xea\xfc\x8a\t\x03\xb0\xaf.\xc9+\xf1\xef\xc89\x89\x89\x05k\xc7^-c\x10\x00\x00\u07d4k\x99%!\xec\x85#p\x84\x8a\u0597\xcc-

 $\label{thm:cond} $$ \left(\frac{x}{x}6Nc\cdot x^{06}\cdot x^{1}\cdot x^{00}\cdot x^{$

\x8e\n\xe4\x8a\bxg\x83&\xea\xc9\x00\x00\x00\u07d4k\xb4\xa6a\xa3:g\xd4\$\u051b\xb5\xdf(b.\xd4\ xdf\xfc\xf4\x89\",\x8e\xb3\xfff@\x00\x00\u07d4k\xb5\b\x13\x14j\x9a\xddB\xee\"\x03\x8c\x9f\x1fti\xd 4\u007fG\x89\n\xdaUGK\x814\x00\x00\u07d4k\xbc?5\x8af\x8d\u0461\x1f\x03\x80\xf3\xf71\bBj\xbd J\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4k\xbd\x1eq\x93\x90\xe6\xb9\x10C\xf8\xb6\xb9\u07c9\ x8e\xa8\x00\x1b4\x89||O\xa6\xc3\xdaX\x80\x00\u07d4k\xc8Z\xcdY(r.\xf5\tS1\xee\x88\xf4\x84\xb8\ 9d\x9f\x8965\u026d\xc5\u07a0\x00\x00\u07d4k\xd4W\xad\xe0Qy]\xf3\xf2F\\89\xae\xd3\xc5\xde\xe 9x\x8964\xbf9\xab\x98x\x80\x00\u07d4k\xe1c\x13d>\xbc\x91\xff\x9b\xb1\xa2\xe1\x16\xb8T\xea\x9 3:E\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4k\xe7Y^\xa0\xf0hH\x9a'\x01\xecFI\x15\x8d\xdcC\ xe1x\x89lk\x93[\x8b\xbd@\x00\x00\u07d4k\xe9\x03\x0e\xe6\xe2\xfb\u0111\xac\xa3\xde@\"\xd3\x 01w+{}\x89\x01s\x17\x90SM\xf2\x00\x00\xe0\x94k\xec1\x1a\xd0P\b\xb4\xaf5<\x95\x8c@\xbd\x06 s\x9a?\xf3\x8a\x03w\xf6*\x0f\nbp\x00\x00\u07d4k\xf7\xb3\xc0e\xf2\xc1\xe7\xc6\xeb\t+\xa0\xd1Pf\x f3\x93\u0478\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4k\xf8o\x1e/+\x802\xa9\\Mw8\xa1\t\xd3\xd 0\xed\x81\x04\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4l\x05\xe3N^\xf2\xf4.\u041d\xef\xf1\x02l\xd6k \xcbi`\xbb\x89lk\x93[\x8b\xbd@\x00\x00\u07d4l\b\xa6\xdc\x01s\xc74)U\xd1\xd3\xf2\xc0e\xd6\\x83\ xae\u01c9\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4l\n\xe9\xf0C\xc84\xd4Bq\xf14\x06Y=\xfe\tO8\x9f\ a8\x00\x00\xe0\x94\x0eq/@\\Yr \xe8)\xe9wK\xf4\xdf\u007fM\xd9e\x8a\f(h\x88\x9c\xa6\x8aD\x00\ x00\xe0\x94I\x10\x12\x05\xb3#\xd7uD\xd6\xdcR\xaf7\xac\xa3\xce\xc6\xf7\xf1\x8a\x02\x1e\x19\xe0 \u027a\xb2@\x00\x00\u07d4l\x15\xec5 \xbf\x8e\xbb\xc8

 $\label{thm:convoluo7d4lc} $$ \x00\x00\u07d4lc\xf8EV\u0490\xbf\u0359\xe44\ue657\xbf\xd7yWz\x89lk\x93[\x8b\xbd@\x00\x00\u07d4le 07d4lc\xfc\x85\x02\x9a&T\u05db+\xeaM\xe3l\xe4REw\u0149\#\xc7W\a+\x8d\xd0\x00\x00\u07d4le d\xe5\xc9\xc2N\xaa\xa7D\xc9\xc7\xc9h\xc9\xc2\xc9\xf1\xfb\xae\x89l\x9bB\xa2\x119d\x00\x00\xe0 $$$

 $\x94\lg\xd6\xdb\x1d\x03Q\x12\x8b\x8f\xf24\xbf=I\xb2m)A\x8a\x15-$

)!\x8a\xc8\xe9\x8a&\f\x1e\x06@)4\x889\x87[\x8a\x01\x0f\x97\xb7\x87\xe1\xe3\b\x00\x00\u07d4l\x 84\u02e7|m\xb4\xf7\xf9\x0e\xf1=^\xe2\x1e\x8c\xfc\u007f\x83\x14\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94l\x86\x87\xe3Aw\x10\xbb\x8a\x93U\x90!\xa1F\x9ej\x86\xbcw\x8a\x02[-

\xa2x\xd9k{\x80\x00\xe0\x94I\x88,'s,\xef\\|\x13\xa6\x86\xf0\xa2\xeawUZ\u0089\x8a\x15-

 $\label{thm:prop:condition} $$ \xe9\x15\xf8\x98\x04\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4l\xd2\x12\xae\xe0N\x01?=*\xba\u04a0#`k\xfb\j\u01c9lj\xccg\u05f1\xd4\x00\x00\u07d4l\xd2(\xdcq!i0\u007f\xe2|\xebtw\xb4\x8c\xfc\x82r\xe5\x89\x044\xea\x94\u06caP\x00\x00\u07d4l\xe1\xb0\xf6\xad\xc4pQ\xe8\xab8\xb3\x9e\xdbA\x86\xb0;\xab\u0309Ay\x97\x94\xcd\xcc\x00\x00\u07d4l\xea\xe3s=\x8f\xa4=l\xd8\f\x1a\x96\xe8\xeb\x93\x10\x9c\x83\xb7\x89\x10'\x94\xad$

 $\label{thm:convention} $$ \x00\x00\u07d4m\x05i\xe5U\x8f\xc7\xdf'f\xf2\xba\x15\u070a\xef\xfc[\xebu\x89\xd8\xe6\x00\x1el0+\x00\x00\u07d4m\x12\x0f\f\xaa\xe4O\xd9K\xca\xfeU\xe2\xe2y\uf5ba\z\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4m\x14V\xff\xf0\x10N\xe8D\xa31G7\x8438\xd2L\xd6l\x89\a\xb0l\xe8\u007f\xddh\x00\x00\u07d4m$

\xef\x97\x04g\nP\v\xb2i\xb5\x83.\x85\x98\x02\x04\x9f\x01\x89\af\x1c\xc7;\x00\xc8\x00\x00\x00\xe0\x9 4m/x97g4\xb9\xd0\a\r\x18\x83\xcfz\u02b8\xb3\xe4\x92\x0f\xc1\x8a\x02\x1e\x19\xe0\u027a\xb2@ \x00\x00\u07d4m9\xa9\u93c1\xf7i\xd7:\xad,\xea\xd2v\xac\x13\x87\xba\xbe\x89\x15[\xd90\u007f\x9 f\xe8\x00\x00\u07d4m;x6\xa2\xb9\u0619r\x1aM#{R#\x85\xdc\xe8\xdf\u034966\xc2^f\xec\xe7\x00\ x00\u07d4m?+\xa8V\u033b\x027\xfava\x15k\x14\xb0\x13\xf2\x12@\x8965\u026d\xc5\u07a0\x00\x 00\xe0\x94m@\b\xb4\xa8\x88\xa8&\xf2H\xeej\v\r\xfd\xe9\xf92\x10\xb9\x8a\x01'\xfc\xb8\xaf\xae \xd0\x00\x00\u07d4m@\xca'\x82m\x97s\x1b>\x86\xef\xfc\u05f9*Aa\xfe\x89\x89lk\x93[\x8b\xbd@\x 00\x00\u07d4mD\x97J1\u0447\xed\xa1m\xddG\xb9\xc7\xecP\x02\xd6\x1f\xbe\x892\xf5\x1e\u06ea \xa30\x00\x00\x00\xe0\x94mK\\\x05\xd0j

 $xc9\#B\xf8\x00\x00\u07d4m\x91\x93\x99k\x19F\x17!\x11\x06\xd1c^\xb2l\u0136ll\x89\x15\xaa\x1e-\x9d\xd5\x1c\x00\x00\u07d4m\x99\x97P\x98\x82\x02-\xa9G\#\x14$\xbe\xde\xde\ee\u043a\x89l\x81\u01f3\x11\x95\xe0\x00\x00\u07d4m\xa0\xed\x8f\x1di3\x9f\x05\x9f^\x0e\x02G\x1c\xb4O\xb8\u00fb\x892\xbc8\xbbc\xa8\x16\x00\x00\u07d4m\xb7+\xfdC\xfe\xf4e\xcaV2\xb4Z\xabra@N\x13\xbf\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4m\xc3\xf9+\xaa\x1d!\u06b78+\x892a\xa05o\xa7\xc1\x87\x89]\u02\x22\xaa\x111\xc8\x00\x00\u07d4m\xc7\x05:q\x86\x16\xcf\u01cb\xeec\x82\xeeQ\xad\xd0\xc7\x030\x89lk\x93[\x8b\xbd@\x00\x00\x00\x00\x94m\xcc-d\xfc\xaf\xcb\xc2\xdcl\x0e^f,\xb3G\xbf\xfc\xd7\x02\x88\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4m\xdb\x8d\x00\x00\x00\x00\u07d4m\xdb\x92w\x9dXB\xea\xd3x\xe2\x1e\x81\xfd\Lk\xc12\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4m\xdb\xef\xef\xs91U\u06ab\n\\xb4\x95:\xa8\u016f\xa$

 $\label{thm:converse} $$ \ao(x) \ao($

 $\label{thm:linear} $$ \int (x88I\"x94\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4n\a;f\u0478\xc6gD\u0600\x96\xa8\u0759\xec~\x02(\u0689\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4n\x0e\xe7\x06\x12\xc9v()I\x9d\u07e6\xc0\xdc\xc1,\x06\xde\xea\x89\a\v\u0579V!F\x00\x00\x00\x00\x94n\x12\xb5\x1e\"[JCr\xe5\x9a\u05e2\xa1\xa1>\xa3\u04e17\x8a\x03\x00F\xc8\xccw_\x04\x00\x00\u07d4n\x1a\x04I\xaf[JW\xf4\xfdK\xc1sb!&\xb4\xe2\xfd\x86\x89a\xe2\xe0\x00\x00\u07d4n\x1e\xa4\xb1\x83\xe2R\u027\bwg\xa0\x06\u05346\x89\xo0\x00\x00\x00\u07d4n\xe7\x13\x8aK\xac\xf2(\x88\xa9\xe2\xc0\n(^\xec\x89\xd8\xd7\x85\xee\u0400\x00\u07d4n\n\xd5)\xf1\xf0\xb8\xd9\xcbm$\xc81b$~\xc6Jt\x89\n\u05ce\xbcZ\xc6$$

$\x9b\x1cTj\x86\xee\xfd]\nQ$

 $\label{thm:convenience} $$ \an x893 \cdot xc5I \cdot x901r \cdot f(x00) \cdot x00 \cdot u07d4n \cdot x82 \cdot x12 \cdot x07 \cdot xaf(xd4) \cdot xa7 \cdot xa7 > \xd3 \cdot xe29^ \cdot xe6EJ \cdot x030 \cdot x89 \cdot x91y \cdot x94 \cdot xf7 \cdot x1c \cdot x00 \cdot x00 \cdot u07d4n \cdot x84 \cdot x87m \cdot xbb \cdot x95 \cdot xc4 \cdot yfV \cdot xe4 + \xa9 \cdot xa0 \cdot x8 \cdot x99; T \cdot u0709; \cdot xbc^ \cdot xe3 \cdot xb6 \cdot u02fe \cdot x00 \cdot x00 \cdot u07d4n \cdot x84 \cdot xc2 \cdot xfd \cdot x18 \cdot xd8 \cdot tW \cdot x14 \cdot xa9h \cdot x17 \cdot x18 \cdot x9c \cdot xa6 \cdot x$

\xa2\x1c\xcab\xba\xb1\x89\x12{lp&!\u0340\x00\u07d4n\x86m\x03-

 $\label{thm:coy} $$ \a6\x91HR\xc0Y\x8a\x8b\u00ab\xf4\x02!\xf4\x80\x00\x00\u07d4n\xbb^iW\xaa\x82\x1e\xf6Y\xb6\x01\x8a9:PL\xaeDP\x89lk\x93[\x8b\xbd@\x00\x00\u07d4n\xbc\xf9\x95\u007f_\xc5\u916d\xd4u\";\x00\xb8\xc1Jz\xed\x89]\u0212\xaa\x111\xc8\x00\x00\u07d4n\xc3e\x95q\xb1\x1f\x88\x9d\xd49\xbc\xd4\xd6u\x10\xa2[\xe5-\x89\x06\xaa\xf7\xc8Qm\f\x00\x00\u07d4n\u021b9\xf9\xf5'jU>\x8d\xa3\x0en\xc1z\xa4-\xef\u01c9\x18BO_\v\x1bN\x00\x00\u07d4n\xc9m\x13\xbd\xb2M\u01e5W)?\x02\x9e\x02\xddt\xb9zU\x89\xd8\xd7\x17z\x80\x00\x00\u07d4n\xca\xef\xa6\xfc>\xe54bm\xb0,o\x85\xa0\u00d5W\x1ew\x89$

\x93\xf1\x00\x00\xe0\x94n\xdf\u007fR\x83r\\\x95>\xe6C\x17\xf6a\x88\xaf\x11\x84\xb03\x8a\x01\xb4d1\x1dE\xa6\x88\x00\x00\u07d4n\xe8\xaa\xd7\xe0\xa0e\u0605-

];\x9an_\xdcK\xf5\f\x00\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4n\xef\u0705\x0e\x87\xb7\x15\xc 7'\x91w<\x03\x16\xc3U\x9bX\xa4\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4n\xf9\xe8\u0276!}\V\ x9a\xf9}\xbb\x1c\x8e\x1b\x8b\xe7\x99\u0489\t\xdd\xc1\xe3\xb9\x01\x18\x00\x00\u07d4n\xfb\xa8\xf b*\u0176s\a)\xa9r\xec\"D&\xa2\x87\u00ed\x89\x0fY\x85\xfb\xcb\xe1h\x00\x00\xe0\x94n\xfd\x90\xb 55\xe0\v\xbd\x88\x9f\xda~\x9c1\x84\xf8y\xa1Q\u06ca\x02#\x85\xa8'\xe8\x15P\x00\x00\u07d4o\x0 5\x16f\xcbO{\u04b1\x90r!\xb8)\xb5U\u05e3\xdbt\x89_h\xe8\x13\x1e\u03c0\x00\x00\u07d4o\x0e\xd d#\xbc\xd8 \\x15\xf9(\x9c(\x84\x1f\xe0L\x83\xef\xeb\x89\x01\t\x10\xd4\xcd\xc9\xf6\x00\x00\u07d4 o\x13zq\xa6\xf1\x97\xdf,\xbb\xf0\x10\u073d<DN\xf5\xc9%\x89lk\x93[\x8b\xbd@\x00\x00\u07d4o\x 17`e\xe8\x8e<o\xe6&&}\x18\xa0\x88\xaa\xa4\u06c0\xbc\x89\xbe\xd1\xd0&=\x9f\x00\x00\u07d 4o\x18\xecv~2\x05\b\x19 \x13tP\x0e?.\x12V\x89\xff\x8965\u026d\xc5\u07a0\x00\x00\u07d4o\x1fl\ a\xb8\xf6\x1f\fQV\x8di(\x06\xb3\x82\xf5\x03\$\xf5\x89lk\x93[\x8b\xbd@\x00\x00\u07d4o\$\u026f+v4 \x80Q]\x1b\tQ\xbbw\xa5@\xf1\xe3\xf9\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4o%v\xdaM\u20fb\xe8\ xe3\xeei\xdd\xd6n^q\x1d\xb3\xf5\x89DY\x1dg\xfe\u0300\x00\u07d4o)\xbb7[\xe5\xed4\ud65b\x b80\xee)W\xdd\xe7m\x16\x89lk\x93[\x8b\xbd@\x00\x00\u07d4o*1\x90\x0e\$\x03\x95\xb1\x9f\x15\x 9c\x1d\x00\xdf\xe4\u0618\xeb\u07c9If\x06E\xaaG\x18\x00\x00\u07d4o*B\xe6\xe03\xd0\x10a\x13\ x19)\xf7\xa6\xee\x158\x02\x1eR\x89lk\x93[\x8b\xbd@\x00\x00\u07d4o9\xcc7\u02aa-

 $\label{thm:convent} $$ \u071ba\x0fa1\xe0a\x9f\xaew*<\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4oD\xca\t\xf0\u01a8) $$ L\xbdQ\x9c\xdcYJ\xd4,gW\x9f\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4oP\x92\x97w\x82L) $$ \x1a\xc4m\xc8T\xf3y\xa6\xbe\xa0\x89\x13\x84\x00\xec\xa3d\xa0\x00\x00\x00\xe0\x94ol\xf2\x06l\xa9\xe9s\x17z\xc6\xba\xde\xe4\xeb\xe5\u01fd\u068a\x01\x13c)\x01\xa8\x00\x00\u07d4oy\x1d5\x9b\xc3Sj1]c\x82\xb8\x83\x11\xaf\x8e\xd6\xdaG\x89\x04\xfc\xc1\xa8\x90'\xf0\x00\x00\u07d4oy\M\x$

 $bd\xf6\#\u06a6\xe0\xd0\at\xadibs\x92\x1e\xa4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4oz\u0181\xd4^A\x8f\u038b:\x1d\xb5\xbc;\xe6\xf0l\x98l\x89lk\x93[\x8b\xbd@\x00\x00\u07d4o\x81\xf3\xab\xb1\xf9\x8b\xbd@\x00\x00\u07d4o\x81\xf3\xab\xb1\xf9\x8b\xb1\xf9\x8b\xb6\xb6\x89\x0f-$

 $\label{thm:color$

 $\xf5{\u042b\x9a\xe8\x19l\xd5\n\xb0\xc5!\xab\xa9\xf9\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4p\#\xc7\t}$ V\xe0J\x92\xd7\x00%\xaa\u0497\xb59\xaf5Xi\x89lk\x93[\x8b\xbd@\x00\x00\u07d4p%\x96]+\x88\x da\x19}DY\xbe=\xc98cD\xcc\x1f1\x89I\xb7\xe7Hg\xd5\xe6\x00\x00\u07d4p(\x02\xf3m\x00%\x0f\xa b\$\xad\xbc\u0596\xf0\x17oc\x8aI\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4pH\x19\xd2\xe4Mn\xd1\xda %\xbf\u0384\u011f\u0322V\x13\xe5\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4pJn\xb4\x1b\xa3O\ x13\xad\xdd\xe7\xd2\xdb}\xf0I\x15\u01e2!\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4pJ\xb1\x15\r^\x1 0\xf5\xe3I\x95\b\xf0\xbfpe\x0f\x02\x8dK\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4pJ\xe2\x1dvn\x1d\xde(\xc25\xd11\x04Yr6\xdb\x1a\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4pM\$<)x\xe4I,\x86\xad\x be\xcd\$n;)_\xf63\x89m\x12\x1b\xeb\xf7\x95\xf0\x00\x00\u07d4pM]\xe4\x84m9\xb5<\xd2\x1d\x1cl\ xd7\u05e8\x17\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\xe0\x94pan(\x92\xfa&\x97\x05\xb2\x04k\x8f\x e3\xe7/xa5X\x16\u04ca\x04<3\xc1\x93ud\x80\x00\x00\u07d4pg\x0f\xbb\x05\xd30\x14DK\x8d\x1e \x8ew\x00%\x8b\x8c\xaam\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4p\x81\xfak\xaa\xd6\u03f7\xf5\x1b,\ $xca\x16\xfb\x89p\x99\x1ad\x89\f\xae\xc0\x05\xf6\xc0\xf6\x80\x00\xe0\x94p\x85\xae\alpha=\mbox{M}\x93!\$ x97\xb5\u01c5\x8c\x00\xa3gF&\xb7\xa5\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4p\x86\xb4\xb d\xe3\xe3]J\xeb\$\xb8%\xf1\xa2\x15\xf9\x9d\x85\xf7E\x89lh\xcc\u041b\x02,\x00\x00\u07d4p\x8a*\x f4%\u03b0\x1e\x87\xff\xc1\xbeT\xc0\xf52\xb2\x0e\xac\u0589\aE\u0503\xb1\xf5\xa1\x80\x00\u07d 4p\x8e\xa7\a\xba\xe45\u007f\x1e\xbe\xa9Y\u00e2P\xac\u05aa!\xb3\x89\x1b\x1a\xe4\xd6\xe2\xefP \x00\x00\u0794p\x8f\xa1\x1f\xe3=\x85\xad\x1b\xef\u02ee8\x18\xac\xb7\x1fj}~\x88\xfc\x93c\x92\x8 0\x1c\x00\x00\u07d4p\x9101\x16\xd5\xf28\x9b##\x8bMej\x85\x96\u0644\u04c9;N~\x80\xaaX3\x00

 $\label{thm:collinear} $$ \x95\x94/\x89\|x\y95\|x\y94/\x89\|x\y93\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\y90\|x\$

 $\label{thm:convention} $$ \end{tabular} $$ \end{tabular$

N\u02e8q\x97t\x1a\xa9\xdf\xe9c8\x89\x03@\xaa\xd2\x1b;p\x00\x00\xe0\x94q+vQ\x02\x14\xdcb\x 0fl:\x1d\u049a\xa2+\xf6\xd2\x14\xfb\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4q/\xf77\n\x13\xed 6\ts\xfe\u071f\xf5\xd2\xc9:P^\x9e\x89\u0556{\xe4\xfc?\x10\x00\x00\u07d4q3\x84:x\xd99\u019dD\x 86\xe1\x0e\xbc{*4\x9f\xf7\x89\x11\xd5\xca\xcc\xe2\x1f\x84\x00\x00\u07d4qH\xae\xf32a\xd8\x03\x 1f\xac?q\x82\xff5\x92\x8d\xafT\u0649\xdeB\xee\x15D\u0750\x00\x00\u07d4qcu\x8c\xbblLR^\x04\x 14\xa4\n\x04\x9d\xcc\xcc\xe9\x19\xbb\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convolu07d4qh} $$ \x00\x00\u07d4qh\x00\x00\x00\u07d4qirN\xe7\q\xc54\xca\xd6B\x0f\xb0N\xe6D\u02c6\xfe\x89\x16<+@\u06e5R\x00\x00\u07d4\qi\xd3\xc3:\x9b\x9a\n\x18\x96sW\x96\x9b\x94\xee}^*\xbc\x10\x89\x1a!\x17\xfeA*H\x00\x00\xe0\x94\qk\xa0\x1e\xad*\x91'\x065\xf9_%\xbf\xaf-\xd6\x10\xca\#\x8a\ty\xe7\x01$

\x16?\xed\x8a\x032n\xe6\xf8e\xf4\"\x00\x00\u07d4q\x80\xb8>\xe5WC\x17\xf2\x1c\x80r\xb1\x91\u0615\xd4aS\u00c9\x18\xef\xc8J\xd0\u01f0\x00\x00\u07d4q\x94kq\x17\xfc\x91^\xd1\a8_B\u065d\xda\x62I\u0089lk\x93[\x8b\xbd@\x00\x00\x00\x00\x00\u07d4q\x9e\x89\x1f\xbc\xc0\xa3>\x19\xc1-\xc0\xf0\9\xca\x05\xb8\x01\u07ca\x01OU8F:\x1bT\x00\x00\u07d4q\xc7#\n\x1d5\xbd\u0581\x9e\u0539\xa8\x8e\x94\xa0\xeb\a\x86\u0749\uc80b5=\$\x14\x00\x00\u07d4q\xd2\xccm\x02W\x8ce\xf7<W^v\u038f\xbc\xfa\xdc\xf3\v\x89\x03\xec\xc0xh\x8aH\x00\x00\u07d4q\xd9INP\xc5\xddY\u0159\u06e3\x81\v\xa1u^e7\xf0\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4q\xe3\x8f\xf5E\xf3\x0f\xe1L\xa8c\xd4\xf5)\u007f\u050cs\xa5\u0389\xc2\x12z\xf8X\xdap\x00\x00\u07d4q\xea[\x11\xad\x8d)\xb1\xa4\xcbg\xbf X\xcal\x9f\x9c3\x8c\x16\x89\v\xbcu\xe2\xd61\x00\x00\u07d4q\xec:\xec?\x8f\x92!\xf9\x14\x9f\x ed\xe0i\x03\xa0\xf9\xa22\xf2\x89\n\u05ce\xbcZ\xc6

k}p\x1a\x16:\r\xab1\xaeM1\u0589WG=\x05\u06ba\xe8\x00\x00\u07d4r\x01\xd1\xc0i

 $5\xe8\xe4\xeex\tu0009b08a\x02\x1e\x19\xe0\tu027a\xb2@\x00\x00\tu07d4r\x1f\x9d\x17\xe5\xa0\xe7B\x05\x94z\xeb\x9b\tu01a7\x93\x89a\x03\x8f\x89\x02\xd0A\xd7\x05\xa2\xc6\x00\x00\tu07d4r\tw17\xe5\xe7q\x17\x81\xd2n\xaaN\x84\x85\xf7\xaa?\xacD\x83\x89\x18\xb8Ep\x02*$

\x00\x00\u07d4r9=7\xb4Q\xef\xfb\x9e\x1f\xf3\xb8U'\x12\xe2\xa9p\xd8\u00895e\x9e\xf9?\x0f\xc4\x 00\x00\u07d4r=\x8b\xaa%Q\u04ad\xdcC\xc2\x1bE\xe8\xafL\xa2\xbf\xb2\u0089 h\xe8\x13\x1e\u0 3c0\x00\x00\xe0\x94r@#\x00\xe8\x1d\x14I.dN+\xbd\xa1\xda\x16<\xa3\xfbV\x8a\x01\x\x83\xc0i\x1 6\x00\x00\x94rH\v\xed\xe8\x1a\xd9d#\xf2\"\x8b\\a\xbeD\xfbR1\x00\x8a\x01Z\xf1\u05cbX\xc4\ x00\x00\x00\u07d4rL\xe8X\x85~\xc5H\x1c\x86\xbd\x90n\x83\xa0H\x82\xe5\x82\x1d\x89\xa2\xa1]\t Q\x9b\xe0\x00\x00\x00\x94rj\x14\xc9\x0e?\x84\x14Lv\\\xff\xac\xba>\r\xf1\x1bH\xbe\x8a\x02\x1e\x 19\xe0\u027a\xb2@\x00\x00\u07d4r\x83\xcdFu\xdaX\u0116UaQ\xda\xfd\x80\xc7\xf9\x95\xd3\x18\ x89)3\x1eeX\xf0\xe0\x00\x00\u07d4r\x86\xe8\x9c\xd9\u078fz\x8a\x00\xc8o\xfd\xb59\x92\u0752Q\ u0449i*\xe8\x89p\x81\xd0\x00\x00\u07d4r\x8f\x9a\xb0\x80\x15}\xb3\a1V\xdb\xca\x1a\x16\x9e\xf3\ x17\x94\a\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4r\x94\xc9\x18\xb1\xae\xfbM%\x92~\xf9\u0 5d9\xe7\x1f\x93\xa2\x8e\x85\x89\n\xad\xec\x98?\xcf\xf4\x00\x00\xe0\x94r\x94\uc763\x10\xbckK\x bd\xf5C\xb0\xefE\xab\xfc>\x1bM\x8a\x04\xa8\x9fT\xef\x01!\xc0\x00\u07d4r\x9a\xadF'tNS\xf5\ xd6c\t\xaatD\x8b:\xcd\xf4o\x89lk\x93[\x8b\xbd@\x00\x00\u07d4r\xa2\xfc\x86u\xfe\xb9r\xfaA\xb5\r\ xff\u06fa\xe7\xfa*\u07f7\x89\x9a\xb4\xfcg\xb5(\xc8\x00\x00\u07d4r\xa8&\b&)G&\xa7[\xf3\x9c\u066 $a\x9e\a\x3\xea\x14\u0349\k\x93\xeb\xbd@\x00\x00\u07d4r\xb0Yb\xfb*\u0549\xd6Z\xd1j\"U\x9e\xeq$ xba\x14X\xf3\x87\x89\a?u\u0460\x85\xba\x00\x00\u07d4r\xb5c?\xe4w\xfeT.t/\xac\xfdi\f\x13xT\xf2\ x16\x89Z\x87\xe7\xd7\xf5\xf6X\x00\x00\u07d4r\xb7\xa0=\xda\x14\u029cf\x1a\x1dF\x9f\xd376\xf6s \xc8\xe8\x89lk\x93[\x8b\xbd@\x00\x00\u07d4r\xb9\x04D\x0e\x90\xe7

\xfb\x1b\xd2yB\xa6\x96\xba\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4r\xd0=M\xfa\xb3P\f\xf8\x9b\x86\x86\x15\xd4R\x8e\x14\xa1\x95\x89\xf3K\x82\xfd\x8e\x91

x00\u07d4s\x06\xde\x0e(\x8bV\xcf\u07d8~\xf0\xd3\xcc)f\a\x93\xf6\u0749\x1b\x8a\xbf\xb6.\xc8\xf6\ x00\x00\x00\x94s\r\x87c\u01a4\xfd\x82J\xb8\xb8Y\x16\x1e\xf7\xe3\xa9j\x12\x00\x8a\x04<3\xc1\x9 3ud\x80\x00\x00\u07d4s\x12\x81sH\x95(\x01.v\xb4\x1a^(\u018b\xa4\xe3\xa9\u050965\u026d\xc5\ u07a0\x00\x00\u07d4s\x13F\x12\bETUFTE\xa4Y\xb0l7s\xb0\xeb0\x89lk\x93[\x8b\xbd@\x00\x00\u07d4s\x13F\x12\bETUFTE\xa4Y\xb0l7s\xb0\xeb0\x89lk\x93[\x8b\xbd@\x00\x00\u07d4s\xea\xd6\x0f{\xfd\u05a9\xde\u0101%\xe3s]\xb1\xb6eO\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4sB#\xd2\u007f\xf2>Y\x06\xca\xed\"YW\x01\xbb4\x83\f\xa1\x89lk\x93[\x8b\xbd@\x00\x00\u07d4sG>r\x11Q\x10\xd0\xc3\xf1\x17\b\xf8nw\xbe+\xb0\x98<\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u007d4sRXm\x02\x1a\xd0\xcfw\xe0\xe9(@JY\xf3t\xffE\x82\x89\xb8Pz\x82\a(

 $\label{thm:convolu07d4sUvxebs+xa9u076f} $$ \x00\x00\u07d4sUvxebs+\xa9\u076f\xdaz\xe4\x06\xe1\x8f\u007f\xeb\x0f\x8b\xb2\x89\x97\xc9\xceL\xf6\xd5\xc0\x00\x00\u07d4s[\x97\xf2\xfc\x1b\xd2K\x12\an\xfa\xf3\xd1(\x80s\xd2\f\x8c)\x89\x01\xseF\t\x13\xd0\x00\x00\u07d4s^2\x86f\xedV7\x14+3\x06\xb7\xccT\xe7,=\x89j\xb8\xf3\xy\u025 1\x00\x00\u07d4sc\u0350\xfb\xab[\xb8\u011a\xc2\x0f\xc6,9\x8f\xe6\xfbtL\x89lk\x93[\x8b\xbd@\x00\x00\u07d4skDP=\xd2\xf6\xddTi\xffL[-$

\xb8\xeaO\xece\u0409\x11\x04\xeeu\x9f!\xe3\x00\x00\xe0\x94sk\xf1@,\x83\x80\x0f\x89>X1\x92X* \x13N\xb52\xe9\x8a\x02\x1e\x19\u0493\xc0\x1f&\x00\x00\xe0\x94s\x8c\xa9M\xb7\u038b\xe1\xc3\ x05|\u0598\x8e\xb3v5\x9f3S\x8a\x05f[\x96\xcf5\xac\xf0\x00\x00\u07d4s\x91K\"\xfc/\x13\x15\x84\$}\ x82\xbeO\ucfd7\x8a\u053a\x89|k\x93[\x8b\xbd@\x00\x00\u07d4s\x93'\t\xa9\u007f\x02\u024eQ\xb 0\x911(e\x12#\x85\xae\x8e\x89M\x85<\x8f\x89\b\x98\x00\x00\u07d4s\x93\xcb\xe7\xf9\xba!e\xe5\x a7U5\x00\xb6\xe7]\xa3\xc3:\xbf\x89\x05k\xc7^-

\xd7\xc0/\xa1\x89lk\x93[\x8b\xbd@\x00\x00\u07d4tK\x03\xbb\xa8X*\xe5l\x8e-\xc2-\x19\x94\x94g\xabS\xfc\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4tL\fw\xba\u007f#i \xd1\xe44\xde]\xa3>H\xeb\xf0,\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4tP\xff\u007f\x99\xea\xa9\x11

\u0089\x03@\xaa\xd2\x1b;p\x00\x00\xe0\x94t\x80\xdeb%O+\xa8+W\x82\x19\xc0{\xa5\xbeC\r\xc3\\u02ca\x01}\xa3\xa0L{>\x00\x00\xe0\x94t\x84\xd2k\xec\xc1\xee\xa8\xc61^\xc3\xee\nE\x01\x17\\u0706\xa0\x8a\x85t%Fo\x80\x00\x00\u07d4t\x86:\xce\xc7]\x03\xd5>\x86\x0ed\x00/,\x16^\S\x83w\x8965\u026d\xc5\u07a0\x00\x00\u07d4t\x89\u030a\xbeu\u0364\xef\r\x01\xce\xf2`^G\xed\\xa6z\xb1\x89\a?u\u0460\x85\xba\x00\x00\u07d4t\x8c(^\xf1#?\xe4\xd3\x1c\x8f\xb17\x833r\x1c\x12\xe2z\x89lk\x93[\x8b\xbd@\x00\x00\u07d4t\x90\x87\xac\x0fZ\x97\xc6\xfa\xd0!S\x8b\xf1\xd6\u0361\x8e\r\xaa\x8965\u026d\xc5\u07a0\x00\x00\u07d4t\x95\xaex\xc0\xd9\x02a\xe2\x14\x0e\xf2\x061\x04\x1a`\xd1\xed\x89\x01\xdbPq\x89%!\x00\x00\u07d4t\x9aJv\x8b_#rH\x93\x8a\x12\xc6#\x84{\xd4\xe6\x88\u0709\x03\xe73b\x87\x14}

 $\label{thm:convolu07d4t} $$ \x00\x00\u07d4t\x9a\xd6\xf2\xb5pk\xbe/h\x9aD\u0136@\xb5\x8e\x96\xb9\x92\x89\x05k\xc7^-c\x10\x00\x00\u07d4t\xa1\u007f\x06K4N\x84\xdbce\u0695\x91\xff\x16(\%vC\x89\x01\x15\x8eF\t\x15\xd0\x00\x00\u07d4t\xae\xec\x91]\xe0\x1c\u019b,\xb5\xa65o\xee\xa1FX\xc6\u0149\f\x9a\x95\xee)\x86R\x00\x00\u07d4t\xaf\xe5l\x02\xd6\x15x\%v\xf8\xba\xac\x13\xac\x97\f\x05\x0f\n\x89\t\xa1\xaa\xa3\xa9\xfb\xa7\x00\x00\u07d4t\xb7\xe0\"\x8b\xae\xd6YW\xae\xbbM\x91m3:\xae\x16O\x0e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4t\xbcJ^$

 $E\xf4\xff\x8d\xb1\x84\xcf:\x9b\f\x06Z\xd8\a\u0489lk\x93[\x8b\xbd@\x00\x00\u07d4t\xbc\xe9\xec86]$

\x00\x00\u07d4t\xd3zQt{\xf8\xb7q\xbf\xbfC\x9493\xd1\x00\xd2\x14\x83\x8965\u026d\xc5\u07a0\x 00\x00\u07d4t\xd6q\u065c\xbe\xa1\xabW\x90cu\xb6?\xf4+PE\x1d\x17\x8965\u026d\xc5\u07a0\x 0\x00\u07d4t\xeb\xf4BVF\xe6\u03c1\xb1\t\xce{\xf4\xa2\xa6=\x84\x81_\x89\x02+\x1c\x8c\x12'\xa0\ x00\x00\u07d4t\xed3\xac\xf4?5\xb9\x8c\x920\xb9\xe6d.\xcbS0\x83\x9e\x89\$\xf6\xdf\xfbI\x8d(\x00\ x00\u07d4t\xef(i\xcb\xe6\b\x85`E\xd8\xc2\x04\x11\x18W\x9f\"6\xea\x89\x03<\xd6E\x91\x95n\x00\x 00\u07d4t\xfcZ\x99\xc0\xc5F\x05\x03\xa1;\x05\tE\x9d\xa1\x9c\xe7\u0350\x89\n\u05ce\xbcZ\xc6 \x00\x00\u07d4u\v\xbb\x8c\x06\xbb\xbf\$\bC\xccux.\xe0\b\xa9t\$\x89-

 $C\xf3\xeb\xfa\xfb,\x00\x00\u07d4u\x14\xad\xbd\xc6?H?0M\x8e\x94\xb6\u007f\xf30\x9f\x18\v\x82\x89!\u0120n-$

\x13Y\x80\x00\u0794u\x17\xf1I(\xd12\xbb@\xe3\xba6\u01ae\xf11\xc4b\xda\x17\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4u\x1a,\xa3Nq\x87\xc1c\u048e6\x18\xdb(\xb1<\x19m&\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\x00\x94u\x1a\xbc\xb6\xcc\x030Y\x91\x18\x15\xc9o\u04516\n\xb0D-

rj\x13\xd0\xf2\x13\r\x9f\x89k\x8965\u026d\xc5\u07a0\x00\x00\u07d4ub\x18e\xb6Y\x13e`n\xd3x0\x8c-

\xa7F\x876_I\x89\t\xf7J\xe1\xf9S\xd0\x00\x00\u07d4v\x1el\xae\xc1\x89\xc20\xa1b\xec\x00e0\x19 >g\u03dd\x19\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94v\x1f\x8a:*\U00028f7e\x1d\xa0\t2\x1f\xb2\x97

 $d\x00\x01\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4v)\x98\xe1\xd7R'\xfc\xedzp\xbe\x10\x9aL\vN\xd8d\x14\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4v-$

o0\u06b9\x915\xe4\xec\xa5\x1dRC\xd6\xc8b\x11\x02\u0549\x0fI\x89A\xe6d(\x00\x00\u07d4v3\x1 e0yI\xe6d\xb2p\x0e\rASp\x0e\u0706\x97w\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4v8\x86\xe33\xc5o\xef\xf8[\xe3\x95\x1a\xb0\xb8\x89\xce&.\x95\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4v:|\xba\xb7\rzd\u0 427\xe5)\x80\xf6\x81G%\x93I\f\x89

\x88\xb9\x8b\xc8)\xa6\xf9\x00\x00\u07d4vF\x92\xcc\xcb3@]\u042b\f3y\xb4\x9c\xaf\x8eb!\xba\x89\ x01\x15\x8eF\t\x13\xd0\x00\u07d4vMR\x12&:\xffJ*\x14\xf01\xf0N\xc7I\u0708>E\x89dI\xe8NG\ xa8\xa8\x00\x00\xe0\x94vO\xc4mB\x8bm\xbc\"\x8a\x0f U\xc9P\x8cw.\xab\x9f\x8a\x05\x81v{\xa6\ x18\x9c@\x00\x00\u07d4vPn\xb4\xa7\x80\xc9Q\xc7J\x06\xb0=;\x83b\xf0\x99\x9dq\x89\x1b\x1a\x e4\xd6\xe2\xefP\x00\x00\x94v[\xe2\xe1/b\x9ecI\xb9}!\xb6*\x17\xb7\xc80\xed\xab\x8a\x01EB\x ba\x12\xa37\xc0\x00\x00\xe0\x94vb\x81P\xe2\x99[['\x9f\xc8>\r\xd5\xf1\x02\xa6q\xdd\x1c\x8a\bxg\ x83&\xea\xc9\x00\x00\x00\u07d4vk7Y\xe8yN\x92m\xacG=\x91:\x8f\xb6\x1a\xd0\xc2\u0249\x04\xb 0m\xbb\xb4\x0fJ\x00\x00\u07d4vp\xb0/,<\xf8\xfdOG0\xf38\x1aq\xeaC\x1c3\u01c9\x0e~\xeb\xa3A\ vt\x00\x00\u07d4vz\x03eZ\xf3`\x84\x1e\x81\r\x83\xf5\xe6\x1f\xb4\x0fL\xd1\x13\x895e\x9e\xf9?\x0f \xc4\x00\x00\u07d4vz\u0190y\x1c.#E\x10\x89\xfelp\x83\xfeU\u07b6+\x89,s\xc97t,P\x00\x00\u07d 4v\u007f\xd7y}Qi\xa0_sd2\x1c\x19\x84:\x8c4\x8e\x1e\x89\x01\x04\xe7\x04d\xb1X\x00\x00\u0794v \x84o\r\xe0;Zv\x97\x1e\xad)\x8c\xdd\b\x84:K\xc6\u0188\xd7\x1b\x0f\u088e\x00\x00\xe0\x94v\x84\ x98\x93N7\xe9\x05\xf1\xd0\xe7{D\xb5t\xbc\xf3\xecJ\xe8\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4 v\x8c\xe0\u06a0)\xb7\xde\xd0\"\xe5\xfcWM\x11\xcd\xe3\xec\xb5\x17\x89\x11t\xa5\xcd\xf8\x8b\xc8 \x00\x00\xe0\x94v\x93\xbd\xebo\xc8+[\xcar\x13U\"1u\xd4z\bKM\x8a\x04\xa8\x9fT\xef\x01!\xc0\x0 0\x00\u07d4v\xaa\xf8\xc1\xac\x01/\x87R\xd4\xc0\x9b\xb4f\a\xb6e\x1d\\\xa8\x89\x01\x15\x8eF\t\x1 $8b\xbd@\x00\x00\u07d4v\xaf\xc2\%\xf4\xfa0}\xe4\x84U+\xbe\x1d\x9d?\x15\aLJ\x89\xa2\x90\xb5\u$ 01ed9h\x00\x00\xe0\x94v\xbe\xca\xe4\xa3\x1d6\xf3\xcb\W\u007f*CYO\xb1\xab\xc1\xbb\x96\x8a\x 05C\xa9\xce\x0e\x132\xf0\x00\x00\u07d4v\xc2u5\xbc\xb5\x9c\xe1\xfa-

 $\x8b\xfc\x14,\xb1\ue25a\x18\xff\xe7B\d\x00\x00\xe0\x94v\xf9\xad=\x9b\xbd\x04\xae\x05\\\x14w\xc0\xc3^u\x92\xcb^* \x8a\b\x83?\x11\xe3E\x8f$

 $\label{thm:convoluo7d4v} $$ \x00\x00\u07d4v\xff\xc1W\xadk\xf8\xd5m\x9a\x1a\u007f\u077c\x0f\xea\x01\n\xab\xf4\x8965\u026d\xc5\u07a0\x00\x00\u07d4w\x02\x8e@\x9c\xc4:;\xd3=!\xa9\xfcS\xec`n\x94\x91\x0e\x89\xd2U\xd1\x12\xe1\x03\xa0\x00\x00\u07d4w\f/\xb2\u0128\x17S\xac\x01\x82\xeaF\x0e\xc0\x9c\x90\xa5\x16\xf6\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4w\r\x98\xd3\x1bCS\xfc\xee\xe8V\fL\u03c0>\x88\xc0\xc4\xe0\x89$

 $\label{thm:convolu07d4w} $$ \x95\xadtY\xc7W`\u077 $$ \x82\xff\xd8\u0368\x89\kLM\xa6\u077e\x00\x00\u07d4w'\xaf\x10\x1f\n\xab\xa4\xd2:\x1c\xaf\xe1| n\xb5\u06b1\xc6\u0709\k\x93[\x8b\xbd@\x00\x00\u07d4w,)\u007f\n\u0454H.\xe8\xc3\xf06\xbd\xeb\xb1\xc2\xo1\xc6\u0309\n\u05ce\xbcZ\xc6\x00\x00\xe0\x94\w0o\xfe.J\x8f<\xa8&\xc1\xa2l\xf7!-\xa4:\xef\xfd\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\w1A\x12\x8c\xf3\x18\xae\xbf\x886Z\xdd=U'\xd8[j\x8966\u05ef^\u024e\x00\x00\u07d4\wF\xb6\xc6i\x9c\x8f4\xca'h\xa8$$

 $[\&CE\x823\xc6O\xc3?\xd7[\x89]k\x93[\x8b\xbd@\x00\x00\u07d4wa~\xbcK\xeb\xc5\xf5\xdd\xeb\x1 bzp\xcd\xebj\xe2\xff\xa0$\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4wiC\xff\xb2\xef\\xd5\xb8<(\xbc\x04k\xd4\xf4gp\x98\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\xe0\x94wp\x1e,I=\xa4|\x1bX\xf4!\xb5I]\xeeE\xbe\xa3\x9b\x8a\x01H\xf6I\xcfaB\xa5\x80\x00\u07d4wy\x8f$

 $\label{thm:condition} $$ \a4\x1d\x89lk\x93[\x8b\xbd@\x00\x00\u07d4w\xbekd\xd7\xc73\xa46\xad\xec^\x14\xbf\x9a\xd7@ +\x1bF\x8965\u026d\xc5\u07a0\x00\x00\u07d4w\xbf\xe9<\u0367P\x84~A\xa1\xaf\xfe\xe6\xb2\u06 96\xe7!N\x89\x10C\x1a\x88)0\x00\x00\u07d4w\u0126\x97\xe6\x03\xd4+\x12\x05l\xbb\xa7a\xe7\xf5\x1d\x04C\xf5\x89\xdc\xe5M4\xa1\xa0\x00\x00\u07d4w\xcc\x02\xf6\#\xa9\u03d8S\t\x97\xeag\xd9\xf5\x1d\x04C\xf5\x89\x03\xc3n\xa0\xc2\x00\x00\u07d4w\xd4?\xa7\xb4\x81\xdb\xf3\xdbS\f\xfb\xf5\xfd\xce\xd0\xe6W\x181\x89lk\x93[\x8b\xbd@\x00\x00\u07d4w\xda^lr\xfb6\xbc\xe1\xd9y\x8f\xcd\xf1\u044fE\x9c.\x89\x016\x95\xbbl\xf9>\x00\x00\u07d4w\xf4\xe3\xbd\xf0V\x88<\xc8r\x80\xdb\xe6@\xa1\x88\r\x92\xa2\a2\a2\a2\a2\a2\a2\a2\x89\n\x81\x99:+\xfb[\x00\x00\u0794w\xf6\t\u0287\xa0\#\&,U\xc4o-$

&\xfb90\xaci\x88\xf0\x15\xf2W6B\x00\x00\u07d4w\xf8\x1b\x1b&\xfc\x84\xd6\u0797\uf2df\xbdr\xa3 10\xccJ\x8965\u026d\xc5\u07a0\x00\x00\u07d4x\x19\xb0E\x8e1N+S\xbf\xe0\f8I_\u0539\xfd\xf8\u 0589\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4x\x1b\x15\x01dz.\x06\xc0\xedC\xff\x19\u007f\xcc\xec 5\xe1p\v\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4x\x1b\x15\x01dz.\x06\xc7w\x16\xd5t\xc8\x1e\xc4hO\x9a\x 02\n\x97\x89.\x14\xe2\x06\xb70\xad\x80\x00\u07d4x5]\xf0\xa20\xf8=\x03,p1TAM\xe3\xee\u06b5 W\x89\k\x93[\x8b\xbd@\x00\x00\u07d4x6\xf7\xefk\u01fd\x0f\xf3\xac\xafD\x9c\x84\xddk\x1e,\x93\x 9f\x89\xe0\x8d\xe7\xa9,\xd9|\x00\x00\u07d4x7\xfc\xb8v\xda\x00\xd1\xeb;\x88\xfe\xb3\xdf?\xa4\x0 4\xac\x82\x89_h\xe8\x13\x1e\u03c0\x00\x00\u07d4x\\x8e\xa7t\xd70D\xa74\xfay\n\x1b\x1et>w\xed|\x89\fxf1Rd\f\\x83\x00\x00\u07d4x`\xa3\xde8\xdf8*\xe4\xa4\xdc\xe1\x8c\f\a\xb9\x8b\xce=\xfa\x89

65\u026d\xc5\u07a0\x00\x00\x94xcCq\xe1s\x04\xcb\xf39\xb1E*L\xe48\xdcvL\u038a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4xd\u0719\x9f\xe4\xf8\xe0\x03\xc0\xf4=\xec\u00da\xae\x15\"\x dc\x0f\x89\x05\x1e\x10+\xd8\xec\xe0\x00\x00\u07d4xtj\x95\x8d\xce\xd4\xc7d\xf8vP\x8cAJh4,\uce 49\x02\xbe7O\xe8\xe2\xc4\x00\x00\x00\xe0\x94x\1?\xd3k\x05>\xee\xae\xdb\xcet\xb9\xfb\x06x32\x89\x8a\x05\xc0X\xb7\x84"\x19`\x00\x00\u07d4x\x85\x9c[T\x8bp\r\x92\x84\xce\xe4\xb6c</R\xe5)\u008 9\xa00\xdc\xeb\xbd/L\x00\x00\xe0\x94x\x8e\x80\x97A\xa3\xb1J\"\xa4\xb1\xd97\xc8,\xfe\xa4\x89\u ef8a\x01\x\x83\xc0i\x16`\x00\x00\u07d4x\xa1\xe2T@\x9f\xb1\xb5Z|\xb4\u074e\xba;0\u023a\xd9\x ef\x89\x05k\xc7^-

\n\b\xc7\x0f\x99\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4x\u03c36\xb3(\xdb=\x87\x81:G+\x9e\x89\xb7^\f\xf3\xbc\x8965\u026d\xc5\u07a0\x00\x00\u07d4x\xd4\xf8\xc7\x1c\x1eh\xa6\x9a\x98\xf5/\xcbE\u068a\xf5n\xa1\xa0\x89lk\x93[\x8b\xbd@\x00\x00\u07d4x\xdf&\x81\xd6\xd6\x02\xe2!B\xd5A\x16\u07a1]EIW\xaa\x89\x10'\x94\xad

\xf1\xdc@2n\x85\x05\x8965\u026d\xc5\u07a0\x00\x00\u07d4yu\x10\xe3\x86\xf5c\x93\xce\xd8\xf4\w7\x8aDLHO}\xad\x8965\u026d\xc5\u07a0\x00\x00\u07d4y{\xb7\xf1W\xd9\xfe\xaa\x17\xf7m\xa4\xf7\x04\xb7M\xc1\x03\x83A\x89\xb5\x0f\u03ef\xeb\xec\xb0\x00\x00\u07d4y\x88\x90\x131\xe3\x87\xf7\x13\xfa\u03b9\x00\\\xb9\xb6Q6\xeb\x14\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4y\x89\u041f8&\xc3\u5bccu*\x81\x15r:\x84\xd8\tp\x89\x16\x86\xf8aL\xf0\xad\x00\x00\x00\x00\u07d4y\x89\u041f8&\xc3\u5bccu*\x81\x15r:\x84\xd8\tp\x89\x16\x86\xf8aL\xf0\xad\x00\x00\x00\x00\x00\u07d4y\x8e\xe2\xe0\xc6\{\xf1\u01e51\xd4w\xbc\xa1\xb2\xb9ua\x8a\x01BH\xd6\x17\x82\x9e\xce\x00\x00\u07d4y\xae\xb1\x\exp\x52\x\x81\xde\xc0\xy2\\xa7\xdf]%\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4y\xb4\x8d-a7\u00c5Ma\x1c\x01\xeaBBz\x0fY\xb7\x89\nZ\xa8P\t\xe3\x9c\x00\x00\u07d4y\xb8\xaa\xd8y\xdd0\\v~\x87x\xd2\xd21\xc8\xf3z\xb8sN\x89lk\x93[\x8b\xbd@\x00\x00\u07d4y\xbf/\n2\x8a\xaf&\xe0\xbb\t?\xa2-

 $\x 2\x 9 e\x f 2\x f 4 q\x 8 9 a\t = \|, m 8\x 0 0\x 0 0\u 0 7 d 4 y\x c 1 0\x c 7 b\x b 8 v [\x 1 9\u 0 4 a b\u 0 2 6 0\x 8 3\x a b\x 8 f:\x a d\x 0 0\x 0 0\x$

 $\label{thm:convention} y@\x89\u0556{\xe4\xfc?\x10\x00\u07d4y\xc1\xbe\x19q\x1fs\xbe\xe4\xe61j\xe7T\x94Y\xaa\u0} 3a2\xe0\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4y\xc6\x00/\x84R\xca\x15\u007f\x13\x17\xe8\n/\xaf\GUY\xb7\x89\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4y\xca\xc6IO\x11\xef'\x98t\x8c\xb52\x85\xbd\x8e''\xf9|\u0689lk\x93[\x8b\xbd@\x00\x00\u07d4y\u03e9x\n\xe6\xd8{,1\x88?\t'i\x86\u021ag5\x8965\u026d\xc5\u07a0\x00\x00\u07d4y\u06e2VG-}$

 $\label{thm:color$

\xfcw\x0e\$6\x811\xb7\x84w\x95\xf2\x03\xf3\xd5\r[V\x8a\x02i\xfe\xc7\xf06\x1d\x00\x00\u07d4z3\x83N\x85\x83s>-

\x86\xac5\x10R`\x00\x00\xe0\x94z\xbb\x10\xf5\xbd\x9b\xc3;\x8e\xc1\xa8-

 $d\xb5[k\x18wuA\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4z\u010d@\xc6d\u031am\x89\xf1\xc5\xf5 \xc8\n\x1cp\xe7D\u6263\x10b\xbe\xee\xd7\x00\x00\x00\u07d4z\u014fo\xfcO\x81\a\xaen07\x8eN\x9f\x99\xc5\u007f\xbb\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4z\xd3\xf3\aao\x19\u0731C\xe6D \M\xab\x9c<3a\x1fR\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4z\xd8,\xae\xa1\xa8\xb4\xed\x$

051\x9b\x9c\x98p\x17<\x81N\x06\xee\x89!d\xb7\xa0J\u0220\x00\x00\u07d4z\xde]f\xb9D\xbb\x86\f x90E\v\x85U\x02p\x88<{\xb7\x89\x11x\xfa@Q]\xb4\x00\x00\u07d4z\xe1\xc1\x9eS\xc7\x1c\xeeLs\ xfa\xe2\xd7\xfcs\xbf\x9a\xb5\u348965\u026d\xc5\u07a0\x00\x00\u07d4z\xe6Y\xeb;\xc4hR\xfa\x86 \xfa\xc4\xe2\x1cv\x8dP8\x89E\x89\x0f\x81\f\x1c\xb5\x01\xb8\x00\x00\u07d4z\xea%\xd4+&\x12(n\ x99\xc56\x97\u01bcA\x00\xe2\u06ff\x89lk\x93[\x8b\xbd@\x00\x00\u07d4z\xef{U\x1f\v\x9cF\xe7U\ xc0\xf3\x8e[:s\xfe\x11\x99\xf5\x89P\xc5\xe7a\xa4D\b\x00\x00\u07d4{\v1\xffn\$t^\xad\x8e\u067b\x8 5\xfc\v\xf2\xfe\x1dU\u0509+^:\xf1k\x18\x80\x00\x00\x00\x94{\x0f\xea\x11v\xd5!Y3:\x14<)IC\xda6\x bb\u0774\x8a\x01\xfc}\xa6N\xa1L\x10\x00\x00\u07d4{\x11q<\xc0\x19bk)\f\xbd\xce&\x04o~m\x14\x $1e!\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x12!b\xc9\x13\xe7\x14\xad\v~\xd3z\xff\xc9*\v\xeq$ f2\u007f\x89Q\xaf\tk#\x01\u0440\x00\u07d4{\x1b\xf5:\x9c\xbe\x83\xa7\u07a44W\x9f\xe7*\xac\x8d* \f\u0409\n\xd4\xc81j\v\f\x00\x00\u07d4{\x1d\xaf\x14\x89\x1b\x8a\x1e\x1b\xd4)\u0633k\x9aJ\xa1\u 066f\xbf\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4{\x1f\xe1\xabM\xfd\x00\x88\xcd\xd7\xf6\x01 c\xefY\xec*\xee\x06\xf5\x89lk\x93[\x8b\xbd@\x00\x00\u07d4{%\xbb\x9c\xa8\xe7\x02!~\x933\"RP\x e5<6\x80MH\x89e\xea=\xb7UF`\x00\x00\u07d4{'\xd0\xd1\xf3\xdd<\x14\x02\x94\xd0H\x8bx>\xbf@\ x15'}\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\xe0\x94{@\a\xc4^ZW?\u06f6\xf8\xbdtk\xf9J\xd0J<&\x8a \x038!\xf5\x13]%\x9a\x00\x00\u07d4{C\xc7\xee\xa8\xd6#U\xb0\xa8\xa8\x1d\xa0\x81\xc6Dk3\xe9\x e0\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4{M*8&\x90i\xc1\x85Ww\rY\x1d\$\xc5\x12\x1f^\x83\x8 9%\xf2s\x93=\xb5p\x00\x00\xe0\x94{au\xec\x9b\xef\xc78\$\x955\xdd\xde4h\x8c\xd3n\xdf%\x8a\x0 2\x1e\x19\xe0\u027a\xb2@\x00\x00\xe0\x94{f\x12hy\x84M\xfa4\xfee\xc9\xf2\x88\x11\u007f\xef\xb 4I\xad\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4{j\x84q\x8d\xd8nc3\x84)\xac\x81\x1d|\x8a\x86\ xaeMn.\xf5\x00\x00\u07d4{s\$-

 $u (u 0 2 9 a x d 5 X x d 6 P) (r x f 1 v x 9 2 x d 5 L (u 0 6 3 8 x 8 9 ln Y x e 6 | x T x 0 0 x 0 0 (u 0 7 d 4 { v x 1 f x e b (u 0 0 7 f (u 0 3 e 7 x d e x d 1 x f 0 x e b x 0 5 x 8 f J ` v x f 3 x a 7 b (u 0 2 c 9 x f 9] x d 2 x e c 'x c c x e 0 x 0 0 x 0 0 x e 0 x 9 4 { x 8 2 | x a e (u 0 0 7 f (x f 4 t t x 1 8 x f 2 x e 0 0 x a b & u 0 2 d 8 x c 4 x f 4 | x f 5 x 8 a x 0 1 x 9 4 h L v 9 x d e x 1 0 x 0 0 x 0 0 x 0 0 x e 0 x 9 4 { x 8 9 2 x 8 6 } e r x d b! x 9 a! x f c M x c d_x b f Y (< 1 x 8 a x 0 2 x 1 e x 1 9 x e 0 (u 0 2 7 a x b 2 @ x 0 0 x 0 0 u 0 7 d 4 { x 9 2 & x d 4 o x e 7 Q x 9 4 v x c 4 x 1 6 x a 7 x 9 8 x b 6 x 9 c x c f r x f a x b 6 g x 8 9 u 3 b b 5 s r @ x a 0 x 0 0 x 0 0 u 0 7 d 4 { x 9 8 x e 2 < x b 9 k x e e x e 8 n x 1 6 x 8 0 i u b e 8 f$

\xed\xd5\\\u03c9\v\xa0\xc9\x15\x87\xc1J\x00\x00\u07d4{\xb0\xfd\xf5\xa6c\xb5\xfb\xa2\x8d\x9c\x9\x9\x10\xc8\x11\xe2R\xf2\x98\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convolu07d4} $$\x00\x00\u07d4{\xb9W\x1f9K\vx1a\x8e\xbaVd\xe9\u0635\xe8@g{\xea\x89\x01\x11du\x9f\xfb2\x00\x00\xe0\x94{\xb9\x84\xc6\u06f9\xe2y\x96j\xfa\xfd\xa5\x9c\x01\xd0&'\xc8\x04\x8a\x01\xb4d1\x1d}$$$E\xa6\x88\x00\x00\u07d4{\xbb\xec^p\xbd\xea\u063b2\xb4(\x05\x98\x8e\x96H\xc0\xaa\x97\x8966\u05ef^\u024e\x00\x00\u07d4{\xca\x1d\xa6\xc8\nf\xba\xa5\xdbZ\u0245A\u013e'kD}\x89\xcf\x04\x96\x80\xfa<\x00\x00\u07d4{\u0772\xee\x98\xde\x19\xeeL\x91\xf6a\xee\x8eg\xa9\x1d\x05K\x97\x8965\u026d\xc5\u07a0\x00\x00\x00\u0794{\xe2\xf7h\x80-}$

 $\label{thm:condition} $$ \xa6\x15L\x92\xc0\x19J\xe72Qzqi\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4{\xe7\xf2Eiq\x88;\x9a\x80\xbeL\x91\xde\xc0\x8a\xc3N\x88b\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4{\xe8\u0334\xf1\x1bf\xcan\x1dW\xc0\xb59b!\xa3\x1b\xa5:\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\x00\xe0\x94{\xeb\x81\xfb/^x}$$ 91Rk*\xc9y^v\u019b\xcf\xf0K\xc0\x8a\x0e\xb2.yO\n\x8d\x00\x00\u07d4|\b\x83\x05L-$

 $\x02\xbcz\x85+\x1f\x86\xc4'w\xd0\xd5\xc8V\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x0f\a$

C\xc9\xeet\x02B\x19~x\xccK\x98\xcd\xf9`\x89\n\u05ce\xbcZ\xc6

 $8q'; U xf5; x89 \ln xb6 @ 9 x12 x010 x00 \times 00 \ln 07 d4 > xb7 x13 xc4 xc9 xe08 x1c xd8 x15L | x9a x xb8d x x1c xd8 x x15L | x9a xb8d x x1c xd8 x x15L | x9a xb8d x x1c xd8 x x15L | x9a xb8d x x15$

 $\label{local} $$ \x00\x00\u07d4|D\x01\xae\x98\xf1.\xf6\xde9\xae\u03df\xc5\x1f\x80\xeb\xa1k\x89\n\u05ce\xbcZ\xde9\xae\xf1.$

 $< :\x8a?\x87\bW\xa3\xe0\xe3\x80\x00\x00\u07d4|`\xa0_zJ_\x8c\xf2xC\x916.uZ\x83A\xefY\x89f\x94 \xf0\x18*7\xae\x00\x00\u07d4|`\xe5\x1f\v\xe2(\xe4\xd5o\xdd)\x92\xc8\x14\xdaw@\u01bc\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4|i\xd0|>\xf5\x89\x19f\xfe\nxV\xc8{\xef}\x9d$

4\x89|k\x93[\x8b\xbd@\x00\x00\x94|\x8b\xb6Zo\xbb|\xbdA3\x96\xa9\xd7\xe3\x10S\xbb\xb3z\x a9\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\xe0\x94|\x9a\x11\f\xb1\x1f%\x98\xb2\xb2\xb2\x0e,\xa4\x002^ A\xe9\xdb3\x8a\x05\x81v{\xa6\x18\x9c@\x00\x00\u07d4|\xbc\xa8\x8f\xcaj\x00`\xb9`\x98\\\x9a\xa1\ xb0%4\xdc\"\b\x89\x19\x12z\x13\x91\xea*\x00\x00\u07d4|\xbe\xb9\x992\xe9~n\x02\x05\x8c\xfcb\u 0432k\xc7\u0325+\x89|k\x93[\x8b\xbd@\x00\x00\u07d4|\xc2Jj\x95\x8c

 $\label{total label} $$ \xc7\xd1$\x96`\xf7Xb&\x95\v/r\x9a\x89\x0b=\xf2-\x1f\x88\x00\x00\u07d4\xd2\x0e\u0335\x18\xb6\fxab\t[r\x0fW\x15p\u02aaD-\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xd5\xd8\x1e\xab7\xe1\x1ebv\x33\x31\tx12Q`-\r-8\x89\x03hM^\xf9\x81\xf4\x00\x00\u07d4\xdft\9E\x95=\xb3\x9a\xd0\xe8\x9a\xd0\xe8\x39\xx1a\xddy.M\x1d\x89\xb3\xb4\xb0\xb0\x00\x00\u07d4\xe4hdF\u000547be\xd6r\x15\xeb\rZ\x1d\xd7,\x11\xb8\x89\x9\xd3\xb8\x1a\xb8\x00\x00\x00\u07d4\xefMC\xaaA\u007f\x9e\xf8\xb7\x87\xf8\xb9\x9dS\xf1\xfe\xa1\ue209q\x8a\x93$

b\xe4\x18\x00\x00\u07d4\\x03P\xe4\v3\x8d\xdasfa\x87+\xe3?\x1f\x97R\xd7U\x89\x02\xb4\xf5\xa6 \U00051500\x00\xe0\x94}\x04\xd2\xed\xc0X\xa1\xaf\xc7a\xd9\u025a\xe4\xfc\\\x85\xd4\u0226\x8a $x01\x9f\x8euY\x92L\x00\x00\xe0\x94\x13\xd6pX\x84\xab!W\u074d\xccpF\xca\xf5\x8e\xe9K\xe4\x$ 8a\x1d\r\xa0|\xbb>\xe9\xc0\x00\x00\u07d4}'>c~\xf1\xea\u0101\x11\x94\x13\xb9\x1c\x98\x9d\xc5\x ea\xc1\"\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4*R\xa7\xcf\f\x846\xa8\xe0\a\x97kl&\xb7\"\x 9d\x1e\x15\x89\x17\xbf\x06\xb3*\$\x1c\x00\x00\u07d4\4\x805i\xe0\v\u05b5\x9f\xff\b\x1d\xfa\\\n\xb4 $0\x18\x89\xa2\xa1\tQ\x9b\xe0\x00\x00\u07d4\9(R\xf3\xab\xd9\xf4\xbb[\xb2\xb6\bt\xf2\xbeg\x95\xb]$ 8966\xc2^f\xec\xe7\x00\x00\u07d4}DRg\u015a\xb8\u04a2\xd9\xe7\t\x99\x0e\th%\x80\u011f\x8965 \u026d\xc5\u07a0\x00\x00\xe0\x94\U\x13\x97\xf7\x9a)\x88\xb0d\xaf\xd0\xef\xeb\xee\x80,w!\xbc\x 8a\bW\xe0\xd6\xf1\xdav\xa0\x00\x00\u07d4\Z\xa3?\xc1KQ\x84\x1a\x06\x90n\xdb+\xb4\x9c*\x11ri\ x89\x10D\x00\xa2G\x0eh\x00\x00\xe0\x94}]/s\x94\x9d\xad\xda\bV\xb2\x06\x98\x9d\xf0\a\x8dQ\xa 1\xe5\x8a\x02<upr\xb8\xdd\x00\x00\x00\x00\xe0\x94\n\x99\r\xaaq\x05\xde%&3\x983\xf7{\\\v\x85\xd8O \x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4}s\x8608\xcc\xca\"\xf9j\xff\xda\x10InQ\xe1\xe6\xcdH\x89 $\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4}\xd5\xeeaM\xbbo\xbf\xbc\xd2c\x05\x8cA\xfa\xa1\x$ 89lk\x93[\x8b\xbd@\x00\x00\u07d4}~|aw\x9a\xdbw\x06\xc9M2@\x9a+\xb4\u953f`\x89.\xf2\r\x9f\xc

7\x1a\x14\x00\x00\u07d4}\x82\xe5#\xcc-

\x05y<\x97!\x13\xea\u8b88\x89b\x8d\xd1w\u04bc(\x00\x00\u07d4}\x90\x1b(\xbf\u007f\x88\xefs\xd8\xf7<\u0297VI\x13\xea\x8a\$\x893\xc5I\x901r\f\x00\x00\u07d4}\x98\x0fKVk\xb0EQ~L\x14\xc8wP\u0793FtK\x89Hz\x9a0E9D\x00\x00\xe0\x94}\x9cYc\x1e+\xa2\xe8\xe8(\x91\xf3\x97\x99\"\xaa\xa3\xb5g\xa1\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4}\x9d\"\x1a=\xf8\x9d\xd4{_a\xc1F\x8cg\x87\u05b33\xe6\x89\a{\"|\xd8;\xe8\x00\x00\x00\u07d4}\xa7a4E\xa2\x12\x99\xaat\xf0\xadqC\x1e\xc4?\xbb\x1b\xe9\x89\x03\xaf\xb0\x87\xb8v\x90\x00\x00\u07d4}\xb4\xc7\u0577\x97\xe9)nc\x82\xf2\x03i=\xb4\tD\x9db\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4}\xb9\xea\xccR\xe4)\u0703\xb4a\xc5\xf4\xd8\x\10\xe58:(\x8965\u026d\xc5\u07a0\x00\u07d4}\xd8\u05e1\xa3O\xa1\xf8\xe7<\xcb\x00_\u00a0:\x15\xb8\\"\x9c\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convolu07d4} $$\x00\x00\u07d4}\x00\x00\u07d4\\\xe4B\xc8\#\x86\x15M.\x99<\xbd\x12\x80\xbb|\xa6\xb1*\u0689\xd8\xf2\xe8$$\sim\xc9H\x00\x00\u07d4\\\xe7\xfeA\x9c\xc6\x1f\x91\xf4\b\xd24\u0300\xd5\xca=\x05M\x99\x89\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4\\\xec\u664a\xe1\x90\r\xd3w\f\xf4\xb98\x12\xba\xd8O\x03\"\x89\x05k\xc7^-c\x10\x00\x00\u07d4\\\xfc4-$

 $$$ \x 0.0 \times 0.0$

 $c\x10\x00\x00\u07d4~\x86I\xe6\x90\xfc\x8c\x1b\xfd\xa1\xb5\xe1\x86X\x1fd\x9bP\xfe3\x89\x05V\xf6L\x1f\xe7\xfa\x00\x00\u07d4~\x87\x86>\xc4:H\x1d\xf0M\x01\wb\xed\xcb\\\xaab\x9bZ\x89\x02\''\xc8\xeb?\xf6d\x00\x00\u07d4~\x8f\x96\xcc)\xf5{\tu\x12\fxb5\x93\xb7\u0743=\kS\x89\n\xad\xec\x98?}$

 $\label{thm:convolu07d4-xf10} $$ \x 00 \x 00 \u 07d4-xf10 \x 00 \x 00 \x 00 \u 07d4-xf9 \x 00 \x 00 \x 00 \u 07d4-xf9 \x 00 \$

 $\label{thm:convention} $$ \x86\xac5\x10R^\x00\x00\u07d4\u007f7\t9\x1f?\xbe\xba5\x92\xd1u\xc7@\xe8z\tT\x1d\x02\x89\x1a\x05V\x90\xd9\u06c0\x00\x00\u07d4\u007f8\x9c\x12\xf3\xc6\x16OdFV\wf\x95\x03\xc2y%'\x89\x05V\xf6L\x1f\xe7\xfa\x00\x00\xe0\x94\u007f:\x1eE\xf6~\x92\u0200\xe5s\xb43y\xd7\x1e\xe0\x89\xdb\T\x8a\x15-$

05e7\xbe\xf4\xc2y\x97\x89\x03@\xaa\xd2\x1b;p\x00\x00\u07d4\u007f`:\xec\x17Y\xea_\a\xc7\xf8\x d4\x1a\x14(\xfb\xba\xf9\xe7b\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\u007falo\x00\x8a\u07e0\x82\xf3M\xa7\xd0e\x04`6\x80u\xfb\x8965\u026d\xc5\u07a0\x00\x00\u07d4\u007fa\xfal\xf5\xf8\x98\xb4@\xda\u016b\xd8`\rmi\x1f\xde\xf9\x89\x0f-

c\x10\x00\x00\u07d4\u007f\x8d\xbc\xe1\x80\xed\x9cV65\xaa\xd2\xd9{L\xbcB\x89\x06\u0649\x90\x f54`\x8ar\x88\x00\x00\xe0\x94\u007f\x99=\xdb~\x02\u0082\xb8\x98\xf6\x15 h\x0e\xf5\xb9\xaf\xf9\ a\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\u007f\x9f\x9bV\xe4(\x9d\xfbX\xe7\x0f\xd5\xf1*\x97\xb5 $m5\u01a5\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\u007f\xa3~\xd6x\x87u\x1aG\x1f\x0e\xb3\x06\xbe$ D\xe0\xdb\xcd`\x89\x899vt\u007f\xe1\x1a\x10\x00\x00\u07d4\u007f\xaa0\xc3\x15\x19\xb5\x84\xe9 rP\xed*<\xf38^\xd5\xfdP\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u007f\xcf[\xa6fo\x96ITH\xc1{\xf1\xcb \v\xbc\xd8\x01\x9b\x06\x89\x05k\xc3\u042e\xbeI\x80\x00\xe0\x94\u007f\xd6y\xe5\xfb\r\xa2\xa5\xd 1\x16\x19M\xcbP\x83\x18\xed\u0140\xf3\x8a\x01c\x9eI\xbb\xa1b\x80\x00\x00\u07d4\u007f\u06e0 1\u01cf\x9c\tmb\xd0Z6\x9e\uac3c\xccU\u5257\xc9\xceL\xf6\xd5\xc0\x00\x00\u07d4\u007f\xdb\u00 e8D\xe4\r\x96\xb2\xf3\xa652.`e\xf4\xca\x0e\x84\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u007f\xdf\u0 20dx\xbf\x1b(Z\xc6O\x1a\xdb5\xdc\x11\xfc\xb09Q\x89|\x06\xfd\xa0\/xb06\x00\x00\u07d4\u007f\xe a\x19b\xe3]b\x05\x97h\xc7l\xbe\u0756\u02b90\xd3x\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u007f\x ef\x8c8w\x9f\xb3\a\xeco\x04K\xeb\xe4\u007f<\xfa\xe7\x96\xf1\x89\t#@\xf8l\xf0\x9e\x80\x00\u07d4 $\u007f\xf0\xc6?p\x1b\xec\xe1\x9bs~SA\xb1+\x10\x901\u0609\x12\xc1\xb6\xee\xd0=(\x00\x00\xee)$ 0\x94\u007f\xfa\xbf\xbc9\f\xbeC\u0389\x18\x8f\bh\xb2}\xcb\x0f\f\xad\x8a\x01YQ\x82\"K&H\x00\x0 0\xe0\x94\u007f\xfd\x02\xed7\fp`\xb2\xaeS\xc0x\xc8\x01!\x90\u07fbu\x8a\x02\x1e\x19\xe0\u027a\ xb2@\x00\x00\u0794\x80\x02*\x12\a\xe9\x10\x91\x1f\xc9(I\xb0i\xab\f\xda\xd0C\u04c8\xb9\x8b\xc 8)\xa6\xf9\x00\x00\u07d4\x80\t\xa7\xcb\u0452\xb3\xae\u052d\xb9\x83\xd5(ER\xc1ltQ\x89\xd8\xd7 &\xb7\x17z\x80\x00\u07d4\x80\x0e\c\x1cnW:\x903/\x17\xf7\x1f \u045bR\x8c\xb9\x89\b=Iz\xa bc`\x00\x00\u07d4\x80\x15m\x10\ufa320\u0254\x10c\r7\xe2i\xd4\t<\xea\x89lk\x93[\x8b\xbd@\x00\ x00\u07d4\x80\x172\xa4\x81\u00c0\xe5~\xd6-I)\u0799\x8a\xf3\xfa;\x13\x89\x05k\xc7^-

 $c\x10\x00\x00\u07d4\x80\x1de\xc5\x18\xb1\x1d\x0e?OG\x02!Ap\x13\xc8\xe5>\u0149\xd8\xd7\&xb7\x17z\x80\x00\x00\u07d4\x80\&CZ\xacr\x8dI\{\x19\xb3\xe7\xe5|(\xc5c\x95O+\x89]\u0212\xaa\x111\xc8\x00\x00\u07d4\x80-\xc3\xc4\xff-$

 $\# \u0789\x10CV\x1a\x88)0\x00\u07d4\x805\xfeNkj\xf2z\u44a5xQ^\x9d9\xfao\xa6[\x89\xd8\xd7 & \xb7\x17z\x80\x00\u07d4\x80C\xed\"\xf9\x97\u58a4\xc1n6D\x86\xaed\x97V\x92\u0109=I\x0 & \xff\xc9\x11.\x80\x00\u07d4\x80C\xfd\u043cL\x97=\x16c\xd5_\xc15P\x8e\xc5\xd4\xf4\xfa\x89\x01 & \x15\x8eF\t\x13\xd0\x00\u07d4\x80L\xa9IrcOc:Q\xf3V\v\x1d\x06\xc0\xb2\x93\xb3\xb1\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\x80R-$

\u07d4N\xc5.'\xd7\xedL\x93\xe1\xf7\xbe`\x83\u0589\n\u05ce\xbcZ\xc6

 $c\x10\x00\x00\u07d4\x80\x90\u007fY1H\xb5|F\xc1w\xe2=\%\xab\u012a\xe1\x83a\x89\x05k\xc7^-c\x10\x00\x00\u07d4\x80\x97s\x16\x94NYB\xe7\x9b\x0e:\xba\u04cd\xa7F\be\x19\x89\x02\x1auJm\xc5(\x00\x00\xe0\x94\x80\xa0\xf6\xcc\x18|\xf6$

\xe1p\xdb\xd7#\xf4T\xe8\x8fw\x16E-\x92\x98P\x92\x89\x10F#\xc0v-

 $\label{thm:converse} $$ \x00\x00\u07d4\x80\xb7\x9f3\x83\x90\u047a\x1b77\xa2\x9a\x02W\xe5\xd9\x1e\a1\x89\x01\x15\x8eF\tx13\xd0\x00\u07d4\x80\xbf\x99^\u063a\x92p\x1d\x10\xfe\u011f\x9e}\x01M\xbe\xe0&\x89\x1f\x047\xca\x1a\x12\x80\x00\u07d4\x80\xc0N\xfd1\x0fD\x04\x83\xc7?tK[\x9edY\x9c\xe3\xec\x89A\xf]$

\x8bJ\x13\x01%\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x80\xcc!\xbd\x99\xf3\x90\x05\u014f\xe4\xa4 H\x90\x92

 $\label{thm:linear_lin$

 $R0 \times 35 \times 1 \times 100 \times 40 \times 100 \times 100$

?r\x95\x8cT;e\x80\xd4\f\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\x81\x14a\xa2\xb0\u0290\xba\xda\xc 0j\x9e\xa1nx{3\xb1\x96\u0309\b\xe3\xf5\v\x17<\x10\x00\x00\u07d4\x81\x16M\xeb\x10\x81J\xe0\x 83\x91\xf3,\bf{bH\xc2}z\x89\x15[\xd90\u007f\x9f\xe8\x00\x00\u07d4\x81\x18i1\x18A7\xd1\x19*\u0 20c\xd3\xe1\xe5\xd0\xfd\xb8jt\x89\x9d5\x95\xab\\$8\xd0\x00\x00\u0794\x81*U\xc4<\xae\xdcYr\x18 7\x90\x00\xceQ\rT\x886\xfd\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\x81.\xa7\xa3\xb2\xc8n\xed2\xffO,sQL\xc6;\xac\xfb\u038965\u026d\xc5\u07a0\x00\x00\u07d4\x814\xdd\x1c\x9d\xf0\xd6\u0225\x81\\$&\xbbU\xc7a\u0283\x1f\b\x89\x06\xa2\x16\v\xb5|\xcc\x00\x00\u07d4\x81A5\u068f\x98\x11\a\W\x83\xbf\x1a\xb6pb\xaf\x8d>\x9f@\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x81I\x8c\xa0{\x0f\x17\xe8\xbb\xc7\xe6\x1a\u007fJ\xe7\xbef\xbf\xb7\x8b\x89\x05\x81\xfb\xb5\xb3;\xb0\x00\x00\u07d4\x81U\x

falQ\xeb1\xd8\bA-

 $t\x8a\xa0\x86\x10P\x18\x12\x89e\xea=\xb7UF`\x00\x00\xe0\x94\x81V6\v\xbd7\ta\xce\xcakf\x91\xd7P\x06\xad$

 $L\xf2\x8a\bxg\x83\&\xea\xc9\x00\x00\x00\u07d4\x81a\xd9@\xc3v\x01\x00\xb9\b\x05)\xf8\xa6\x03 \\ \%\x03\x0fn\u0709\x10C\v\x1a\x88)0\x00\x00\xe0\x94\x81d\xe7\x83\x14\xae\x16\xb2\x89\&\xccU=,\xcb\x16\xf3V'\r\x8a\x01\xca\x13N\x95\xfb2\xc8\x00\x00\u07d4\x81e\u02b0\xea\xfbZ2\x8f\xc4\x1a\xc6M\xaeq[.\xef,e\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x81h\xed\xce\u007f)a\xcf)[\x9f\xcdZE\xc6] \\ \xc6M\xde\xdan\xf5\x89\n\u05ce\xbcZ\xc6]$

L\xa0\x00\x00\u07d4\x81y\xc8\tp\x18,\u0177\xd8*M\xf0n\xa9M\xb6:%\xf3\x89'o%\x9d\xe6k\xf4\x0 0\x00\u07d4\x81z\xc3;\xd8\xf8G\ysr\x95\x1fJ\x10\u05e9\x1c\xe3\xf40\x89\n\xd7\xc4\x06\xc6m\xc1 \x80\x00\xe0\x94\x81\x8f\xfe'\x1f\u00d75e\xc3\x03\xf2\x13\xf6\xd2\u0689\x89~\xbd\x8a\x016\xe0 SB\xfe\u1e40\x00\u07d4\x81\x97\x94\x81!s.c\xd9\xc1H\x19N\xca\xd4n0\xb7I\u0209\xd8\xd7&\xb7 \x17z\x80\x00\x00\u07d4\x81\x9a\xf9\xa1\xc2s2\xb1\xc3i\xbb\xda\x1b=\xe1\xc6\xe93\xd6@\x89\x 11\t\xe6T\xb9\x8fz\x00\x00\x00\u07d4\x81\x9e\u06a506x\xef|\xecY\u050c\x82\x16:\xcc`\xb9R\x8a\x0 3\x13QT_y\x81I\x00\x00\u07d4\x81\x9e\xb4\x99\vZ\xbaUG\t=\xa1+k<\x10\x93\xdfmF\x8965\u026 d\xc5\u07a0\x00\x00\u07d4\x81\xa8\x81\x96\xfa\xc5\xf2<>\x12\xa6\x9d\xecK\x88\x0e\xb7\xd9s\x 10\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\x81\xbc\xcb\xff\x8fD4~\xb7\xfc\xa9['\xce|\x95\$\x92\xaa\xa d\x89\b@\xc1!e\xddx\x00\x00\u07d4\x81\xbdu\xab\xd8e\xe0\xc3\xf0J\vO\xdb\xcbt\xd3@\x82\xfb\x b7\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x81\xc1\x8c*#\x8d\xdcL\xba#\n\a-

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\x82.\xdf\xf66\V:a\x06\xe5.\x9a\%\x98\xf7\xe6\xd0\xef'\x82\x89\x01\xf4\xf9i=B\u04c0\x00\u07d4\x822\x19\xa2\v\xbb^*\xa4\xaf\x8b\xadA\xac5&\xb4\x936\x1f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x822\xd1\xf9t.\u07cd\xd9'\xda5;*\xe7\xb4\xcb\xceu\x92\x89$=M\x18\"\x9c\xa2\x00\x00\u07d4\x824\xf4c\u0444\x85P\x1f\x8f\x85\xac\xe4\x97,\x9bc-$

\xbc\u0309Ik\x93[\x8b\xbd@\x00\x00\u07d4\x827htg7\xcem\xa3\x12\xd5>TSN\x10o\x96|\xf3\x89\x01\x15\x8eF\t\x13\xd0\x00\u07d4\x82;\xa7dr8\xd1\x13\xbc\xe9\x96JC\u0420\x98\x11\x8b\xf

eM\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\x82@t1(\x06\xdaGHCBf\xee\x00!@\u305a\u0089Q\xb1\u04c3\x92a\xac\x00\x00\u07d4\x82C\x8f\u04b3*\x9b\xddgKI\xd8\xcc_\xa2\xef\xf9x\x18G\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x82HW(\xd0\xe2\x81V7X\xc7Z\xb2~\xd9\u80a0\x00-

x15\x8eF\t\x13\xd0\x00\x00\u07d4\x82Q5\x8c\xa4\xe0`\u0775Y\xcaX\xbc\v\u077e\xb4\a\x02\x03\ x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x82Q5\xb1\xa7\xfc\x16\x05aL\x8a\xa4\u042cm\xba\u040fH\x 0e\x89M\x85<\x8f\x89\b\x98\x00\x00\u07d4\x82S\t\xa7\xd4]\x18\x12\xf5\x1en\x8d\xf5\xa7\xb9ol\x 90\x88\x87\x89\x804\xf7\u0671f\xd4\x00\x00\u07d4\x82Z\u007fN\x10\x94\x9c\xb6\xf8\x96Bh\xf1\x fa W\xe7\x12\xb4\u0109\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x82a\xfa#\f\x90\x1dC\xffW\x9fG\ x80\u04d9\xf3\x1e`v\xbc\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x82b\x16\x9baXp\x13N\xb4\xacl_G\ x1ck\xf2\xf7\x89\xfc\x89\x19\x12z\x13\x91\xea*\x00\x00\u07d4\x82c\xec\xe5\xd7\t\xe0\u05eeq\u0 328h\xed7\xcd/\xef\x80{\x895\xab\x02\x8a\xc1T\xb8\x00\x00\xe0\x94\x82I\xe5y\x052\xe0T\x8ca\x 02\xa3\r>\xac\x83k\xd68\x8f\x8a\x03\xcf\xc8.7\xe9\xa7@\x00\x00\u07d4\x82n\xb7\xcds\x19\xb8-82\xb0\v\x97T\xfc\xf7LU\xe22\x89\xc3(\t>a\xee@\x00\x00\u0794\x82u\xcdhL6y\u0548}\x03fN3\x8 $3E\xdc<\xdd\xe1\x88\xdbD\xe0I\xbb,\x00\x00\u07d4\x82\x84\x92;b\u62ff|+\x9f4\x14\xd1>\xf6\xc8\xc8$ x12\xa9\x04\x89\xd2U\xd1\x12\xe1\x03\xa0\x00\x00\u07d4\x82\x8b\xa6Q\u02d3\x0e\xd9xqV)\x9a =\xe4L\u040br\x12\x89Hz\x9a0E9D\x00\x00\u07d4\x82\xa1\\\xef\x1dl\x82`\xea\xf1Y\xea?\x01\x80 \xd8q}\xce\x1c\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x82\xa8\xb9kl\x9e\x13\xeb\xec\x1e\x9f\x18\xa c\x02\xa6\x0e\xa8\x8aH\xff\x89lk\x8c@\x8es\xb3\x00\x00\u07d4\x82\xa8\u02ff\xdf\xf0+.8\xaeK\xb f\xca\x15\xf1\xf0\xe8;\x1a\xea\x89\x04\x9b\x99\x1c'\xefm\x80\x00\u07d4\x82\xe4F\x1e\xb9\xd8I\xf 0\x04\x1c\x14\x04!\x9eBr\u0110\n\xb4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x82\xe5w\xb5\x15\xcb +\b`\xaa\xfe\x1c\xe0\x9aY\xe0\x9f\xe7\xd0@\x89

\x1ebl\xa5Fv\x86\x8a\x15-

 $\label{thm:colling} $$ \xo2\xc7\xe1J\xf6\x80\xo0\xo0\u07d4\x82\xffqo\xdf\xo3>\xc7\xe9B\xc9\t\u0643\x18g\xb8\xb6\xe2\xef\x89a\t=|,m8\xo0\xo0\u07d4\x83\b\xed\n\xf7\xf8\xa3\xc1u\x1f\xaf\xc8w\xb5\xa4*\xf7\xd3X\x82\x8965\u026d\xc5\u07a0\xo0\u07d4\x83\x1cD\xb3\b@G\x18K*\xd2\x18h\xo6@\x907P\xc4]\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\x83!\x05\x83\xc1jN\x1e\x1d\xac\x84\xeb\xd3~=\x0f|W\ub909lk\x93[\x8b\xbd@\x00\x00\u07d4\x83,T\x17k\xdfC\xd2\u027c\u05f8\b\xb8\x95V\xb8\x9c\xbf1\x89\n\u05ce\xbcZ\xc6$

\x8c9J\xf1\u0208\x00\x00\u07d4\x83\x8b\xd5e\xf9\x9f\xdeH\x05?y\x17\xfe3<\xf8J\xd5H\xab\x89\n\u05ce\xbcZ\xc6

 $n\x8a\x01\xf1\x0f\xa8'\xb5P\xb4\x00\x00\u07d4\x83\x98\xe0~\xbc\xb4\xf7_\xf2\x11m\xe7|\x1c*\x99\xf3\x03\xa4\u03c9\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x83\xa3\x14\x883\xd9d|\x84\xf7\xc4\u\xa7\x85\a\x16\ufd00\xff\x89\xb8Pz\x82\a($

\x00\x00\u07d4\x83\xa4\x02C\x8e\x05\x19w=TH2k\xfba\xf8\xb2\f\xf5-

\x89Rf<\u02b1\xe1\xc0\x00\x00\u07d4\x83\xa9;[\xa4\x1b\xf8\x87

 $\xe4\x15y\f\xdc\yg\xb4\xaf4\u0109\n\u05ce\xbcZ\xc6$

 $\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\x84\x00\x8ar\xf8\x03o?\xeb\xa5B\xe3Px\xc0W\xf3*\x88\x89\x05k\xc7^-$

c\x10\x00\x00\u07d4\x84\x0e\xc8>\xa96!\xf04\xe7\xbb7b\xbb\x8e)\xde\xd4\xc4y\x89\x87\x86x2n\x ac\x90\x00\x00\x00\x00\x94\x84\x11E\xb4H@\xc9F\xe2\x1d\xbc\x19\x02d\xb8\xe0\xd5\x02\x93i\x8a?\ x87\bW\xa3\xe0\xe3\x80\x00\x00\u07d4\x84#!\a\x93+\x12\xe01\x86X5%\xce\x02:p>\xf8\u0649lk\x 93[\x8b\xbd@\x00\x00\u07d4\x84\$O\xc9ZiW\xed|\x15\x04\xe4\x9f0\xb8\xc3^\xcaKy\x89lk\x93[\x8 b\xbd@\x00\x00\u07d4\x841']\xdd\x10E\xc0\x17@\x8c\x8d\xbb\xbdAJ\x8d\xf3\x89\x02\"\xc8\xeb ?\xf6d\x00\x00\u07d4\x847Z\xfb\xf5\x9b:\x1da\xa1\xbe2\xd0u\xe0\xe1ZO\xbc\xa5\x89\n\u05ce\xb cZ\xc6

 $\label{thm:linear} $$ \int_{xf4}\xf4_{xbd}(xbe_x02_u0689Hz_x9a0E9D_x00_x00_u07d4_x84_xccxx_xda___xdb_x01_x9f_xab_x9bL_xcf_xc1Wp_x9c_u0765_x89Hy_x85_x13_xaf_x04_xc9_x00_x00_u07d4_x84_xdb_x14Y_xbb_x00_x81.\\ 0\\x81.\\xa6_xcb=\\xc1_x89_xb7_x87_xd9_xc5_x01_x89_b_x11_xb8_xfb_u0685_xab_x80_x00_u07d4_x84_u9516_x80_xbe_xcehA_xb9_xa7_xe5_xrb_xac_xd8_x16_u0349_n_u05ce_xbcZ_xc6$

\x00\x00\u07d4\x84\xe9\u03c1f\xc3j\xbf\xa4\x90S\xb7\xa1\xad@6

 $\label{thm:linear_control_co$

 $c\x10\x00\x00\u07d4\x852I\b\x97\xbb\xb4\u038b\u007fk\x83\xb2\x84\x8f\xbe\x99v\x89\x05k\xc7^-$

c\x10\x00\u07d4\x85>j\xba\xf4Di\xc7\x15\x1dN\"8\x19\xac\xedN7(\x89lk\x93[\x8b\xbd@\x00\\x00\u07d4\x85F\x91\xceqO2\\\xedU\xceY(\u039b\xa1\xac\u0478\x89\xedp\xb5\xe9\xc3\xf2\xf0\x00\\u07d4\x85F\x91\xceqO2\\\xedU\xceY(\u039b\xa1\xac\u0478\x89\xedp\xb5\xe9\xc3\xf2\xf0\x00\\u07d4\x85L\fF\x9c\$k\x83\xb5\u0473\xec\xa4C\xb3\x9a\xf5\xee\x12\x8a\x89\\xbcu\xe2\xd61\\x00\x00\u07d4\x85[\x9a\xef,9\xc6#\r\t\u025e\xf6II\x89\xab\u61c5\x89\b\xbaR\xe6\xfcE\xe4\x00\x00\u07d4\x85c\u0113a\xb6%\xe7hw\x1c\x96\x15\x1d\xbf\xbd\x1c\x90iv\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\x85fa\t\x01\xaa\xce8\xb82D\xf3\xa9\xc810jg\xb9\u0709\xb0\x82\x13\xbc\xff\xe0\x00\x00\\x00\u07d4\x85fa\t\x01\xaa\xce8\xb82D\xf3\xa9\xc810jg\xb9\u0709\xb0\x82\x13\xbc\xff\xe0\x80\x00\x00\\x00\\x00\\x00\\x00\x00\\x

\u05c3'\xb4\x1c\x02\u02c9lk\x93[\x8b\xbd@\x00\x00\u07d4\x85\x94mV\xa4\xd3q\xa93hS\x96\x90\xb6\x0e\xc8%\x10tT\x89]\u0212\xaa\x111\xc8\x00\x00\x94\x85\x99\xcb\u0566\xa9\xdc\u053

\xa0K\xa1\xef\x00\x00\u07d4\x85\xc8\xf3\xccz5O\xea\u025a^{\xfe|\u07e3Q\xcf\xe3U\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u0794\x85\xca\x1er~\x9d\x1a\x87\x99\x1c\xc2\xc4\x18@\xeb\xb9\xed\xf2\x1d\x1b\x88\xb9\x8b\xc8)\xa6\xf9\x00\x00\u07d4\x85\u028b\xc6\xda(\x03\xd0r_^\x1aEl\x89\xf9\xbcwN\x89

 $\label{thm:linear} $$ \x86\xac5\x10R`\x00\x00\u07d4\x85\xd0\u0607T\xac\x84\xb8\xb2\x1b\xa9=\u04bf\xecrbo\xab\xa8\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x85\xeb\%kQ\xc8\x19\xd6\x0e\xa6\x1a\x82\xd1,\x93X\u05\x1c\xae\x89\x18\xef\xc8J\xd0\u01f0\x00\x00\u07d4\x85\xf0\xe7\xc1\xe3\xaf\xf8\x05\xa6'\xa2\xae\x1c\xef\xf6\xb4\xc0\xdb\xe9\u02c9\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4\x86\x02\xae\xae\x1c\xe7\xfc\xa2\xa6\x02\xa6\xa3d\x89\n\u05ce\xbcZ\xc6$$

\x00\x00\xe0\x94\x86c\xa2A\xa0\xa8\x9ep\xe1\x82\xc8E\xe2\x10\\\x8a\xd7&K\u03ca\x03#\xb1=\x 83\x98\xf3#\x80\x00\u07d4\x86g\xfa\x11U\xfe\xd72\u03f8\u0725\xa0\xd7e\xce\r\a\x05\xed\x89\x0 4n\xc9e\u00d3\xb1\x00\x00\u07d4\x86h\xaf\x86\x8a\x1e\x98\x88_\x93\u007f&\x15\xde\xd6u\x18\x 04\xeb-

\x00\x00\xe0\x94\x86\xb7\xbdV<\uad86\xf9bD\xf9\xdd\xc0*\u05f0\xb1K\u008a\x02\x1e\x19\xe0\u0

27a\xb2@\x00\x00\u07d4\x86\u008b\Vx\xaf7\xd7'\xec\x05\xe4Dw\x90\xf1_q\xf2\xea\x89\n\u05ce\x bcZ\xc6

\x00\x00\xe0\x94\x86\xc4\xce\x06\u066c\x18[\xb1H\xd9o{z\xbes\xf4A\x00m\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\xe0\x94\x86\xc8\xd0\u0642\xb59\xf4\x8f\x980\xf9\x89\x1f\x9d`z\x94&Y\x8a\x02\xce\xd3wa\x82O\xb0\x00\x00\u07d4\x86\xc94\xe3\x8eS\xbe;3\xf2t\xd0S\x9c\xfc\xa1Y\xa4\xd0\u04494\x95tD\xb8@\xe8\x00\x00\x00\xe0\x94\x86\xca\x01E\x95~k\r\xfe6\x87_\xbez\r\xecU\xe1z(\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\xe0\x94\x86\u02af\xac\xf3*\xa01|\x03*\xc3k\xab\xed\x97G\x91\xdc\x03\x8a\bxg\x83&\xea\xc9\x00\x00\x00\u07d4\x86\u0377\xe5\x1a\xc4Gr\xbe6\x90\xf6\x1d\x0eYvn\x8b\xfc\x18\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x86\xdfs\xbd7\u007f,\t\xdec\xc4Gr\xb6\xe9=\xa4\x86\xb1Bf\xea\xdf\x05|\xbf\xa4\xd9\x14C\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\x86\xe8g\x0e'Y\x8e\xa0\x96\x99\xabw\x11\u04f9\xfe\x90\x1c\x17\x89\n\u05ce\xbcZ\xc6

\x00\x00\xe0\x94\x86\xefd&!\x19\\xcc7\xf4\xc7^xP6\x9d\f\xf5\xf4y\x8a\x02\xd6_2\xea\x04Z\xf6\x00\x00\u07d4\x86\xf0]\x19\x06>\x93i\xc6\x00N\xb3\xf1#\x94:|\xffN\xab\x89|j\xccg\u05f1\xd4\x00\x00\u07d4\x86\xf2>\x9c\n\xaf\u01cb\x9c@M\xcd`3\x9a\x92[\xff\xa2f\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\x86\xf4\xf4\n\u0644\xfb\xb8\t3\xaebn\x0eB\xf93?\xddA\x8965\u026d\xc5\u07a0\x00\x00\x00\xe0\x94\x86\xf9\\[\x11\xa2\x93\x94\x0e5\xc0\xb8\x98\u0637_\b\xaa\xb0m\x8a\x06D\xe3\xe8u\xfc\xft\x00\x00\u07d4\x86\xff\xf2

\x00\x00\u07d4\x87I?!\x8bGv\xdf<\xa9\xdb\xfb'\r\xe1R\xd9N\xd2R\x89\x05k\xc7^-

\u0665Cr\xf8\x9c\xb0\x1f%/\xb1\x80\x89\n\u05ce\xbcZ\xc6

 $1\x1f\xccEd\x00\x00\u07d4\x87\u0118\x17\t4\xb8\#=\x1a\xd1\xe7i1\}\G_/@\x897\b\xba\xed=h\x90\x00\x00\u07d4\x87\xcf6\xad\x03\xc9\xea\xe9\x05:\xbbRB\u0791\x17\xbb\x0f*\v\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\xe0\x94\x87\u05ec\x06S\xcc\xc6z\xa9\xc3F\x9e\xefCR\x19?}\xbb\x86\x8a*Z\x05\x8f\u0095\xed\x00\x00\x00\xe0\x94\x87\xe3\x06+\#!\xe9\u07f0\x87\\u311c\x9b.5\"\xd5\n\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x87\xe6\x03N\xcf\#\xf8\xb5c\x9d_\x0e\xa7\n\"S\x8a\x92\x04\#\x89\x11\xc7\xea\x16.x$

\\\xaeC\xb2\x1f\x18aK\x89JD\x91\xbdm\xcd(\x00\x00\u07d4\x87\xfcF5&9D\xce\x14\xa4Iu\xfaJ\x82 7e\xc8?\xe7\xfd\xa9\xfc\x89\x05o\x98]8dK\x80\x00\xe0\x94\x88\x01]r\x03\xc5\xe0\"J\xed\xa2\x86\ xed\x12\xf1\xa5\x1bx\x933\x8a\x01\x0f\b\xed\xa8\xe5U\t\x80\x00\u07d4\x88\x10I'\xd2\vt\xb4\xb9\x 8c\xa6+#+\xd5\xc9t\x11\x17\x1f\x89\n\xad\xec\x98?\xcf\xf4\x00\x00\xe0\x94\x88\x120\x04|!\x1d-[\x00\xd8\xdeLQ9\xde^2'\u01ca\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x88*\xa7\x98\xbfA\x df\x17\x9f\x85R\x010\xf1\\\xcd\xf5\x9b^X\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\x88+\u04e2\xe9\x $d7A\x10\xb2la\xc57w\xf2\x1fF\xdc]\x8a\x02\xd4\xca\x05\xe2\xb4<\xa8\x00\x00\xe0\x94\x88,\x8f\xexb2$ 81\x87,y\xfe\xd5!\xcb_\x95\r\x8b\x03#\"\xeai\x8a\bxg\x83&\xea\xc9\x00\x00\x00\u07d4\x88/up\x83 \x86e<\x80\x17\x1d\x06c\xbf\xe3\v\x01~\u042d\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x884I\tdLz\u 0513\x0f\xd8s\xca\x1c\r\xa2\xd44\xc0\u007f\x89\a's\x9f\xcb\x00M\x00\x00\u07d4\x884\xb2E4q\xf 3\$\xfb&\xbe[%\x16k[W&\x02]\x89\x1f\x0f\xf8\xf0\x1d\xaa\xd4\x00\x00\u07d4\x88:x\xae\xab\xaaP\x d8\xdd\xd8W\v\xcd4&_\x14\xb1\x93c\x89\xd2U\"\xfd\xa3y\xa1\x80\x00\u07d4\x88E\xe9\xf9\x0e\x9 63k\xac<ak\xe9\u0604\x02h>\x00L\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\x88F\x92\x8dh2\x89\xa 2\xd1\x1d\xf8\xdbz\x94t\x98\x8e\xf0\x13H\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x88I\ x80\xebEe\xc1\x04\x83\x17\xa8\xf4\u007f\u06f4a\x96[\u4049\xd8\xd6\x11\x9a\x81F\x05\x00\x00\x e0\x94\x88Jz9\u0411n\x05\xf1\xc2B\xdfU`\u007f7\u07cc_\u068a\x04\xf4\x84<\x15|\x8c\xa0\x00\x 00\u07d4\x88T\x93\xbd\xa3j\x042\x97eF\xc1\xdd\xceq\xc3\xf4W\x00!\x89\v\xbfQ\r\xdf\xcb&\x00\x $00\xe0\x94\x88\x9e\nF[n\x99\xfc\xe9\a\x16mW\xe9\xda\b\x14\xf5\u020a\x04\<3\xc1\x93ud\x80\x00$ 0\x00\u07d4\x88m\n\x9e\x17\xc9\xc0\x95\xaf.\xa25\x8b\x89\xecpR\x12\ue509\x01\x84\x93\xfb\xa 6N\xf0\x00\x00\u07d4\x88y~Xq^\xd5\xccL\x19\x98\a\x83\xdb\xd0\xc9V\bQS\x89lk\x93[\x8b\xbd@\ x00\x00\u07d4\x88|\xacA\xcdpo3E\xf2\xd3J\xc3N\x01u*nY\t\x89

07d4\x88\xb2\x17\u0337\x86\xa2T\xcfM\xc5\u007f]\x9a\xc3\xc4U\xa3\x04\x83\x892\$\xf4'#\xd4T\x 00\x00\xe0\x94\x88\xbcC\x01.\xdb\x0e\xa9\xf0b\xacCxC%\n9\xb7\x8f\xbb\x8a\x04<3\xc1\x93ud\x 80\x00\x00\u07d4\x88\xc2Qj|\xdb\t\xa6'mr\x97\xd3\x0fZM\xb1\xe8K\x86\x89\xd8\xd7&\xb7\x17z\x 80\x00\x00\x00\xe0\x94\x88\xc3ad\rki7;\b\x1c\xe0\xc43\xbdY\x02\x87\xd5\xec\x8a\n\x96\x81c\xf0\xa5{ @\x00\x00\u07d4\x88\xd5A\xc8@\xceC\xce\xfb\xafm\x19\xafk\x98Y\xb5s\xc1E\x89\t79SM(h\x00\x00\u07d4\x88\xde\x13\xb0\x991\x87|\x91\rY1e\xc3d\u0221d\x1b\u04c9\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\x88\xde\u017d?N\xba-

\x18\xb8\xaa\xce\xfa{r\x15H\xc3\x19\xba\x89JD\x91\xbdm\xcd(\x00\x00\u07d4\x88\xe6\xf9\xb2G\xf9\x88\xf6\xc0\xfc\x14\xc5o\x1d\xe5>\u019dC\u0309\x05k\xc7^-

 $c\10\x00\x00\u07d4\x88\xee\u007f\x0e\xfc\x8fw\x8ckh~\xc3+\xe9\xe7\xd6\xf0$

\xb6t\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\x88\xf1\x04_\x19\xf2\xd3\x19\x18\x16\xb1\xdf\x18\xbbn \x145\xad\x1b8\x89\r\x02\xabH|\xed\xc0\x00\x00\x00\xe0\x94\x89\x00\x9e<d\x88\xbd^\W\r\x1d\xa3N\x ab\xe2\x8e\xd0\$\xde\x1b\x8a\x04<3\xc1\x93ud\x80\x00\x00\x00\x00\x94\x89\x05D0\xdc\xdc\\xdc\\xa6\x15\xf ac^\xf8|\x10^^+\xf7f\x89\x05\xda\xcd\x13\u029e0\x00\x00\x00\xe0\x94\x89\bv\f\u04db\x9c\x1e\x81\x8 4\xe6\xa7R\ue20e?\vpE\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\x00\x00\xe0\x94\x89\x0f\xe1\x1f<\\u06c72\xd6\xc2\xe7r\xe2)|~e\xf19\x8a\rV'\x13\xa8\xb5\x90\x00\x00\x00\u07d4\x89\x1e\x86\x80\xa5\xae\xc5\" mK\xaa\xec.UR\xb4M\xd7\xc8t\x89\x05|\xd5_\xc6M\xfe\x00\x00\u07d4\x89\x1c\xb8#\x8c\x88\xe9:\x1b\xcfa\xdb\xxb4x\u007fO\x84\x89\x91Hx\xa8\xc0^\xe0\x00\x00\u07d4\x89\x17\xff\x1a\xda\u0519\xaa\x06T\x01\xb4#|\xe6\xe9+bZ\x89|j\xccg\u05f1\xd4\x00\x00\x00\u07d4\x89\x17\xff\x1a\xda\u051\xd\u07c\xaa\u07c\xaa\u07d4\x89\x11\u07c\xaa\u07d4\x89\x00\x00\u07d4\x89\\x11\u07c\xaa\u07d4\x89\x11\u07d4\x89\x11\u07d4\x89\x11\u07d4\x89\x11\u07d4\x89\\u07d

 $c\x10\x00\x00\u07d4\x89V\x13\#o5\x84!j\xd7\] > \a\xe3\xfahc\xa7x\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x89Wr\xspace]$

 $\label{thm:label$

 $89\xa00\xdc\xeb\xbd/L\x00\x00\u07d4\x89\xfe\xe3\r\x17(\xd9\xec\xc1\u06b3\xda.w\x1a\xfb\u03ea$ $A\x89\li\xccg\u05f1\xd4\x00\x00\xe0\x94\x8a\x1c\u016c\x11\x1c\xbf\xcf\xd8H\xf3\xd7h\xaae\u020$ $8\x02\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x8a$

^**\xef\u05e7P\x94\xc8\"\xc4\xf5\xae\uf289\r(\xbc`dx\xa5\x80\x00\u07d4\x8a6\x86\x9a\xd4x\x99|\xbfm\x89\$\xd2\n<\x80\x18\xe9\x85[\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x8aC\x14\xfba\u03 53\x8f\xc3>\x15\xe8\x16\xb1\x13\U000ac267\xfb\x89\x17vNz\xede\x10\x00\x00\u07d4\x8aOJ\u00 7fR\xa3U\xba\x10 \xca

 $0 \times e! \times 3 \times 0 \cup 0 \le V \times 1 dQ \times 0 \times a7, \times 89\% \times 1 \times e \cup 0 \times 0 \cup 0 \le V \times 1 dQ \times 0 \le V \times 1 dQ \times 0 \le V \times 1 \le V$

\xce\xfa\xb6\x97\x90\x00\u07d4\x8b\a\xd0PuM\u027a#\r\xb0\x1c1\n\xfd\xb59Z\xa1\xb3\x89\x 06f\xb0nb\xa6 \x00\x00\u07d4\x8b

 $\label{thm:linear} $$ \left(x89\right\times 4x14p\u03b9\x8a\x02\x8aw\x93n\x92\xc8\x1c\x00\x00\u07d4\x8b\u05b1\xc6\xd7M\x01\x10\b\u06e6\xef\x83]D0\xb3\\2\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4\x8b\xd8\xd4\x c4\xe9C\xf6\xc8\a9!\xdc\x17\xe3\xe8\u05e0v\x16'\x89\x9f\x04!\x9d\x8d4\x95\x00\x00\u07d4\x8b\xd8\xd1W$

c\x10\x00\x00\u07d4\x8cP\xaa*\x92\x12\xbc\xdeVA\x8a\xe2a\xf0\xb3^z\x9d\xbb\x82\x89\x15\xaf\x 1dx\xb5\x8c@\x00\x00\u07d4\x8cT\xc7\xf8\xb9\x89nu\xd7\xd5\xf5\xc7`%\x86\x99\x95qB\xad\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\x8c]\x16\xede\xe3\xed~\x8b\x96\u0297+\xc8as\xe3P\v\x03\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x8cj\xa8\x82\xee2,\xa8HW\x8c\x06\xcb\x0f\xa9\x11\xd3`\x83\x05\x89\x86\xac5\x10R`\x00\x00\xe0\x94\x8cj\xe7\xa0Z\x1d\xe5u\x82\xae'h

 $Bv\\xc0\\xffG\\xed\\x03\\x8a,\\v\\xb3\\xdd0\\xc4\\xe2\\x00\\x00\\u07d4\\x8co\\x9fN[z\\xe2v\\xbfXI\{\\u05ff^*\}\%$ $\$_d\\x89\\x93\\xfe\\|W\\xd7\\x10h\\x00\\x00\\u07d4\\x8cu\\x95n\\x8f\\xedP\\xf5\\xa7\\xdd\\xfd'\\xda$

\x83\x8a\xa1\x87+:\xd5\xd2w\x17h#\x89\x12\xee\x1f\x9d\xdb\xeeh\x00\x00\u07d4\x8d\v\x9e\xa5? \xd2cA^\xac\x119\x1f\xe9\x12<Dpb\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\x8d\x17\x94\xdaP\x9c\x b2\x97\x056a\xa1J\xa8\x92321\xe3\xc1\x89\n\xd2\x01\xa6yO\xf8\x00\x00\u07d4\x8d\x1a\xbd\x89\\xac\xd41.\x18\b\f\x88\xfb\x96G\xea\xb4@R\x89\v\xb5\x9a'\x95<`\x00\x00\u07d4\x8d#\x034\x1e\x 1e\x1e\xb5\xe8\x18\x9b\xde\x03\xf7:`\xa2\xa5Ha\x89\x05k\xc7^-

 $\label{thm:convoluo7d4} $$ \onum{1} \a 6N\x85\xd0\x06\x19\x86\u01d4\xc6\xf5\x19\x89\u0556\xe4\xfc^2\x10\x00\x00\u07d4\x8dak\x1e\xeew\xee\xf6\xf1v\xe0i\x8d\xb3\xc0\xc1A\xb2\xfc\x8f\x89\x1b\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x8dap\xfff\x97\x8ew;\xb6!\xbfr\xb1\xba\xe3\xa7\xf8~\x89\n\u05ce\xbc2\xc6$

\x00\x00\u07d4\x8db\v\xde\x17\"\x8fl\xbb\xa7M\xf6\xbe\x87&M\x98\\\xc1y\x89\x05k\xc7^-c\x10\x00\x00\u07d4\x8db\x9c

 $\label{thm:linear_control_linear_c$

\$w'\x12\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x8d\x9e\xd7\xf4U0X\xc2ox6\xa3\x80-

 $0d\\ x1b6=\\ x89\\ x04\\ xe1\\ x00;\\ (\\xd9\\\\ x00\\\\ x000\\\\ x000\\\\ x000\\\\ x000\\\\ x000\\\\ x000\\\\ x000\\\\ x000\\\\ x000\\\\ x00$

 $\label{lem:condition} $C\xf3\xeb\xfa\xfb,\x00\x00\u07d4\x8d\xb1\x85\xfe\x1bp\xa9Jj\b\x0e~\#\xa8\xbe\xdcJ\xcb\xf3K\x89K\xe4\xe7\&\{j\xe0\x00\x00\u07d4\x8d\xb5\x8e@n-$

 $\label{thm:linear} $$ \frac{\lambda_00x00x00x00x00x00x00x00}{\lambda_00x00x00} & x89\axea(2uw\bx00x00\u07d4\x8ey6\u0552\x00\x8f\xdcz\xa0N\xde\xebuZ\xb5\x13\u06f8\x9d\x89\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4\x8e\u007f\xd28H\xf4\xdb\ax90j\x10\xc0K!\x80;\xb0\x82'\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x8e\x92\xab\xa3\x8er\xa0\x98\x17\v\x92\x95\x92FSz.U $$ $$ V\xc0\x89\x0e\xeb\xa3A\vt\x00\x00\u07d4\x8e\x98\ve\xb0\xcf'G\xc5\r\xd4;\x95gYM\x971\u0789I $$ $$ D\xb7\xc2a\x82(\x00\x00\u07d4\x8e\x9b5\xadJ\n\x86\xf7XDo\xff\xde4\x9d\x94\f\xea\u0349\xd8\xd7\xd7\x80\x00\x00\u07d4\x8e\x9c\b\xf78f\x1f\x96\v\#n\xff\x82\xbaba\xdd?H\"\x89\x05k\xc7^$$ $$$

 $c\x10\x00\x00\u07d4\x8e\x9cB\x92f\xdf\x05\xfax\xdd\x1d\wxfc@t*\xd4f\x89\x10D.\u0475I\x80\x00\u07d4\x8e\xa6V\xe7\x1e\xc6Q\xbf\xa1\|ZWY\xd8`1\xcc5\x99w\x89\x05k\xc7^-$

 $c\x10\x00\x00\u07d4\x8e\xae) CU\x98\xba\x8f\x1c\x93B\x8c\xdb>+M1\a\x8e\x00\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x8e\xb1\xfb\xe4\xe5\xd3\x01\x9c\xd7\xd3\r\xae\x9c\r[Lv\xfbc1\x89lk\x93[\x8b\xbd\xbd\xbd\x8e\xb5\x17t\xaf$

\x00\x00\u07d4\x8e\u03b2\xe1\$SI[_\xfcd\x0e\xd1O\xf1^\u0668\xcbq\x89lk\x93[\x8b\xbd@\x00\x00 \u07d4\x8e\u042f\x11\xff(p\xda\x06\x81\x00J\xfe\x18\xb0\x13\xf7\xbd8\x82\x89\xd8\xd7&\xb7\x17 z\x80\x00\x00\u0794\x8e\xd1Cp\x1f/r(\x0f\xd0J{Ad(\x19y\xea\x87\u0248\xc2I\xfd\xd3'x\x00\x00\u0 7d4\x8e\xd1R\x8bD~\xd4)y\x02\xf69\xc5\x14\u0414J\x88\xf8\u0209\n\xc6\xe7z\xb6c\xa8\x00\x00\ u07d4\x8e\xd4(L\x0fGD\x9c\x15\xb8\u0673\$]\u8fb6\u0380\xbf\x89+^:\xf1k\x18\x80\x00\x00\xe0\x 94\x8e\xde~=\xc5\al\xc6\xc5\x0e.(\x16\x84x\xc3M\xb8\x19F\x8a\x04<0\xfb\b\x84\xa9l\x00\x00\u0 7d4\x8e\xe5\x843}\xdb\xc8\x0f\x9e4\x98\xdfU\xf0\xa2\x1e\xac\xb5\u007f\xb1\x89\x01\x15\x8eF\t\x 13\xd0\x00\x00\u07d4\x8e\xeb\xec\x1ab\xc0\x8b\x05\xa7\xd1\u0551\x80\xaf\x9f\xf0\u044e?6\x89\ x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x8e\xf4\u0622\xc2<Ry\x18{d\xe9ot\x14\x04\bS\x85\xf3\x 89\x10=\xc1\xe9\xa9i{\x00\x00\u07d4\x8e\xf7\x11\xe4:\x13\x91\x8f\x13\x03\xe8\x1d\x0e\xa7\x8c\x 9e\xef\xd6~\xb2\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x8e\xfe\xc0X\xccTaWvjc'u@J3J\xaa\ u0687\x89I]\xb2\xa4\xd8\x15\xdc\x00\x00\u07d4\x8f\x02\xbd\xa6\xc3i\"\xa6\xbejP\x9b\xe5\x19\x0 6\u04d3\xf7\xb9\x9b\x897I\r\xc1.\xbe\u007f\x80\x00\u07d4\x8f\x058\xedq\xda\x11U\xe0\xf3\xbd\x e5f|\xeb\x841\x8a\x1a\x87\x89i*\xe8\x89p\x81\xd0\x00\x00\x00\x94\x8f\x06||\x1b\xbdWx\v{\x9e\xe b\x9e\xc0\x03/\x90\xd0\xdc\xf9\x8a\x04<3\xc1\x93ud\x80\x00\x00\xe0\x94\x8f\n\xb8\x94\xbd?Ni}\ xbc\xfb\x85\x9dIz\x9b\xa1\x95\x99J\x8a\b]c\x8beG*\xa2\x00\x00\u07d4\x8f\n\xf3uf\xd1R\x80/\x1a\ xe8\xf9(\xb2Z\xf9\xb19\xb4H\x89\n\u05ce\xbcZ\xc6

Hd\x9a\xb9K\xb2\xa5\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x8fA\xb1\xfb\xf5B\x98\xf5\u043c

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 $b\{\xe4S\xo5\b\xo0\xo0\u07d4\x8f\xf4`Ehw\#\xdc3\xe4\u0419\xa0i\xo4\xf1\ubd44\u0709lk\x93[\x8b\xbd@\xo0\xo0\u07d4\x8f\xfa\xo6!\"\xac0t\x18\x82\x1a\u06d3\x11\aZ7\x03\xbf\xa3\x8965\u026d\xc5\u07a0\xo0\xo0\u07d4\x8f\xfe2)\x97\xb8\xe4\xo4B-$

\x19\xc5J\xad\xb1\x8f[\xc8\u9dc9\u0556{\xe4\xfc?\x10\x00\x00\u07d4\x90\x01\x94\u0131\aC\x05\\u045d\xe4\x05\xb0\xacx(\x0e\xca\xf9g\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x90\x03\xd2p\x89\\x1b\xa2\xdfd=\xa84\x15\x83\x195E\xe3\xe0\x00\x00\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\x00\x00\xe0\x94\x90\\x05z\xf9\xaaf0~\xc9\xf03\xb2\x97\$\u04f2\xf4\x1e\xb6\xf9\x8a\x19\xd1\u05aa\xdb,R\xe8\x00\x00\u07d4\x90\x0f\v\x8e5\xb6h\xf8\x1e\xf2R\xb18U\xaaP\a\xd0\x12\xe7\x89\x17\n\x0fP@\xe5\x04\x00\\x00\u07d4\x90\x18\xcc\x1fH\xd20\x8e%*\xb6\b\x9f\xb9\x9a|\x1dV\x94\x10\x89\n\u05ce\xbcZ\xc6\\x00\x00\u07d4\x90\x1d\x99\xb6\x99\xe5\u0191\x15\x19\xcb

v\xb4\xc7c0\xc5M\"\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\x90-

 $\label{thm:condition} that the two t$

 $u01d5\"=s\xa1\u06f7\xd9L\xa7Z\u0209lk\x93[\x8b\xbd@\x00\x00\u07d4\x90\xac\xce\xd7\xe4\x8c\x01b94dm\xfa\n\xdf)\u0714\a0\x89\x03\vK\x15\{\xbdl\x00\x00\u07d4\x90\xb1\xf3p\xf9\xc1\xeb\v\xe0\xfb\x8e+\x8a\xd9jAcq\u074a\x890\xca\x020\x98\{\x90\x00\x00\u07d4\x90\xb6\xx13\x1a_)\xb4\uqQ>\xe7\xa7J\x8f\v\#\"\x02\x89\b\x90\xb0\xc2\xe1O\xb8\x00\x00\u07d4\x90\xbdb\xa0P\x84Ra\xfaJ\x9f|\xf2A\xeac\v\x05\ufe09\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\x90\xc4\x1e\xba\x00\x8e\xcb\xe9'\xf3F`?\u0206\x98\x12Yi\x89\x02F\xdd\xf9yvh\x00\x00\u07d4\x90\u0480\x9a\xe1\xd1\xff\xd8\xf6>\xda\x01\xdel\xddU-$

 $\label{thm:continuous} $$ \int_{x_0}^{x_0} (x_0) \cdot (x_0$

 $\label{thm:convoluo7d4} $$ \x00\u07d4\x91Tky\xec\xf6\x9f\x93kZV\x15\b\xb0\xd7\xe5\f\u0159\x89\x0e-\xeb\xa3A\vt\x00\x00\u07d4\x91V\u0440)5\x0eG\x04\b\xf1_\x1a\xa3\xbe\x9f\x04\ng\u018965\u026d\xc5\u07a0\x00\x00\u07d4\x91b\x0f>\xb3\x04\xe8\x13\u048b\x02\x97Ume\xdcN]\u5a89\xcf\x15&@\xc5\xc80\x00\x00\x00\x00\x94\x91k\xf7\xe3\xc5E\x92\x1d2\x06\xd9\x00\xc2O\x14\x12\xbd^p\x8a\x03\xd0\u077c\xf2\xbb\x10\x00\x00\u0794\x91\xf1\qA(\x05\xf4\xaf\xc3DJ\x8d\xd1\xd93\x9d\x16\x88\xc6s\xce<@\x16\x00\x00\u07d4\x91\x8f\x9f:\x8d\t\xe9$$

,R\u009erA\x96\xb8\x97\xd3^\x89\b\xbaR\xe6\xfcE\xe4\x00\x00\u07d4\x91\x89g\x91\x8c\u0617\x dd\x00\x05\xe3m\xc6\u0203\xefC\x8f\xc8\u01c9\a\x96\xe3\xea?\x8a\xb0\x00\x00\u07d4\x91\x89\x 8e\xab\x8c\x05\xc0\"(\x83\xcdM\xb2;w\x95\xe1\xa2J\u05c9lk\x93[\x8b\xbd@\x00\x00\u0794\x91\x 91\xf9F\x98!\x05\x16\xcfc!\xa1B\a\x0e

 $\label{thm:linear} Yvt\xed\x88\xee\x9d[\xe6\xfc\x11\x00\x00\u07d4\x91\xa4\x14\x9a,{\x1b:g\xea(\xaf\xf3G\%\u0fcdu$\x89i*\xe8\x89p\x81\xd0\x00\x00\u07d4\x91\xa7\x87\xbcQ\x96\xf3HW\xfe\f7/M\xf3v\xaa\xa7f\x13\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x91\xa8\xba\xae\xd0\x12\xea.c\x80;Y=\r\f*\xabL[\n\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4\x91\xac\xf9xc5J\xa7\xeb\xfb\xa4HflF\x1a;\x1f\xe2\xe1\x89\x15\xc94\x92\xbf\x9d\xf6\x00\x00\u07d4\x91\xbb?y\x02+\xf3\xc4S\xf4\xff\%n&\x9b\x15\xcf,\x9c\xbd\x89\xf5gM\x9c\x89\xf5gM\x9c\x89$

 $\label{lkx93[x8b} Ik\x93[\x8b\xbd@\x00\x00\u07d4\x91\xc8\f\xaa\b\x1b85\x1d*\x0e\x0e\x0o\x00\xf8\n4\xe5dt\xc1\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x91\xccF\xaa7\x9f\x85jf@\xdc\xcdZd\x8ay\x02\xf8I\u0649\n\u05\xce\xbcZ\xc6$

 $\label{thm:color$

\u01da\x1d:&\xdd8)g{\xf1\xd4\\x8fg+\xb6\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x92C\x8eR\x03\xb64o\xf8\x86\xd7\xc3b\x88\xaa\xcc\xccx\xce\u028965\u026d\xc5\u07a0\x00\x00\u07d4\x92C\xd7v-

 $\label{thm:convention} $$ \x8e^xda^x18M\x946j^x14K\f\x10[\x89K\xe4\xe7&{j\xe0\x00\x00\u07d4\x92y:\u0173rhwJq0\xde+\xbd3\x04\x05f\x17s\x89\x02,\xa3X]\xf4\xeb\x00\x00\xe0\x94\x92y\xb2\''\x8c\xec\x8f{M\xda}?2\x0e\x9a\x04f\xc2\xf5\x85\u028a\x01\x0ff\xf0d\xddY$$$

 $e0\xd6\u0387\xfdP\xe0=\uf7e6@\x05\t\xbdps\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\x92\xc9L(\xdf\xcfqV\xe6\xf10\x88\xec\u754b6\xxfd\x89\x05-$

\x00\x00\u07d4\x93t\x86\x9dJ\x99\x11\xee\x1e\xafU\x8b\xc4\u00b6>\xc6:\xcf\u074965\u026d\xc5\u07a0\x00\x00\u07d4\x93uc\u0628\x0f\u05657\xb0\xe6m

x03e@\x00\x00\u07d4\x93\xf1\x8c\xd2R`@v\x14\x88\xc5\x13\x17M\x1eycv\x8b,\x89\x82\xff\xac\x 9a\u0553r\x00\x00\u07d4\x94\x0fqQ@P\x9f\xfa\xbf\x97EF\xfa\xb3\x90\"\xa4\x19R\u0489K\xe4\xe 7&{j\xe0\x00\x00\u07d4\x94,k\x8c\x95[\xc0\u0608\x12g\x8a#g%\xb3'9\xd9G\x89T\x06\x923\xbf\u0 07fx\x00\x00\u07d4\x94=7\x86JJS}5\xc8\u0657#\xcdd\x06\xce%b\xe6\x89lk\x93[\x8b\xbd@\x00\x 00\u07d4\x94C\x9c\xa9\xcc\x16\x9ay\u0520\x9c\xae^gvJo\x87\x1a!\x89\r\x02\xabHl\xed\xc0\x00\x 00\u07d4\x94D\x9c\x01\xb3*\u007f\xa5Z\xf8\x10OB\xcd\xd8D\xaa\x8c\xbc@\x8a\x03\x81\x11\xa1\xf4\xf0<\x10\x00\x00\x00\x00\u07d4\x94E\xba\\0\xe9\x89a\xb8`\$a\xd08]@\xfb\xd8\x03\x11\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x94O\a\xb9o\x90\xc5\xf0\xd7\xc0\u0140S1l\xf3\xf5\x85\xa0x\x89\x04\x02\xf4\xcf\xeeb\xe8\x00\x00\u07d4\x94T\xb3\xa8\xbf\xf9p\x9f\xd0\u1407~l\xb6\u0219t\xdb\u0589\x90\xf54`\x8ar\x88\x00\x00\u07d4\x94T\xb3\xa8\xbf\xf9p\x9f\xd0\u1407~l\xb6\u0219t\x96\u007f\xf3\x17\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x94a'\x18v\x9d-\xe7'\xc7\x01?\x92\xde\$\xd1\x17\x96\u007f\x63\x17\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x94a'\x94a'\x81\x03;\W\xb1F\xeet\xe7S\xc6r\x01\u007f\xbe\xc6t\xbd\xef\x8a*\xc7\u01ca\x01\x0f\fxf0d\xdd\

\x00\x00\u07d4\x94p\xcc6YE\x86\x82\x18!\xc5\u0256\xb6\xed\xc8;mZ2\x89\x01M\x11

 $\label{thm:linear_db} $$db\cdot xd2\cdot xf9s+.\x89lk\x93[\x8b\cdot xbd@\x00\cdot x00\cdot u07d4\x94\cdot xa7\u0368\xf4\x81\xf9\u061dB\xc3\x03\xae e\x162\xb3\xb7\t\xdb\x1d\x89\x10CV\x1a\x88)0\x00\x00\u07d4\x94\xa9\xa7\x16\x911|$

 $\label{thm:convention} d'\x1bQ\xc95?\xbd\xe05\x01\xa8\x89\xb5\x0f\u03ef\xeb\xec\xb0\x00\x00\u07d4\x94\xadK\xadK\xad\x82\xd0\ub7a4\x9cX\u03bc\xc0\xff^\b4k\x89i^\xe8\x89p\x81\xd0\x00\x00\u07d4\x94\xbb\xc6}\x13\xf8\x9e\xbc\xa5\x94\xbe\x94\xbcQp\x92\f0\xd9\xf3\x89\x04X\xff\xa3\x15\nT\x00\x00\u07d4\x94\xbe:\xe5Ob\xd6c\xb0\xd4\u031e\x1e\xa8\xfe\x95V\ua7bf\x89\x01C\x13,\xa8C\x18\x00\x00\x00\x94\x94\xc0U\xe8X5z\xaa0\xcf$

 $A \ x_1 \ x_2 \ x_3 \ x_3 \ x_4 \ x_2 \ x_2 \ x_2 \ x_2 \ x_2 \ x_3 \$

 $C\x871B\u020e\''\x8a\x01\x045a\x88\x82\x93\x00\x00\u07d4\x95\x03N\x16!\x86Q7\xcdG9\xb3F\xdc\x17\xda:'\xc3N\x89U\xa6\xc2\x9c\xcd\x1d0\x00\x00\u07d4\x95\fh\xa4\t\x88\x15M\#\x93\xff\xf8\xda\u0369\x96\x14\xf7,\x89\xf9AF\xfd\x8d\xcd\xe5\x80\x00\xe0\x94\x95\x0f\xe9\xc6\xca\xd5\f\x18\xf1\x1a\x9e\xd9\xc4W@\xa6\x18\x06\x12\u040a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\x95!\$

l\xce\x10\x1e2\\u\x98\x92\xca\xc3\xf8\x11\x89\x9a\xe9*\x9b\xc9L@\x00\x00\x94\x95h\xb7\xd euV(\xaf5\x9a\x84T=\xe25\x04\xe1^A\xe6\x8a\bxg\x83&\xea\xc9\x00\x00\x00\u07d4\x95i\xc6:\x92\x84\xa8\x05bm\xb3\xa3.\x9d#c\x93GaQ\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\x95\x80\x9e\x8d\x a3\xfb\xe4\xb7\xf2\x81\xf0\xb8\xb1q_B\x0f}\c\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x95\x9f\w\xfd\x edj\xe3y\x13\xd9\x00\xb4\x95\x93\"\xc6"\x89\r\xdb&\x10Gl\x11\x80\x00\u07d4\x95\x9f\xf1\u 007f\x1dQ\xb4s\xb4@\x10\x05'U\xa7\xfa\x8cu\xbdT\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\x95\xa 5w\xdc.\xb3\xael\xb9\xdf\xc7z\xf6\x97\xd7\xef\xdf\xe8\x9a\x10\x89\k\x93[\x8b\xbd@\x00\x00\x00\u07d4\x95\xdf\xp4\x\p10\x88\y0\x00\x00\x00\u07d4\x95\xdf\xp4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10\x88\y0\x00\x00\x00\u07d4\x\p10

4\xcec#\x8965\u026d\xc5\u07a0\x00\x00\x00\x94\x96\x8d\xea`\xdf>\t\xae<\x8d5\x05\xe9\xc0\x80

 $EK\xe0\xe8\x19\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\x96\x92A\x91\xb7\xdfe[3\x19\xdcma7\xf4\x81\xa7:\x0f\xf3\x89\xd9\xec\xb4\xfd$

 $\label{thm:convolu07d4} $$\x8e^{x00}\x00^{u07d4}\x96^{x96}\x96^{x05}.$$\x8e^{x11}_{x81}\xf7t^{y9d}\r;:t^{x89}\x1b^{x1a}\xe4^{xd6}\xe2^{xefP}\x00^{y00}\u07d4^{y96}\xa5_{x00}\xdf^{x4}\x05^{x6}\xe5^{x8c}\xe5^{x8c}\xe5^{x8c}\xe5^{x8c}\xe5^{x8e}\xe6^{x8e}\xe6$

 $\label{thm:control_c$

 $MW\xbb9\u0520\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x97\r\x8b\x8a\x00\x16\xd1C\x05O\x14\x9f\xb3\xb8\xe5P\xdc\a\x97\u01c965\u026d\xc5\u07a0\x00\x00\u07d4\x97,\\/\x96\xaa\x00\u03ca/Z\xbc\xf8\x93[\fu\xf5\xd8\u0649\n\u05ce\xbcZ\xc6$

ea=\xb7UF`\x00\x00\u07d4\x97\x9f0\x15\x8bWK\x99\x9a\xab4\x81\a\xb9\xee\xd8[\x1f\xf8\xc1\x89 4\x95tD\xb8@\xe8\x00\x00\u07d4\x97\xa8o\x01\xce?|\xfdDA3\x0e\x1c\x9b\x19\xe1\xb1\x06\x06\x ef\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\x97\xb9\x1e\xfesP\xc2\xd5~~@k\xab\x18\xf3a{\xcd\xe1J \x8a\x02\x1e\x19\x99\xbb\xd5\u04be\x00\x00\u07d4\x97\xd0\xd9r^;p\xe6u\x841s\x93\x8e\xd3q\xb 6,\u007f\xac\x89\t79SM(h\x00\x00\u07d4\x97\xd9\xe4jv\x04\u05f5\xa4\xeaN\xe6\x1aB\xb3\xd25\x 0f\xc3\xed\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x97\xde\xecg\n1\xe0\"\x1d*u\xbc]\xc9\xf9\fx1fo\ u0509\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\x00\xe0\x94\x97\xde!\xe4!\xc3\u007f\xe4\xb8\x02_\x9aQ\ xb7\xb3\x90\xb5\xdfx\x04\x8a\x10\xf0\xcf\x06M\u0552\x00\x00\x00\u07d4\x97\xe5\xcca'\xc4\xf8\x8 5\xbe\x02\xf4KB\xd1\u0230\xac\x91\u44c9\n\u05ce\xbcZ\xc6

 $\label{thm:convoluo7d4} $$ \x00\x00\u07d4\x97\xf1\xfeL\x80\x83\xe5\x96!*\x18w(\xdd)\xf8\n1\xbe\u0149\x01\x15\x8eF\tx13\xd0\x00\x00\x94\x97\xf7\x06W\xc1\xe2\x02u\x90\x86\x96>\xb4!\x1c_\x819\xb9\x8a\n\x8a\x10\x86\x87\u0165\x8cQQ\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\x98\n\x84\xb6\x86\xfc1\xbd\xc8<\\\x10XTjq\xb1\x1f\x83\x8a\x89*AUH\xaf\x86\x81\x80\x00\u07d4\x98\x10\xe3J\x94\xdbn\xd1V\xd08\x9a\x0e+\x80\xf4\xfd\xn\x8a\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x98\x1d\xdf\x04\x04\x04\xd2-\xdaUj\x8xf0\v-$

\x98\xab\x95i\x8965f3\xeb\xd8\xea\x00\x00\xe0\x94\x98\x1fq'u\xc0\xda\xd9u\x18\xff\xed\xcbG\xb9 \xad\x1dl'b\x8a\x01je\x02\xf1Z\x1eT\x00\x00\u07d4\x984h!\x80\xb9\x82\xd1f\xba\u06dd\x9d\x1d\x 9b\xbf\x01m\x87\xee\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x986\xb4\xd3\x04sd\x1a\xb5j\xee\xe1\x 92Bv\x1drrQx\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\x989sB\xec_=L\xb8w\xe5N\xf5\xd6\xf1\xd3fs \x1b\u050a\x01@a\xb9\xd7z^\x98\x00\x00\xe0\x94\x98Fd\x886\xa3\a\xa0W\x18O\xd5\x1fb\x8a_\ x8c\x12B|\x8a\x04\vi\xbfC\xdc\xe8\xf0\x00\x00\xe0\x94\x98Jy\x85\xe3\xcc~\xb5\xc96\x91\xf6\xf8\ xcc{\x8f\$]\x01\xb2\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\xe0\x94\x98]p\xd2\a\x89+\xed9\x85\x90\ x02N\$!\xb1\xcc\x11\x93Y\x8a\x04<3\xc1\x93ud\x80\x00\x00\xe0\x94\x98m\xf4~v\xe4\u05e7\x89\x cd\xee\x91<\u0243\x16P\x93|\x9d\x8a\x01\x0f\f\xf0d\xddY

\x00\x00\u07d4\x98t\x80?\xe1\xf3\xa06^y\"\xb1Bp\xea\xeb\x03,\xc1\xb5\x89<\xf5\x92\x88\$\xc6\xc2\x00\x00\u07d4\x98ub4\x95\xa4l\xdb\xf2YS\x0f\xf88\xa1y\x9e\u00c9\x91\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x98v\x18\xc8VV

 $| \{ \x a c \x 15 \a \x c 0 \x ff \x e f \x a 2 \x f b d \x b 0 \x 9 \x 89 \x 03 \} \x f e C 1 \x 89 \x e 3 \x 80 \x 00 \u 0 7 d 4 \x 98 \x 9b \x c dn? 9 \x 90 \x 5 + \x e 3 \x e d \x a 4 q f' Q \x 8 f O r \x 89 \x 15 \x a f \x 1 dx \x b 5 \x 8 c @ \x 00 \x 00 \u 0 7 d 4 \x 98 \x 8 2 \x 9 6 | \x e e h \u 0 4 a 89 \x f a \u 0 6 2 b J | = \x d d \x f 6 \x c 0 \x a d \u 0 2 0 9 Hx \x b e \x 1 f \x f a \x f 9] \x 0 0 \x 0 0 \u 0 7 d 4 \x 9 8 \x 8 5 \) \x f b \x e e 3 S D \x 9 0 J \x 1 2 \x c 4 \f s \x 1 7 \x 9 5 \x b 1 : T \x 8 9 \x f b \x a e \x 8 d \x 0 4 -$

i\x91\xc9\xd6\xd4\a\u007f\xdf?\xddE\x85\u06890\xdf\x1ao\x8a\xd6(\x00\x00\u07d4\x98\xe3\xe9\v(\xfc\xca\ue087y\xb8\xd4\nUh\xc4\x11n!\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\x98\xe6\xf5G\u06c8\xe7_\x1f\x9c\x8a\xc2\xc5\xcf\x16'\xbaX\v>\x8965\u026d\xc5\u07a0\x00\x00\x00\x94\x98\xf4\xaf:\xf0\xae\xde \xaf\xdcB\xa0\x81\xec\xc1\xf8\x9e<\xcf

\x8a\x01\xfd\x934\x94\xaa_\xe0\x00\x00\u07d4\x98\xf6\xb8\xe6!=\xbc\x9aU\x81\xf4\xcc\xe6e_\x9 5%+\xdb\a\x89\x11Xr\xb0\xbc\xa40\x00\x00\u07d4\x99\te\r\u05719{\x8b\x8b\x0e\xb6\x94\x99\xb2 \x91\xb0\xad\x12\x13\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\x99\x11s`\x19G\xc2\bJb\xd69R~\x96\x15\x12W\x9a\xf9\x89

 $c\x10\x00\x00\u07d4\x99\xb8\xc8\x86\x9d\xe9\xed\xf3\xbf\xf6\x85L\xb6\xddE\xcc?\x9f\x89e\xea = \xb7UF\x00\x00\u07d4\x99\xc0\x17L\xf8N\a\x83\xc2$

 $c\x10\x00\x00\u07d4\x9a\x99\v\x8a\xebX\x8d\xe7\xec.\xd8\xc2\xe6Os\x82\xa9\xfe\xe2\x89\x01\xeq1'\xdbi\xfd\x8b\x00\x00\u07d4\x9a\x9d\x1d\xc0\xba\xa7\n$

\x00\x00\u07d4\x9a\xaa\xfa\x00gd~\u0659\x06kzL\xa5\xb4\xb3\xf3\xfe\xaao\x8965\u026d\xc5\u07

\xc7\xd4\u007f\x15`\x00\x00\u07d4\x9a\xe1;\u0602\xf2\Weu\x92\x1a\x94\x97L\xbe\xa8a\xba\r5\x8 9\xabM\xcf9\x9a:`\x00\x00\u07d4\x9a\xe9Gk\xfe\xcd5\x91\x96M\xd3%\u03cc*\$\xfa\xed\x82\xc1\x 89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x9a\xf1\x00\xcc=\xae\x83\xa34\x02\x05\x1c\xe4|k\x16a T\x83\xf6\x89|k\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\x9a\xf1\x13\x99Q\x1c!1\x81\xbf\xda:\x8b&L\x05\x fc\x81\xb3\u038a\x02\xf6\xf1\a\x80\xd2\xc0\x00\x00\x00\u07d4\x9a\xf5\u0249L3\xe4,,Q\x8e:\xc6p\xe a\x95\x05\u0475>\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\x9a\xf9\xdb\xe4t\"\xd1\w\xf9E\xbd\xea\xd7\xe6\xd8)\05b0\x89\u0556{\xe4\xfc?\x10\x00\x00\u07d4\x9a\xf8\$\k1f\xb6\xd8\u0133\x00\x99\xd9&\x1f\xdb\xe4\xf1\x03\x9f\u00c6\xf3\xc3!Dn\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\x9b\x11h\u078a\xb6KGU/3\x89\x80\n\x9c\xc0\x8bFf\u03c9]\u0212\xaa\x111\xc8\x00\x00\u07d4\x9b\x18\x11\xc3\x05\x1fF\xe6d\xaeK\xc9\x06\xe6`\xfe\xaca\xf7\xf4\u023f\xfc\x89\xe2G\x8d8\x90\x84\x00\x00\u07d4\x9b\x18\x19b\x18gT\xf5\x05\xe3D\x1a\x10\xf7\xf0\xe2\x0f\x3d\xdd\xf8\x89\x12nr\xa6\x9aP\xd0\x00\u07d4\x9b\x15\xf5\x05\xc5\x63D\x15\xf4\xb3J\x00\xa6La\x875C#\x89\x05\xb8\x1e\u0608

 $\label{lem:class} $$ c\10\x00\x00\u07d4\x9bH$\xff\x9f\xb2\xab\xdaUM\xeeO\xb8\xcfT\x91eW\x061\x89\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4\x9bL'\x15x\f\xa4\xe9\x9e`\xeb\xf2\x19\xf1Y\f\x8c\xadP\n\x89V\xbcu\xe2\xd61\x00\x00\u07d4\x9bY\xeb!;\x1eue\xe4PG\xe0N\xa07O\x10v-$

 $\label{thm:convention} $$ \x80\x00\x00\u07d4\x9bw6i\xe8\v\x01\x8c\t\x0f\x82U\xe5D\t\xb9\u0728\xb2\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x9bw\xeb\xce\xd7\xe2\x15\xf0\x92\x0e\x8c+\x87\x00\xf6\xec\xb2\xff1\x896\x5\u026d\xc5\u07a0\x00\x00\u07d4\x9b\x88\x10\xcc\u021e\x80Nm>8\x12\x18PG\(w\xfe\x89lk\x93)$

9a0E9D\x00\x00\xe0\x94\x9b\xac\xd3\xd4\x0f;\x82\xac\x91\xa2d\xd9\u060d\x90\x8e\xac\x86d\xb9 \x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\x9b\xb7`\xd5\u0089\xa3\xe1\xdb\x18\xdb\tSE\xcaA;\x9a C\u0089\n\xad\xec\x98?\xcf\xf4\x00\x00\u07d4\x9b\xb7b\x04\x18j\xf2\xf6;\xe7\x91h`\x16\x87\xfc\x 9b\xadf\x1f\x89\x10CV\x1a\x88)0\x00\x00\u07d4\x9b\xb9\xb0*&\xbf\xe1\xcc\xc3\xf0\xc6!\x9e&\x1c 9\u007f\xc5\xcax\x89Hz\x9a0E9D\x00\x00\u07d4\x9b\xc5s\xbc\xda#\xb8\xb2o\x90s\xd9\f#\x0e\x8 eq\xe0'\v\x896/u\xa40]\f\x00\x00\u07d4\x9b\xd7\u00caB\x100JMe>\xde\xff\x1b<\xe4_\xcexC\x89\ x0fl\x89A\xe6d(\x00\x00\xe0\x94\x9b\u0600h\xe10u\xf3\xa8\xca\xc4d\xa5\xf9l\xd6\xd8\x18\xc0\xf 6\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\x9b\xd9\x05\xf1q\x9f\u01ec\xd0\x15\x9dM\xc1\xf8\ xdb/!G#8\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x9b\xdb\u071b\x9741\xd1<\x89\xa3\xf9u~\x9b;b u\xbf\u01c9\x1b\x1a}\u03caD\u04c0\x00\u07d4\x9b\xe3\xc3)\xb6*(\xb8\xb0\x88I\xbd\x8b\x99\xf8\x bc\x93\f\xe3\xe6\x89\x04\t\xe5+H6\x9a\x00\x00\xe0\x94\x9b\xf5\x8e\xfb\xea\a\x84\xeb\x06\x8a\xd e\u03e0\xbb!P\x84\xc7:5\x8a\x01:k+VHq\xa0\x00\u07d4\x9b\xf6r\xd9y\xb3fR\xfcR\x82Tzjk\xc 2\x12\xaeCh\x89#\x8f\xd4,\\\xf0@\x00\x00\xe0\x94\x9b\xf7\x03\xb4\x1c6\$\xe1 @T\x96#\x90\xbc\ xba0R\xf0\xfd\x8a\x01H>\x01S<.<\x00\x00\u07d4\x9b\xf7\x1f\u007f\xb57\xacT\xf4\xe5\x14\x94\u0 $07f\xa7\xffg(\xf1m\x89\x01\u03c4\xa3\n\n\f\x00\x00\u07d4\x9b\xf9\xb3\xb2\xf2<\xf4a\xebY\x1f(4\v)$ \xc7\x19\x93\x1c\x83d\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94\x9b\xfce\x9c\x9c`\x1e\xa4*k!\xb8\ xf1p\x84\xec\x87\xd7\x02\x12\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x9b\xff\xf5\r\xb3jx UU\xf0vR\xa1S\xb0\xc4+\x1b\x8bv\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x9c\x05\xe9\xd0\xf0u\x8e y\$\x03g~1\xda!<\xa1W\u618965\u026d\xc5\u07a0\x00\x00\u07d4\x9c\x1bw\x1f\t\xaf\x88*\xf0d0\x 83\xde*\xa7\x9d\xc0\x97\xc4\x0e\x89\x86p\xe9\xece\x98\xc0\x00\x00\u07d4\x9c(\xa2\xc4\b`\x91\x cb]\xa2&\xa6W\xce2H\xe8\xea{o\x89\x0f-

\x00\x00\u07d4\x9c@\\\xf6\x97\x95a8\x06^\x11\xc5\xf7U\x9eg\$[\u0465\x89\n\u05ce\xbcZ\xc6\x00\x00\x94\x9cE

*%\xf6\xad\x00\x11\xf1\x15\xa5\xa7\"\x04\xf2\xf2\x19\x88f\x8a\x01\x0f\xcf:b\xb0\x80\x98\x00\x00\x00\x00\x00\x94\x9cI\xde\xffG\b_\xc0\x97\x04\u02a2\u0728\u0087\xa9\xa17\u068a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\x9cK\xbc\xd5\xf1dJo\aX\$\xdd\xfe\x85\xc5q\u05ab\xf6\x9c\x89a\x94\x04\x9f0\xf7\x00\x00\u07d4\x9cRj\x14\x06\x83\xed\xf1C\x1c\xfa\xa1(\xa95\xe2\xb6\x14\u060b\x89\x06\x04o7\xe5\x94\\\x00\x00\x00\x00\xe0\x94\x9cT\xe4\xedG\x9a\x85h)\u01bbB\u069f\vi*u\xf7(\x8a\x01\x97\xa8\xf6\xddU\x19\x80\x00\x00\x00\xe0\x94\x9cX\x1a`\xb6\x10(\xd94\x16y)\xb2-

 $p\xb3\x13\xc3O\u040a\n\x96\x81c\xf0\xa5{@\x00\x00\u07d4\x9c\\xc1\x11\t,\x12!\x16\xf1\xa8_N\xe3\x14\bt\x1a}/\x89\x1a\xb2\xcf|\x9f\x87\xe2\x00\x00\u07d4\x9ck\u0264k\x03\xaeT\x04\xf0C\xdf\xef!\x88>A\x10\xcc3\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:condition} $$ \x94\f\x90\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\xe0\x94\x9d\%\n\xe4\xf1\x10\xd7\x1c\xaf\u01f0\xad\xb5.\x8d\x9a\xcbfy\xb8\x8a\x02\x15mn\x99r\x13\xc0\x00\x00\xe0\x94\x9d+\xfc6\x10o\x03\x82P\xc0\x18\x01hW\x85\xb1\x86\xc6\r\x8aPw\xd7]\xf1\xb6u\x80\x00\x00\xe0\x94\x9d0\xcb\#\{\xc0\x96\xf1\p6\xfc\x80\xdd!\xcah\x99,\xa2\u064a\x06n\xe71\x8f\u070f0\x00\x00\u07d4\x9d2\x96.\xa9\x97\x00\xd92(\xe9\xdb\xda\xd2\xcc7\xbb\x99\xf0~\x89\xb4c+\xed\xd4\xde\xd4\xd0\x00\x00\u07d4\x9d4\xda\xc2[\xd1X(\xfa\xef\xaa\xf2\x8fq\aS\xb3\x9e\x89\u0709;\x1cV\xfe\xd0-$

 $\label{thm:condition} $$ \sqrt{xf75}\times89\times10CV\times1a\times88} \times 20V\times00\times00\times00\times00\times00^{4}\times9d\times00^{4}\times0$

\xe5\xfd6\x1e\xab\xcfc\x89\x1f[\x87\xb0\x92h\xb8\xeb7\x93\x89\x05k\xc7^-

 $P\a2'\xbb\xfd`\x93~\&\xea>h\xfe\xa8\xd1\xfe\x89\x05k\xc7^-$

c\x10\x00\x00\u07d4\x9e\u007fe\xa9\x0e\x85\b\x86{\xcc\xc9\x14%j\x1e\xa5t\xcf\a\xe3\x89C8t\xf6

 $2\xcc`\x00\x00\x00\x94\x9e\x81D\xe0\x8e\x89dx\x11\xfekr\xd4E\u05a5\xf8\n\xd2D\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\x9e\x8fd\xdd\xcd\u9e34Q\xba\xfa\xa25\xa9\xbfQ\x1a\%\xac\x91\x89\x90\xf54`\x8ar\x88\x00\x00\u07d4\x9e\x95\x1fm\xc5\xe3R\xaf\xb8\xd0B\x99\xd2G\x8aE\x12 Y\xbfV\x89\x03\xe7A\x98\x81\xa7:\x00\x00\u07d4\x9e\x96\r\xcd\x03\u057a\x99\xcb\x11]\x17\xffL\tx8a\xd4\u043e\x89\n\u05ce\xbcZ\xc6$

)\x1aD\t\xc5\xd2S\u011e\xf3\xea\xc1\xd8\xf0\x89\xb9f\b\xc8\x10;\xf0\x00\x00\u07d4\x9e\xf1\x89 k\x00|2\xa1Q\x14\xfb\x89\xd7=\xbdG\xf9\x12+i\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\x9f\x01 w\x06\xb80\xfb\x9c0\ufc20\x9fPk\x91WEu4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x9f\x10\xf2\xa0F; e\xae0\xb0p\xb3\xdf\x18\xcfF\xf5\x1e\x89\xbd\x89g\x8a\x93

r6\xc8\xf3aN\xf0/\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\x9f\xae\xa1<s4\x12\xdcKI\x04\x02\xbf\xef'\xa09z\x9b\u00c9\x10\xce\x1d=\x8c\xb3\x18\x00\x00\u07d4\x9f\xbe\x06m\xe5r6\u0703\a%\xd3*\x02\xae\xf9\$|I^\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\x9f\xd1\x05*`Pk\u0469\xef\x00:\xfd\x9d\x03<&\x3*\x02\xae\xf9\$|I^\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\x9f\xd6Cs\xf2\xfb\u035c\x0f\xac\xa6\x05\x03<&\x3*\x02\xae\x99\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x9f\xd6Cs\xf2\xfb\u035c\x0f\xac\xa6\x05\G\xca\xd6.&\u0645\x1f\x8965\u026d\xc5\u07a0\x00\x00\u07d4\x9f\xe5\x01\xaaW\xea\u05d2x\x93\|\xd60\x8c\\\xfazV)\xfe\x89\x02\xb5\xeeW\x92\x9f\u06c0\x00\u07d4\x9f\xfc_\xe0o3\xf5\xa4\x80\xb7\x2\xa9N\xb8Um\x99z\x16\xc0\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\x9f\xfe\xdc\xc3k|\xc3\x12\xad*\x9e\xdeC\x1aQO\u0334\x9b\xa3\x89\$OW\x9f?\\\xa4\x00\x00\u07d4\xa0\x00\x00\u07d4\xa0\x00\x00\\x01\x98c\xc1\xa7\x14\x99\xeb9\xbb\u05ff-

 $\label{thm:color$

 $\label{thm:condition} $$ \u01aa2\x8b\x88\r\u97acTh\#\xfc\xcfw@G\xfb\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xa0.?\x8fYY\xa7\xaa\xb7A\x86\x12\x12\x9bp\x1c\xa1\xb8\x00\x10\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xa0a04\u007f\n\x98\wc\x90\x16\x16\m2\x96;\xf7M\xcd\n\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xa05\xa3e$x\xf8-\xbdm\x11 \xaa\x8c\xa9F\xec\x9eh\x1d\x89\x05\xf4\xe4-$

 $L\xefS\xbe\x8965\u026d\xc5\u07a0\x00\xe0\x94\xa0O*\xe0*\xdd\x14\xc1/\xafe\xcb\%\x90\"\u0403\n\x8e\&\x8a\x15-$

\x86\xac5\x10R`\x00\x00\u07d4\xa0\x8d![j\xacHa\xa2\x81\xac~@\vx\xfe\xf0L\xbf\x89\x01\x15\x8e

F\t\x13\xd0\x00\x00\u07d4\xa0\x95\x19p\xdf\u0403\xb8;\xda\x12\xc25E\xe7\x90Aul\x89 \x86\xac5\x10R`\x00\x00\u07d4\xa0\x9fM^\xaae\xa2\xf4\xcbu\nI\x924\x01\xda\u5410\xaf\x89\a\x9 6\xe3\xea?\x8a\xb0\x00\x00\x00\xe0\x94\xa0\xa0\xe6R\x04T\x1f\u029b\xb2\x82\u0355\x13\x8f\xae\x 16\xf8\t\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xa0\xaa_\x02\x01\xf0M;\xbe\xb8\x98\x1 3\|\x11g\x94f\xd9\x01\x89\x01\xfb\xedR\x15\xbbL\x00\x00\u07d4\xa0\xaa\xdb\xd9P\x97\"p_m#X\x a5\u01df7\x97\x0f\x00\xf6\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\xa0\xb7q\x95\x1c\xe1\xde\xee6:\xe2\xb7q\xb7>\a\u0135\xe8\x00\x89K\xe4\xe7&{j \xe0\x00\x00\u07d4\xa0\xde\\`\x1eif5\u0198\xb7\xae\x9c\xa4S\x9f\u01f9A\xec\x89\x12\xc3\xcb\xd 7\x04\xc9w\x00\x00\u07d4\xa0\xe8\xbaf\x1bH\x15L\xf8C\xd4\u00a5\xc0\xf7\x92\xd5(\xee)\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xa0\xfc~S\xc5\xeb\xd2z*\xbd\xacE&\x1f\x84\xab;Q\xae\xfb\x 89\xa3\x13\xda\xec\x9b\xc0\xd9\x00\x00\x00\x00\x00\xe0\x94\xa0\xff[L\xf0\x16\x02~\x83#I}D(\xd3\xe5\xa8;\x87\x95\x8a\x01e\x98\xd3\xc8>\xc0B\x00\x00\x00\u07d4\xa1\x06F[\xbd\x19\u1dbc\xe5\r\x1b\x11W\xdcY \t260\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\xa1\x06\xe6\x92>\xddS\u028e\xd6P\x96\x8a\x91\b\xd6\xc0\xfd\x96p\x8a\x02\xfe\x15\x05\xaf\uc240\x00\u07d4\xa1\x1\u12f0\xa3\x9c\x9e\xf8\xa1\x95\x97\xfc^\xd8\xe9\xebmX\x89X\xe7\x92n\xe8X\xa0\x00\u07d4\xa1\x1e\xff\xabl\xf0\xf5\x97,\xff\xe4\xd5e\x96\xe9\x89h\x14J\x8f\x89Z\x87\xe7\xd7\xf5\xf6X\x00\x00\u07d4\xa1

 $M \times ad_V a(\xa3) (\xa3) (\x$

\x00\x00\u07d4\xa1pp\xc2\xe9\u0169@\xa4\xec\x0eIT\xc4\xd7\xd6C\xbe\x8fI\x89Ik\x17\x03;6\x1c \x80\x00\u07d4\xa1|\x9eC#\x06\x95\x18\x18\x9dR\a\xa0r\x8d\u02d20j?\x8965\u026d\xc5\u07a0\x 00\x00\u07d4\xa1\x83`\xe9\x85\xf2\x06.\x8f\x8e\xfe\x02\xad,\xbc\x91\xad\x9aZ\xad\x89\xa2\xa1]\t Q\x9b\xe0\x00\u07d4\xa1\x91\x14\x05\xcfn\x99\x9e\xd0\x11\xf0\xdd\xcd*O\xf7\u008f%&\x89\x2+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xa1\x92\x80\a\xcc\x11\xaa`=\"\x1d_\xee\xa0v\xbc\xf7\xc3\r\ x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xa1\x92\xf0j\xb0R\xd5\xfd\u007f\x94\xee\xa81\x8e\x82x\x15\ xfegz\x89\a\x1f\x8a\x93\xd0\x1eT\x00\x00\u07d4\xa1\x99\x81D\x96\x8a\p\xa6AUT\xce\xfe\u0082 F\x90\u0125\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xa1\xa1\xf0\xfam

 $\label{lem:control} $$ c\x10\x00\x00\u07d4\xa1\xe48\n;\x1ft\x96s\xe2p\"\x99\x93\xeeU\xf3\Vc\xb4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xa1\xf1\x93\xa0Y\x1f\xeb\x9f\xdf\xc9\n\xa8\x13xN\xb8\x04q\u0249K\xe4\xe7\&\{j\xe0\x00\x00\u07d4\xa1\xf2\x85@P\xf8re\x8e\xd8.R\xb0\xad\{\xbc\x1c\xb9!\xf6\x89m\x03\x17\xe2\xb3&\xf7\x00\x00\u07d4\xa1\xf5\xb8@\x14\x72\x9a\xce\xf4\x02\xac<\u00c8jh\xca\xd2H\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xa1\xf7e\xc4O\xe4_y\x06w\x94HD\xbeO-\\ \end{tabel}$

 $\x 00\x 00\u 07d4\x a 2\x 02TrB\x 80onp\x e 7@X\x d 6\x e 5)-$

 $\label{thm:c8xc8u0509l} $$ \operatorname{thm:c8xf3fb} \noindent $$ \operatorname{thm:c8xf3fb} \noindent $$ \operatorname{thm:c8xf3fb} \noindent $$ \noindent$

\x00\x00\u07d4\xa2\x14B\xab\x054\n\xdeh\xc9\x15\xf3\xc39\x9b\x99U\xf3\xf7\xeb\x89*\x03I\x19\u07ff\xbc\x00\x00\u07d4\xa2\"\"Y\u075c>=\xed\x12p\x84\xf8\b\xe9*\x18\x870,\x89\b\xc83\x9d\xaf\xedH\x00\x00\u07d4\xa2\"\"Y\u075c>=\xed\x12p\x84\xf8\b\xe9*\x18\x870,\x89\b\xc83\x9d\xaf\xedH\x00\x00\u07d4\xa2*\xde\r\xdb\\n\xf8\xd0\u034d\xe9M\x82\xb1\x10\x82\xcb.\x91\x897KW\xf3\xce\xf2p\x00\x00\u07d4\xa2E:\xb6!\x81\xe9\xa1[x\xc4b\x1eL|X\x81'\xbe&\x89\b\xcd\xe4:\x83\xd31\x00\x00\u07d4\xa2W\xadYK\u0603(\xa7\xd9\x0f\xc0\xa9\a\u07d5\xee\xca\xe3\x16\x89\x1c7\x86\xff8F\x93\x00\x00\u07d4\xa2[\bd7\xfd!\x92\u0420\xf6On\xd0D\xf3\x8e\xf3\xda2\x89\x12)\x0f\x15\x18\v\xdc\x00\x00\u07d4\xa2\x\b0X\u02d8\u060b\xee\xdbg\xe5CPl\x9a\r\x94\p\u0609\x90\xaa\xfcv\xe0\xbe\x00\x00\u07d4\xa2\x82\xe9i\xca\xc9\xf7\xa0\xe1\xc0\u0350\xf5\xd0\xc48\xacW\r\xa3\x89\\"\a\xeb\x89\xfc'8\x00\x00\x00\x00\x00\xe0\x94\xa2\x91\xe9\u01d9\rU-

c\x10\x00\x00\u07d4\xa2\xb7\x01\xf9\xf5\xcd\u041eK\xa6+\xae\xba\u3a02W\x10X\x85\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xa2\u0145O\xf1Y\x9f\x98\x89,W%\xd2b\xbe\x1d\xa9\x8a\xad\xac\x89\x11\t\xff30\x10\xe7\x80\x00\u07d4\xa2\xc7\xea\xff\xdc,\x9d\x93sE

 $\label{thm:convenient} $$ \|x90\|x9aR\|u07f1LG\|x8f\|x89\|a\|xc0\|x86\|x0eZ\|x80\|xdc\|x00\|u07d4\|xa2\|u04aabk\|t\|xd6\|xd4\|xe4\|xb1\|u007f\|xfcZ\|x88\|xbdx\|xd3gB\|x89\|xfb\|x80xPuS\|x83\|x00\|x00\|u07d4\|xa2\|u04cd\|xe1\|xc79\|x06\|xf6\|xa7\|xcan\|xfe\|xb9\|xf6\|xf6\|x9c\|xc4\|x8965\|u026d\|xc5\|u07a0\|x00\|x00\|x90\|x94\|xa2\|xdce\|xee\%kY\|xa5\|xbdy\|w0\|x90K5\|x8d\|U000ed84a\|x04\|x83\|xbc\|xe2\|x8b\|xeb\|t\|xf8\|x00\|x00\|u07d4\|xa2\|xe0h\|xe6\|xa0\|xdb\|xfb\|xb5\|xe90\|x05p\|xb67\|u00c9\|x01\|x15\|x8eF\|t\|x13\|xd0\|x00\|u07d4\|xa2\|u1e2a\|x90\|x0e\|x9c\|x13\|x9b\|xa1\|"5OaV\|xd9\|x18\|xb1\|x89\|x1b\|x1a\|xe4\|xd6\|xe2\|xefP\|x00\|x00\|u07d4\|xa2\|u2d54\|x1e\|f\|x01\|x94\|xfe\|x1d\|xb4\|xe8\|xa3K\|x92\|u03f1\|x89\|n\|u05ce\|xbcZ\|xc6$

 $0\x95\xed\xb7\x02\x8ehq\xce\n\x84\xf5HE\x9f\x830\n\x89\xd8\xd7\&\xb7\x17z\x80\x00\u07d4\x33!\t\x1d0\x18\x06By\xdb9\x9d+*\x88\xa6\xf4@\xae\x89\xadx\xeb\u016cb\x00\x00\x00\u07d4\xa3#-$

 $\label{thm:condition} $$ \operatorname{V}(0)^{1}F\cdot d^{x11}. \ee_{\mathbb{F}(n)} $$ \ee_{\mathbb{$

 $72Ea)\t\x89\b!\xd2!\xb5)\x1f\x80\x00\u07d4\xa3u\xb4\xbc\xa2N\x1fyu\x93\xcc0+/3\x10c\xfa\\x89\xnu05ce\xbcZ\xc6$

 $\label{thm:continuous} $$ \x8ae\x9e\x89\xa2\xc4~\x90T0\xb2\xa8'\x97\x89P\xa7\x8965\u026d\xc5\u07a0\x00\u07d4\xa3\x89\x83\x06\xcbp\xba\xa8\u4446\xbdh\xaap\xa8=$/)\a\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xa3\x87\xceN\x96\x1a\xG\xf5\a\d\xe1YkVA\xd2\x1c\x89\=M\x18\"\x9c\xa2\x00\x00\u07d4\xa3\x87\xec\xde\x0e\xe4\xc8\a\x94\x99\xfd\x8e\x03G;\u060a\xd7R*\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xa3\x88:\xf7\xf1f$

 $c\x10\x00\x00\x00\x94\x3\x93^*1\xd6\xffu\xfb;\x12q\xac\xe7\u02a7\xd5\xe1\xff\x10Q\x8a\x04<3\xc1\x93\ud\x80\x00\x00\xe0\x94\xa3\x94\xadO\xd9\xe6S\x0eo\S\xfa\xec\xbe\u0781\xcb\x17-$

c\x10\x00\x00\x94\xa3\x9b\xfe\xe4\xae\u027du\xbd\"\u01b6r\x89\x8c\xa9\xa1\xe9]2\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xa3\xa2b\xaf\u0493h\x19#\b\x92\xfd\xe8O-

 $\label{lem:convergence} ZYJ\xb2\x83\x89e\xea=\xb7UF`\x00\x00\u07d4\xa3\xa2\xe3\x19\xe7\u04e1D\x8bZ\xa2F\x89S\x16\xeq{16}$ \f-

 $\label{thm:linear} $$ \xbc\xbaq\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xa3\xa5{\a\x16\x13(\x04\xd6\n\xac(\x11\x97\xff+=\#\x01\x89K\xe4\xe7\&\{j\xe0\x00\x00\u07d4\xa3\xa9>\xf9\xdb\xea\&6\&=\x06\xd8l/jA\u0790|\"\x89\x003@\xaa\xd2\x1b;p\x00\x00\x00\x00\xe0\x94\xa3\xae\x18y\x00}\x80\x1c\xb5\xf3RqjM\u063a'!\xde=\x8a*Z\x05\x8f\u0095\xed\x00\x00\x00\u07d4\xa3\xba\r:6\x17\xb1\xe3\x1bNB,\xe2i\xe8s\x82\x8d]i\x89.\x14\x1e\xa0\x81\xca\b\x00\x00\u07d4\xa3\xbc\x97\x9bp\x80\t/\xa1\xf9/n\x0f\xb3G\u2359PE\x89\x97\xc9\xceL\xf6\xd5\xc0\x00\x00\u07d4\xa3\xbf\xf1\u07e9\x97\x16h6\f\xx82\x82\x842\xe2\{\xf5\Ng\x89\xn005ce\xbcZ\xc6$$

\x94\x86\a\x00\x00\xe0\x94\xa40\x99]\xdb\x18[\x98e\xdb\xe6%9\xad\x90\xd2.Ks\u008a\x02\x1e\x 19\xe0\u027a\xb2@\x00\x00\u07d4\xa46\xc7TS\xcc\xcaJ\x1f\x1bb\xe5\u0123\r\x86\xdd\xe4\xbeh\ x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\xa47\xfen\xc1\x03\u028d\x15\x8fc\xb34\"N\u032c[>\xa3\x8 a\x01\xb1\xaeMn.\xf5\x00\x00\x00\x00\u07d4\xa4;m\xa6\xcbz\xacW\x1d\xff'\xf0\x9d9\xf8F\xf57i\xb1\x8

 $9\x14\x99\x8f2\xacxp\x00\x00\u07d4\xa4;\x81\xf9\x93V\xc0\xaf\x14\x1a\x03\x01\rw\xbd\x04,q\xc1\xee\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xa4>\x19G\xa9$+5Ua\xc3\n\x82\x9d\xfe\uc881Z\xf8\x89\xd2=\x99\x96\x9f\u0591\x80\x00\u07d4\xa4H\x9aP\xea\xd5\xd5DZ{\xeeM-}$

U6\u00a7IA\xf8\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\xa4O\xe8\x00\xd9o\xca\xd7;qp\xd0\xf6\x10\u02cc\x06\x82\xd6\u0389\xd8\xd7&\x b7\x17z\x80\x00\x00\u07d4\xa4T2\xa6\xf2\xac\x9dVW{\x93\x8a7\xfa\xba\xc8\xcc|F\x1c\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xa4f\xd7p\u0618\xd8\xc9\xd4\x05\xe4\xa0\xe5Q\xef\xaf\xcd\xe5<\xf 9\x89\x1a\xb2\xcf|\x9f\x87\xe2\x00\x00\x00\x00\x00\x00\u07d4\xa4g\a1\x17X\x93\xbb\xcf\xf4\xfa\x85\u0397\xd9O\xc5\x1cK\xa8\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\xa4kC\x87\xfbM\xcc\xe0\x11\xe7nMsT}D\x81\xe0\x9b\xe5\x89Hz\x9a0E9D\x00\x00\u07d4\xa4l\xd27\xb6>\xeaC\x8c\x8e;e\x85\xf6y\xe4\x86\b2\xac\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xa4\x82kl8\x82\xfa\xd0\xed\\\x8f\xbb\%\xcc@\xcCO3u\x9f\x89p\x1bC\xe3D3\xd0\x00\x00\u07d4\xa4\x87Y(E\x8e\xc2\x00]\xbbW\x8c\\\xd35\x80\xf0\xcf\x14R\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xa4\x9fR:\xa5\x13d\xcb\xc7\u0655\x16=4\xebY\rxed\b\x89\x90'B\x1b*\x9f\xbc\x00\x00\u07d4\xa4\x84\x9f\v\xc8h\x8c\xc9\xe6\xdc\x04\xe1\xe0\x8\dR\x10&\xe6Ut\x89\n\u05ce\xbcZ\xc6

 $tE \x8c\xa4\x85~\xe0\v\xcd\u07c9\x123\xe22\xf6\x18\xaa\x00\x00\u07d4\xa5u\xf2\x89\x1d\xcf\u03\\68<\xf0\x14t\xaf\x11\xee\x01\xb7-$

 $\label{thm:converse} $$ \u0089\x051\xd5_\xc6M\xfe\x00\x00\u07d4\xa5x;\xf342\xff\x82\xac1\x89\x85\xd7\xd4\xaeg\xec6s\x89\xa9\x92\xe5:\n\xf0\x00\u07d4\xa5\x87MuF5\xa7b\xb3\x81\xa5\xc4\u01d2H:\xf8\xf2=\x1d\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\xe0\x94\xa5\xa4\"\u007fl\xf9\x88\%\xc0\u057a\xffS\x15\u,\xcc\x1a\x13\x91\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xa5\xabK\xd3X\x8fF\xcb'.V\xe9=\xee\u04c6\xba\x8bu=\x89HB\xf0A\x05\x87,\x80\x00\xe0\x94\xa5\xba\xd8e\t\xfb\xe0\xe0\xe0\xe3\xc0\xe9?m8\x1f\x1a\xf6\xe9\u0501\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\x00\u07d4\xa5\xc36\b;\x04\xf9\G\x1b\x8cn\xd76\y\xb7Mf\xc3c\uc263e\nL\x9d$

\xe2\x00\x00\u07d4\xa5\xcd\x129\x92\x19K4\xc4x\x13\x140;\x03\xc5IH\xf4\xb9\x89I\xfc\xc3\xd9\x 1d\xa5\x00\x00\u07d4\xa5\u0578\xb6-\x00-

 $\label{thm:control} $$ \operatorname{thm:control} (x_0) \times (x_0)$

\x1dw\x86\xec7:\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\xe0\x94\xa6\x13Ei\x96@\x8a\xf1\xc2\xe9>\x17w\x88\xabU\x89^+2\x8a\x01Y\x19\xffG|\x88\xb8\x00\x00\u07d4\xa6\x18\x87\x81\x8f\x91J\xe3\x10w)\v\x83qZk-

 $\x 91\x 9e\x e4l\x c2\x d0\x cd\x ff\x 04: uX\%\x 89\x 04\x 13t\x fd!\x b0\u 0600\x 00\u 07d4\x a6\x 8e\f 0\u 02e 3\x bc\x 2\x 88>T\x 03$

 $\label{thm:linear_continuous_co$

 $\label{lem:condition} $$C\times 8\times 2^{\frac{1}x1a}x89\times 9csK\xadQ\x11X\x00\x00\u07d4\xa7\x01\xdfy\xf5\x94\x90\x1a\xfe\x14D}$$H^k$$$

 $\label{thm:colored} $$ \onum{1} \end{tag} in $$ \onum{2} \end{tag} in$

 $\label{thm:converse} $$ \x00\x00\u0794\xa7kt?\x98\x1bi0r\xa11\xb2+\xa5\x10\x96\V/\xef\u05c8\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xa7m?\x15bQ\xb7,\f\xcfKG\xa39<\xbdol\xa9\u0149Hz\x9a0E9D\x00\x00\u07d4\xa7t(\xbc\xb2\xa0\xdbv\xfc\x8e\xf1\xe2\x0eF\x1a\n2\u016c\x15\x89\x15\xbeat\xe1\x91.\x00\x00\u07d4\xa7u\x8c\xec\xb6\x0e\x8faL\u0396\x13~\xf7+O\xbd\awJ\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xa7w^J\xf6\xa2:\xfa$

\x1f\xb7\x8b\x91^Q\xa5\x15\xb7\xa7(\x89\x06\x81U\xa46v\xe0\x00\x00\u07d4\xa7\u007f>\u1793\x 88\xbb\xbb\"\x15\xc6#\x97\xb9e`\x13#`\x89\n\u05ce\xbcZ\xc6

\x00\x00\xe0\x94\xa7\x85\x9f\xc0\u007fun\xa7\xdc\xeb\xbc\xcdB\xf0X\x17X-

 $\label{thm:condition} $$ \x97?\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xa7\x96IH\x9fLt\x8az\u902a'\xa5t\%\x17g\xca\xf9\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xa7\xa3\xbba9\xb0\xad\xa0\fx1f\u007f\x1f\x9fV\u0654\xbaM\x1f\xa8\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xa7\xa3\xf1S\xcd\u00c8!\xc2\f]\x8c\x82A\xb2\x94\xa3\xf8+$\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xa7\xa5\x17\u05ed5\x82\v\t\u0517\xfa\xe9\u04c8\x89Ik\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\xa7\xc9\u04c8\xeb\xd8s\xe6k\x17\x13D\x83\x97\xd0\xf3\u007f\x8b\u04e8\x8a\x01\x0f\f\xf0d\xddY$

 $\x00\x00\u07d4\xa7\u073b\xa9\xb9\xbfgb\xc1EAlPjq\u3d17$

\x0f\x90\x06\xaa*&\r\xba\xa8H=\xc5+0\x89\vB\xd56f7\xe5\x00\x00\x00\x94\xa7\xef5\u0387\xed\xa6\u008d\xf2HxX\x15\x05>\xc9zPE\x8a\x01\x0f\f\xe9I\xe0\x0f\x93\x00\x00\u07d4\xa7\xf9\"\f\x80G\

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\xa83\x82\xb6\xe1Rg\x97J\x85P\xb9\x8fqv\xc1\xa3S\xf9\xbe\x89\xbf\xfd\xaf/\xc1\xb1\xa4\x00\x00\xe0\x94\xa8DIG\x81\xa77\xacC(\xb1\xe1[\x8a\v?\xbb\x0f\xd6\xx8a\x04\x87\x94\xd1\xf2F\x19*\x00\x00\u07d4\xa8E[A\x17e\u0590\x1e1\x1erd\x03\t\x1eB\xc5f\x83\x89\xb7:\xec;\xfe\x14P\x00\x00\xe0\x94\xa8f\x13\xe6\u0124\xc9\xc5_\\x10\xbc\xda2\x17]\u02f4\xaf\x8a\x02C\xd6\xc2\xe3k\xe6\xae\x00\x00\u07d4\xa8m\xb0}\x9f\x81/G\x96b-$

@\xe0=\x13Xt\xa8\x8at\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xa8\u007fz\xbdo\xa3\x11\x94(\x96x\xef\xb6<\xf5\x84\xee^*a\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\x00\xe0\x94\xa8\x80\u2a3f\x88\xa1\xa8&H\xb4\x01<|\xc4YLC<\u020a\x01\x00N.E\xfb~\xe0\x00\x00\u07d4\xa8\x85w\xa0s\xfb\xaf3\xc4\xcd

\x14S3<u\u007fj\u067c\xb5U\xc0-

\xa9;\x89wB\xb7\x83\x0f4\x1d\x00\x00\u07d4\xa8\xe4*N3\xd7RI\xca\x19\u0663m\xcdn\x80@\xd0\xeas\x89:\x8c\x02\xc5\xea-\xe0\x00\x00\u07d4\xa8\xe7

 $\x1f\xf6\x19\xfa\xff\xc32\xe6\xad7\xedA\xe3\x01\xbf\x01J\x89$

 $\label{thm:label} $$ \ac5\x10R`\x00\x00\u07d4\xa8\xee\x1d\xf5\xd4K\x12\x84i\xe9\x13V\x9e\xf6\xac\x81\xee\xda O\u0209\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\xe0\x94\xa8\xef\x9a\xd2tC`B\x90>A<;\fb\xf5\xf5.\u054 4\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xa8\xf3\u007f\n\xb3\xa1\xd4H\xa9\xe3\xce@\x96_\x97\xa6F\b:4\x89\x11\xe0\xe4\xf8\xa5\v\xd4\x00\x00\u07d4\xa8\xf8\x9d\xd5\xccnd\u05f1\xee e\xac\xe0\a\x02\x02,\xd7\xd2\xf0=\x89\%\xf2s\x93=\xb5p\x00\x00\x00\xe0\x94\xa9\x04\v\xe2\xef\xdf\xee eO8\{\x0f2\xa5\x06\xxb0\xef\xb5s\xb5\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\x00\u07d4\xa9\x14P F\xfa6(\xcf_\xd4\xc6\x13\x92\{\xe51\xe6\xdb\x1f\u0749\x06\x12O\xee\x99;\xc0\x00\x00\x00\x00\xe0\x94\x89\x878\x99G\x13y\x80\x00\xe0\x94\x89\x878\x99G\x13y\x80\x00\xe0\x99$

\xa9\x1aZ{4\x1f\x99\xc55\x14N

\xbe\x9ck;\xb4\u008eM\x8a\x01&u:\xa2\$\xa7\v\x00\x00\u07d4\xa9%%Q\xa6\$\xaeQ7\x19\u06beR\ a\xfb\xef\xb2\xfdwI\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xa9'\u050b\xb6\u02c1K\xc6\t\xcb\u0 2a9\x15\x1f]E\x9a'\xe1\x89\x0e\xb95\t\x00d\x18\x00\x00\u07d4\xa9)\u023dq\xdb\f0\x8d\xac\x06\b \n\x17G\xf2\x1b\x14e\xaa\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xa9K\xbb\x82\x14\u03cd\ xa0\xc2\xf6h\xa2\xacs\xe8bHR\x8dK\x894\n\xad!\xb3\xb7\x00\x00\x00\u07d4\xa9Q\xb2D\xffP\u03 eeY\x1d^\x1a\x14\x8d\xf6\xa98\xef*\x1a\x89^\x00\x15\x84\xdf\xcfX\x00\x00\u07d4\xa9`\xb1\xca\x dd;\\\x1a\x8e\\xb3\xab\xca\xf5.\xe7\xc3\xd9\xfa\x88\x89R\x8b\xc3T^Rh\x00\x00\u07d4\xa9a\x17\x 1fSB\xb1s\xddp\xe7\xbf\xe5\xb5\xca#\x8b\x13\xbc\u0749\xb8'\x94\xa9\$O\f\x80\x00\u07d4\xa9u\x b0w\xfc\xb4\u030e\xfc\xbf\x83\x84Y\xb6\xfa\$:AY\u0589\x02+\x1c\x8c\x12'\xa0\x00\x00\xe0\x94\x a9{\xeb:H\xc4_\x15((L\xb6\xa9_}\xe4S5\x8e\u018a\x06\x90\x83l\n\xf5\xf5`\x00\x00\u07d4\xa9~\a! DI\x9f\xe5\xeb\xbd5J\xcc~~\xfbX\x98]\b\x89\x90\xf54`\x8ar\x88\x00\x00\u07d4\xa9\x86v/zO)O.\v\x 172y\xad,\x81\xa2\"4X\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xa9\x8f\x10\x985\xf5\xea\xcd\x 05Cd|4\xa6\xb2i\xe3\x80/\xac\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xa9\x97\xdf\u01d8j'\x05\ bH\xfa\x1cd\u05e7\xd6\xe0z\u0322\x89\a\xc0\x86\x0eZ\x80\xdc\x00\x00\u07d4\xa9\x99\x91\u03b d\x98\xd9\xc88\xc2 zt\x16\xd9\xe2D\xca%\r\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94\xa9\xa1\xc d\xc3;\xfd7o\x1c\rv\xfbl\x84\xb6\xb4\xac'Mh\x8a\x01\x0f\f\xf0d\xddY

\x00\x00\xe0\x94\xa9\xad\x19&\xbcf\xbd\xb31X\x8e\xa8\x197\x88SM\x98,\x98\x8a\x06ZM\xa2]0\x 16\xc0\x00\x00\u07d4\xa9\xaf!\xac\xbeH/\x811\x89j\"\x806\xbaQ\xb1\x94S\u00c9\x02\xb5\xe0!\x9 8\f\xc1\x80\x00\xe0\x94\xa9\xb2\xd2\xe0IN\xab\x18\xe0}7\xbb\xb8V\xd8\x0e\x80\xf8L\u04ca\x02\x 1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xa9\xbaoA;\x82\xfc\xdd\xf3\xaf\xfb\xbd\u0412\x87\xdc\xf5\x04\x15\u0289\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xa9\xbe\x88\xad\x1eQ\x8b\v\xbb\x02J\xb1\xd8\xf0\xe7?y\x0e\fv\x89\x97\xc9\xceL\xf6\xd5\xc0\x00\x00\u07d4\xa9\xbf\xc4\x10\xdd\xdb q\x1eE\xc0s\x87\xea\xb3\n\x05N\x19\xac\x89>\x99`\x1e\xdfNS\x00\x00\u07d4\xa9\u0522\xbc\xbe [\x9e\bi\xd7\x0f\x0f\xe2\xe1\u05aa\xcdE\xed\u0149\n\xc6\xe7z\xb6c\xa8\x00\x00\x00\u07d4\xa9\xd6 KO;\xb7\x85\a\"\xb5\x8bG\x8b\xa6\x917^\"NB\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\xa9\xd6 6\xf8q\xcax\x1au\x9a

 $94\xaa\x16p\&\u04da\xb7\xa8V5\x94N\xd9\xed\xb2\xbf\xeb\xa1\x18P\x8a\x01\xc1\xd5\xe2\x1bO\xcfh\x00\x00\u07d4\xaa\x1b7h\xc1m\x82\x1fX\x0ev\xc8\xe4\xc8\xe8m\u01c8S\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xaa\x1d\xf9.Q\xdf\xf7\v\x19s\xe0\xe9\xc6b\x87\xb4\x94\xa1x\x89\x1c\xf8J0\xa0\xa0\xc0\x00\x00\u07d4\xaa,g\x00\x96\xd3\xf990S\%B~\xb9U\xa8\xa6\r\xb3\u0149l\x95Y\x06\x99\#-$

 $\label{thm:convoluo7d4} $$ \x00\x00\u07d4\xaa\xe6\x1eC\xcb\rf\x96\xb3\x06\x99\xf7~\x00\xd7\x11\u0423\x97\x9b\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xaa\xe72\xed\xa6Y\x88\u00e0\f\u007fG/5\x1cF;\x1c\x96\x8e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xaa\xf0#\xfe\U0009091b\xb7\x8b\xb7\xab\xc9]f\x9cP\xd5(\xb0\x89\n)-\u05ce\xbcZ\xc6\x00\x00\x94\xaa\xf5\xb2\a\xb8\x8b\r\xe4\xac@\xd7G\xce\xe0n\x17-$

 $b\xe4\x18\x00\x00\xe0\x94\xab\x14\xd2!\xe3=TF)\x19\x8c\u0416\xedc\u07e2\x8d\x9fG\x8a\x01EB \xba\x12\xa37\xc0\x00\x00\xe0\x94\xab$

\x9f\u0729y\u0426G\x01\n\xf9\xa8\xb5/\xc7\xd2\r\x8c\u044a\x01\xee\xe2S,|-

 $\x04\x00\x00\u07d4\xab'\xbax\xc8\xe5\xe3\xda\xef1\xad\x05\xae\xf0\xff\x03\%r\x1e\b\x89\x19^\xce \x00n\x02\xd0\x00\u07d4\xab\(q\xe5\a\u01fe9eI\x8e\x8f\xb4b\x02Z\x1a\x1cBd\x89^\x03I\x19\u$

07ff\xbc\x00\x00\u07d4\xab8a\"o\xfe\xc1(\x91\x87\xfb\x84\xa0\x8e\xc3\xed\x042d\xe8\x8965\u026 d\xc5\u07a0\x00\x00\u07d4\xab=\x86\xbc\x82\x92~\f\xd4!\xd1F\xe0\u007f\x91\x93'\xcd\xf6\xf9\x8 9q\x8a\x93

 $b\xe4\x18\x00\x00\xe0\x94\xab>b\xe7z\x8b\"^A\x15\x92\xb1\xaf0\aR\xfeA$c\x8a\x02\x15\xf85\xbc v\x9d\xa8\x00\x00\u07d4\xab>x)K\xa8\x86\xa0\xcf\xd5\xd3H\u007f\xb3\xa3\a\x8d3\x8dn\x89j\xcb =\xf2-\x1f\x88\x00\x00\u07d4\xab@\x04\xc0@?-\xab\xb0\xeaXo!!V\xc4$

 $= g \times f1 \times 89 i \times ccg \times 0.05 f1 \times 0.00 \times 0$

 $01f7K\x95P\x82\xbb\xaa\xf2\xa1\x1dx\xbc\x05\x89K\xe4\xe7\&{j}\xe0\x00\x00\u07d4\xac\x02OYO\x95X\xf0ICa\x8e\xb0\xe6\xb2\xeeP\x1d\xc2r\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xac\x12*\x03\xcd\x05\x8c\x12._\xe1{\x87/Hw\xf9\u07d5r\x89j}\xc5\xc6-$

 $\x 94\x 86\a\x 00\x 00\u 07d4\x ac\x 14.\x da\x 11W\x b9\x a9\x a6C\x 90\x df\x j\x e6\x 94\x fa\u 0249\x 05\x 89\x n\u 05\c e\x bc\x 2\x c6$

\x00\x00\u07d4\xac\x1d\xfc\x98Kq\xa1\x99)\xa8\x1d\x81\xf0J|\xbb\x14\a7\x03\x89

\x86\xac5\x10R`\x00\x00\x94\xac!\xc1\xe5\xa3\xd7\xe0\xb5\x06\x81g\x9d\xd6\u01d2\xdb\u0287\xde\u02ca\x15-

\x00\x00\u07d4\xac(\xb5\xed\xea\x05\xb7o\x8c_\x97\bEA'|\x96ijL\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xac,\x8e\t\xd0d\x93\xa68XC{\xd2\v\xe0\x19bE\x03e\x89g\x8a\x93

\u007fW\x19\x8fk\x89\yt\x12?d\xa4\x00\x00\u07d4\xacN\xe9\xd5\x02\xe7\xd2\xd2\xd2\xe9\x9eY\xd8\x ca}_\x00\xc9KM\u058965\u026d\xc5\u07a0\x00\x00\u07d4\xacR\xb7~\x15fH\x14\xf3\x9eO'\x1b\x e6A0\x8d\x91\xd6\u0309\v\xed\x1d\x02c\xd9\xf0\x00\u07d4\xacY\x99\xa8\x9d-

\u0486\u0568\fm\xee~\x86\xaa\xd4\x0f\x9e\x12\x89\xd2U\xd1\x12\xe1\x03\xa0\x00\u07d4\xaccbr1H\r\r\x950.m\x89\xfc2\xcb\x1dO\xe7\xe3\x89\n\u05ce\xbcZ\xc6

 $\label{thm:condition} $$ \xen{x}00\x00\x00\x00\x00\u07d4\xac\x8bP\x9a\xef\xea\x1d\xbf\xaf+\xb35\x00\x06W\vo\xd9mQ\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\xac\x8e\x87\xdd\xda^x\xfc\xbc\xb9\xfa\u007f\xc3\xce\x03\x8f\x9f\.4\x89lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\xac\x9f\xffh\xc6\x1b\x01\x1e\xfb\xec\xf08\xedr\u06d7\xbb\x9er\x81\x8a\x02\x05\xb4\u07e1\xeetx\x00\x00\u07d4\xac\xa1\xe6\xbcd\xcc1\x80\xf6$$

6

\x00\x00\u07d4\xac\xc0bp,Ya]4D\xefb\x14\xb8\x86+\x00\x9a\x02\xed\x89QO\xcb\$\xff\x9cP\x00\x0

\xc4\x00\x00\u07d4\xac\xd8\u0751\xf7\x14vLEg|c\xd8R\xe5n\xb9\xee\xce.\x89lk\x93[\x8b\xbd@\x 00\x00\u07d4\xac\u2af6;\x06\x04@\x9f\xbd\xe3\xe7\x16\u0487mD\xe8\xe5\u0749\b=|z\xabc`\x00\x00\x00\u07d4\xac\u2af6;\x06\x04@\x9f\xbd\xe3\xe7\x16\u0487mD\xe8\xe5\u0749\b=|z\xabc`\x00\x00\x00\xe0\x94\xac\xec\x91\xefiA\xcfc\v\xa9\xa3\u71e0\x12\xf4\xa2\xd9\x1d\u050a\x10\xf0\xcf\x06M\u0552\x00\x00\x00\u07d4\xad\nJ\xe4x\xe9cn\x88\xc6\x04\xf2B\xcfT9\xc6\xd4V9\x89\xbe\xd1\xd0\&=\x9f\x00\x00\x00\u07d4\xad\x17\x99\xaa\xd7`+E@\u0343\x9d\xb5\xf1\x11P\xf1hz\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xad\x17\x99\xaa\xd7`+E@\u0343\x9d\xb5\xf1\x11P\xf1hz\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xad\x1dh\xa08\xfd\%\x86\x06~\xf6\xd15\xd9b\x8ey\xc2\xc9\x89\xfe\t\xa5 \\x9e*\xbc\x00\x00\u07d4\xad*\\\\x00\xf9\xb5\xd4\xed\xb5\xf1\x11\xb9\xf3\xfb\x06\x\f1\x11\x\89\x05k\xc7^-c\x10\x00\x00\u07d4\xadf|\xd2\xb5\x\83\xae\t\x1a\xb9\xf3\xf1\x16\xf4\x84\xaf\u0789i*\xe8\x89\x88\x89\x88\x17\x86\xcfT\x02\x8a\x02\xf6\xf1\a\x80\xd2\x00\x00\x00\u07d4\xadAM)\xcb~\xe9s\xfe\xc5N\"\xa3\x88\x17\x86\xcfT\x02\x8a\x02\xf6\xf1\a\x80\xd2\x00\x00\u07d4\xadD5~\x01~\\$OGi1\u01f8\x18\x9e\xfe\xe8\n]\n\x89\n\u05ce\xbcZ\xc

\x00\x00\u07d4\xadY\xa7\x8e\xb9\xa7J\u007f\xbd\xae\xfa\xfa\x82\xea\u0684u\xf0\u007f\x95\x89\x $1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xadZ\x8d\xef\x9fe\xb3\x83z\xwu\xef\x8e\x1d\xf91\x89$ \x02\x01\V\xe1\x04\xc1\xb3\x00\x00\u07d4\xadf\r\xec\x82U\"\xa9\xf6\\xce\xc3\u01771\x98\r\u0086\ ua262\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xadf(5.\xd39\v\xaf\xa8m\x92>V\x01L\xfc\xb3`\xf4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xadr\x81!\x87?\x04\V\xd0Q\x8b\x80\xabe\x80\xa2\x03pe\x95\x89\x1b\x 1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xads,\x97e\x93\xee\xc4x;N.\xcdy9yx\v\xfe\u06c9lk\x93[\x8b\x bd@\x00\x00\u07d4\xad}\xd0S\x85\x9e\xdf\xf1\xcbo\x9d*\xcb\xedm\xd5\xe32Bo\x89j\xcb=\xf2~\x 1f\x88\x00\x00\u07d4\xad\x80\xd8e\xb8\\4\xd2\xe6IK.z\xef\xeak\x9a\xf1\x84\u06c9\xd8\xd7&\xb7\ x17z\x80\x00\x00\x00\x94\xad\x8b\xfe\xf8\u018aH\x16\xb3\x91o5\xcb{\xfc\xd7\xd3\x04\tv\x8a\bxg \x83&\xea\xc9\x00\x00\x00\u07d4\xad\x8eH\xa3wij\xe0\x146:R:(\xb1\xa4\fx\xf2\b\x8965\u026d\xc 5\u07a0\x00\x00\u07d4\xad\x91\n#\u0585\x06\x13eJ\xf7\x863z\u04a7\bh\xacm\x89lh\xcc\u041b\x 02,\x00\x00\u07d4\xad\x92~\x03\xd1Y\x9ax\xca+\xf0\xca\u04a1\x83\xdc\xebq\xea\xc0\x89j\xcb=\x f2~\x1f\x88\x00\x00\x94\xad\x92\xca\x06n\xdb|q\x1d\xfc[\x16a\x92\xd1\xed\xf8\xe7q\x85\x8a\ a\x9f\x90\\o\xd3N\x80\x00\x00\u07d4\xad\x94#_\u00f3\xf4z\$\x13\xaf1\u8111I\b\xef\fE\x89\x1b\x1b \x01B\xd8\x15\x84\x00\x00\u07d4\xad\x9e\x97\xa0H/5:\x05\xc0\xf7\x92\xb9w\xb6\xc7\xe8\x11\xfa \x89\n\u05ce\xbcZ\xc6

\xe9\x8e`]\v\W\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\xad\xc1\x9e\xc85\xaf\xe3\u5347\u0713\xa8\xa 9!<\x90E\x13&\x89j\xdb\xe54\"\x82\x00\x00\x00\u07d4\xad\xc8\"\x8e\xf9(\xe1\x8b*\x80}\x00\xfb<| y\xcd\x1d\x9e\x96\x89\x01<i\xdf3N\xe8\x00\x00\u07d4\xad\xdb&1r'\xf4\\\x87\xa2\u02d0\xdcL\xfd\x 02\xfb#\xca\xf8\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xad\xe6\xf8\x16;\xf7\u01fbJ\xbe\x8e\x98\x

93\xbd\f\xc1\x12\xfe\x88r\x89\x11\xc2]\x00M\x01\xf8\x00\x00\u07d4\xad\xeb J\xa0\u00ce\x17\x9e\x81\xa9N\u0633\xe7\xd50G\xc2k\x89

 $\label{thm:linear_continuous} $$ \int_{\mathbb{R}\times \mathbb{R}\times \mathbb{R}$

\xce\xd6=\xba\u05c9,\xc6\u034c\u0082\xb3\x00\x00\xe0\x94\xae\x10\xe2z\x01O\r0k\xaf&mH\x97\ u021a\xee\xe2\xe9t\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\xae\x12k8,\xf2W\xfa\xd7\xf0\xbc}\x1 6)~T\xccrg\u0689\x10CV\x1a\x88)0\x00\u07d4\xae\x13\xa0\x85\x11\x11\x0f2\xe5;\xe4\x12xE\ $xc8C\xa1\xa5|{\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\xe0\x94\xae\x17\x9aF\r\xb6c\&t=$\xe6u\#\xae\xe6}$ 5{\$m\xaf\u007f\x8a\x01\x00\a\xae|\xe5\xbb\xe4\x00\x00\u07d4\xae\"(ey\x90y\xaa\xf4\xf0gJ\f\u06a b\x02\xa6\xd5p\xff\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xae#\x9a\xcf\xfdN\xbe.\x1b\xa5\xb4\x17\ x05r\xdcy\xcce3\xec\x8a\x02\x8a\x85t%Fo\x80\x00\x00\u07d4\xae\/x9c\x19\xacv\x13e\x94C#\x93 \xb0G\x1d\b\x90!d\u04c9%\xdf\x05\u01a8\x97\xe4\x00\x00\u07d4\xae4\x86\x1d4\"S\x19O\xfcfR\x df\xdeQ\xabD\xca\xd3\xfe\x89\x19F\bhc\x16\xbd\x80\x00\u07d4\xae6\xf7E!!\x91>\x80\x0e\x0f\xcd \x1ae\xa5G\x1c#\x84o\x89\b\xe3\xf5\v\x17<\x10\x00\x00\u07d4\xae?\x98\xa4C\xef\xe0\x0f>q\x1d R]\x98\x94\u071aa\x15{\x89\x10\x04\xe2\xe4 \xb7\xee\x00\x00\xe0\x94\xaeG\xe2`\x9c\xfa\xfe6\x 9df\xd4\x15\xd99\xde\x05\b\x1a\x98r\x8a\x05\xba\xec\xf0%\xf9\xb6P\x00\x00\u07d4\xaeO\x12.5\x c0\xb1\xd1\xe4\x06\x92\x91E|\x83\xc0\u007f\x96 \xa3\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xa ePU\x81L\xb8\xbe\f\x11{\xb8\xb1\xc8\u04b6;F\x98\xb7(\x89\x01\xbc\x93.\xc5s\xa3\x80\x00\u07d4 \xaeS\x8cs\u0173\x8d\x8dXM~\xbd\xad\xef\xb1\\\xab\xe4\x83W\x896'\xe8\xf7\x127<\x00\x00\u07 d4\xaeW\xcc\x12\x9a\x96\xa8\x99\x81\xda\xc6\r/xfb\x87}]\xc5\xe42\x89<:#\x94\xb3\x96U\x00\x00 xae\\\x9b\xda\xd3\xc5\u0221\"\x04D\xae\xa5\xc2)\xc1\x83\x9f\x1dd\x89\x19\xe2\xa4\xc8\x18\xb9\ x06\x00\x00\u07d4\xae\\\xe35Z{\xa9\xb32v\f\tP\u00bcE\xa8 \xa9\xa0\x89\x15\xaf\x1dx\xb5\x8c@ \x00\x00\xe0\x94\xae]\"\x1a\xfc\xd3\u0493U\xf5\b\xea\xdf\xca@\x8c\xe3<\xa9\x03\x8a\x15-\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\xaec[\xf781\x11\x9d-

)\xc0\xd0O\xf8\xf8\xd8\u0425zF\x89Hz\x9a0E9D\x00\x00\x00\x94\xaed\x81U\xa6X7\x0f\x92\x9b\x e3\x84\xf7\xe0\x01\x04~I\xddF\x8a\x02\xdf\$\xae2\xbe

D\x00\x00\x00\x94\xaeo\fs\xfd\xd7|H\x97'Q!t\u0675\x02\x96a\x1cL\x8a\x01EB\xba\x12\xa37\xc0\x 00\x00\u07d4\xaep\xe6\x9d,J\n\xf8\x18\x80\{\x1a'\x05\xf7\x9f\u0435\xdb\u01095e\x9e\xf9?\x0f\xc4 \x00\x00\u07d4\xaew\9\x12N\xd1S\x05\%\x03\xfc\x10\x14\x10\xd1\xff\xd8\xcd\x13\xb7\x8964\xfb\x 9f\x14\x89\xa7\x00\x00\u07d4\xaex\xbb\x84\x919\xa6\xba8\xae\x92\xa0\x9ai`\x1c\xc4\xcbb\u0449 \x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xae\x84\\"\x10\xf4M\x14\u0124\u06d1\xfc\x9d;;P\x01O\\ xf7\x89\xd8\xd7\x17z\x80\x00\x00\u07d4\xae\x84\\"\x10\xf4M\x14\u0124\u06d1\xfc\x9d;;P\x01O\\ xf7\x89\xd8\xd7\x17z\x80\x00\x00\u07d4\xae\x84\\"\x10\xf4M\x14\u0124\u06d1\xf6\xf6Plhm\xc2\x04\xac\ x15\xbf\x8b\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xae\x89T\xf8\xd6\x16\xe1\max6\x10\x05\n\u0aca\ x82\xa9\x18\x98\u0389\x01\xa0Ui\r\x9d\xb8\x00\x00\u07d4\xae\x9e\xcdk\u0755\xf4\x97\xc0\x05\n\u0aca\ x82\xa9\x18\x98\u0389\x01\xa0Ui\r\x9d\xb8\x00\x00\u07d4\xae\xae\x9f\\?\xbb\xe0\u027c\xbf\x1a\xf8\x fft\xea(\v:]\x8b\x89]\u0212\xaa\x111\xc8\x00\x00\u07d4\xae\xad\x6\u0417\x8e\xda\xd7J2\xbd\x01\xa0\xa5\x1 d7\xf2F\xe6a\x89\x0e\x189\x8e\x01\x90\x00\u07d4\xae\xb9\x16\xeb\xf4\x9d\x0f\x86\xc1?s1\

xce\xf1\x9e\x12\x997Q-\x89 \x85e[\x8d\x1b\n\x00\x00\u07d4\xae\xbdO

 $\label{thm:cf-colored} $$ \x holds on $$ \x holds$

 $\$ \"\x9d~mA\x9d\xf47\x8e\xa9\x87\x15Q_c\x14\x85\x89j\xcb=\xf2~\x1f\x88\x00\x00\x00\x94\xaf X\xc7(,\xf6|\x8c<\xf90\x13<\x89a|\xe7])\x8a\x01w\"J\xa8D\xc7 \x00\x00\u07d4\xaf&\xf7\u01bfE> x\xf0\x89S\u4c80\x04\xa2\xc1\xe2\t\x89\x05k\xc7^-

 $c\x10\x00\x00\u07d4\xaf0\x87\xe6.\x04\xbf\x90\rZT\xdc>\x94bt\u0692B;\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xaf6\x14\u0736\x8a6\xe4ZN\x91\x1ebybG\"-$

 $Y[\x89z\x81\x06_\x11\x03\xbc\x00\x00\u07d4\xaf6\x15\u01c9\u0431\x15^\xd4\xdb\%\xfe]\xcf\"(\x04\xcfb\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xaf<\xb5\x96Y3\xe7\xda\u0603i;\x9c>\x15\xbe\xb6\x84\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xafD\x93\xe8R\x1c\xa8\x9d\x95\xf5\&|\x1a\xb6?\x9fEA\x1e\x1b\x89\n\u05ce\xbcZ\xc6$

\xd6i\xc0\x88>U\x15\xd3\xf3\x11*\x13\xf6\x17\xa4\xc3g\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xaf\x a1\u056d8\xfe\xd4GY\xc0[\x89\x93\xc1\xaa\r\xac\xe1\x9f@\x89\x04V9\x18\$O@\x00\x00\xe0\x94\ xaf\xa59XnG\x19\x17J;F\xb9\xb3\xe6c\xa7\u0475\xb9\x87\x8a\x01\x0f\f\xf0d\xddY

 $\label{thm:convoluo7d4} $$\x00\x00\u07d4\xaf\xa6\x94n\xff\xd5\xffS\x15O\x82\x01\x02S\xdfG\xae(\f\u0309j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xaf\xcb\u860b\xd4\x10Z\xccL\x01\x8eTj\x1e\x8f\x9cx\x88\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\x00\x94\xaf\xcc}\xbb\x83V\xd8B\xd4:\xe7\xe2<\x84\"\xb0\"\xa3\b\x03\x8a\x06o\xfc\xbf\xd5\xe5\xa3\x00\x00\x00\u07d4\xaf\xd0\x19\xff6\xa0\x91U4ki\x97H\x15\xa1\xc9\x12\xc9\n \xa4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xaf\xda\xc5\xc1\xcbV\xe2E\xbfp3\x00f\xa8\x17\uabecL\u0449\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xaf\xdd\x1b\xab\xb81~$

xfc\x99\xd5\ubd28O\xe7x\x8d\x97\xdc\xe2t\xb08\$\x048\x8a\x01\x0f\f\xf0d\xddY

\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xb0\u007f\u07af\xf9\x1dD`\xfel\xd0\u8870\xbd\x8d\"\xa6.\x87\x8a\x01\x1d%)\xf3SZ\xb0\x00\x00\xe0\x94\xb0\x9f\xe6\xd44\x9b\x99\xbc7\x93\x80T\x02-

\xe4\x1f|t\xd0|\u0785i\xc2\x1cu\xc2\xf9\x8a\x01\x93\x9c\x99\xed\xab\x80\x00\x00\u07d4\xb0\xc7\xceL\r\xc3\u00bb\xb9\x9c\xc1\x85\\x8aE_a\x17\x11\u0389\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xb0\xce\xf2\xb0\xce\xf8\xe8\xfb\x89\x84\xa6\x01\x9f\x01\xc6\xf2\xbb\xe6\x8f\\w\x89\b=|z\xabc`\x00\x00\x00\x00\xe0\x94\xb0\xd3+\xd7\xe4\u6577\xb0\x1a\xa3\xd0Ao\x80U\\xba\x99\x03\x8a\x03s\x9f\xf0\xf6\xe6\x13\0\x00\x00\x00\xe0\x94\xb0\xd3\u0247+\x85\x05n\xa0\xc0\xe6\xd1\xec\xf7\xa7~<\u6ac5\x8a\x01\x0f\b\xed\xa8\xe5U\t\x80\x00\u07d4\xb0\xe4i\u0206Y8\x15\xb3IV8Y]\xae\xf0f_\xaeb\x89i*\xe8\x89p\x81\xd0\x00\x00\u07d4\xb0\xe7`\xbb\a\xc0\x81\wsE\xe0W\x8e\x8b\u0218\"mN;\x89ik\x93[\x8b\xbd@\x00\x00\u07d4\xb1\x04\x04\xec\x19A\xa8\xcfO+\x00\xb1W\x00\u076co\xf1~\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xb1\x0f\u04a6G\x10\x88\x1ft\xc9\xfb\xc3\xa62\x94\x9f\u08b\x02+\x1c\x8c\x12\xa0\x00\x00\x00\x00\x00\xe0\x94\xb1\x15\xee:\xb7d\x1e\x1a\xa6\xd0\x00\x00\xe4\x1b\xfc\x1e\xc7!\f/2\x8a\x0\2\xc0\xbb=\xd3\fN

\x00\x00\u07d4\xb1\x17\x8a\xd4s\x83\xc3\x1c\x814\xa1\x94\x1c\xbc\xd4t\xd0bD\xe2\x8965\u026

\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\xb1\x19\u76a9\xb9\x16Re\x81\xcb\xf5!\xefGJ\xe8M\xcf\xf4\x 89O\xba\x10\x01\xe5\xbe\xfe\x00\x00\u07d4\xb1\x1f\xa7\xfb'\n\xbc\xdfZ.\xab\x95\xaa0\u013566\u ffc9+^:\xf1k\x18\x80\x00\x00\u07d4\xb1\$\xbc\xb6\xff\xa40\xfc\xae.\x86\xb4 '\xe3\xf2\x1e\x81\xee\ b\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xb1)\xa5\xcbq\x05\xfe\x81\v\u0615\xdcr\x06\xa9\x91\xa4T T\x88\x89\x01\xa0Ui\r\x9d\xb8\x00\x00\x00\xe0\x94\xb1.\xd0{\x8a8\xadU\x066?\xc0z\vmy\x996\xbd\x af\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xb14\xc0\x049\x1a\xb4\x99(x3zQ\xec\$/B(WB \x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xb1?\x93\xaf0\xe8\xd7fs\x81\xb2\xb9[\xc1\xa6\x99\xd5\xe3\ xe1)\x89\x16\u012b\xbe\xbe\xa0\x10\x00\x00\u07d4\xb1E\x92\x85\x86>\xa2\xdb7Y\xe5F\u03b3\x fb7a\xf5\x90\x9c\x89<\xd7*\x89@\x87\xe0\x80\x00\u07d4\xb1F\xa0\xb9%U<\xf0o\xca\xf5J\x1bM\ xfe\xa6!)\aW\x89InY\xe6|xT\x00\x00\xe0\x94\xb1Jz\xaa\x8fl\xf2\xfb\x9a\x81\x02\u05bb\xe4\u010a \xe7\xc0o\xb2\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\xb1K\xbe\xffpr\tu\xdca\x91\xb2\xa4O\xf 4\x9f&r\x87<\x89\a\xc0\x86\x0eZ\x80\xdc\x00\x00\x00\xe0\x94\xb1L\xc8\xde3\xd63\x826S\x9aH\x90 \xceFU\xa3+\u018a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\xb1M\xdb\x03\x86\xfb`c\x98\xb8\xccG \xee\x1aD\xa3\x18\xa8\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xb1T\x0e\x94\xcf\xf3F\\\xc3\u0 447\xe7\xc8\u3f6f\x98FY\u2262\x15\xe4C\x90\xe33\x00\x00\u07d4\xb1X\xdbC\xfab\xd3\x0ee\xf3\ u041b\xf7\x81\u01f6sr\uba89l]\xb2\xa4\xd8\x15\xdc\x00\x00\u07d4\xb1ar \xdc\xed\xd1yR\xd5{#\x ef([~K\x11i\xe8\x89\x02\xb6\xdf\xed6d\x95\x80\x00\u07d4\xb1dy\xba\x8e}\xf8\xf6>\x1b\x95\xd1I\u 0345)\xd75\xc2\u0689-

\xe4wt\xf5\x9dIT\xd5\xe3*\xb1\x89V\xf7\xa9\xc3<\x04\xd1\x00\x00\u07d4\xb1\x88\a\x84D\x02~8g\x98\xa8\xaehi\x89\x19\xd5\xcc#\r\x89\x0e~\xeb\xa3A\vt\x00\x00\u07d4\xb1\x89j7\xe5\u0602Z-\x01vZ\xe5\xdeb\x99w\u0783R\x89\n\u05ce\xbcZ\xc6

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 $PU\xd9b15\x96\x1ej\xbd'<\x90\xde\xea\x16\xa3\xe7\x89K\xe4\xe7\&\{j\xe0\x00\x00\x00\u07d4\xb2-\xad\xd7\xe1\xe0R2\xa927\xba\xed\x98\xe0\u07d2\xb1\x86\x9e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xb24\x03_uDF<\xe1\xe2+\xc5S\x06F\x84\xc5\x13\xcdQ\x89\r\x89\xfa=\u010d\xcf\x00\x00\u07d4\xb2G\u03dcr\xecH*\xf3\xea\xa7Ye\x8fy=g\nW\f\x891p\x8a\xe0\x04T@\x00\x00\u07d4\xb2ghA\xee\x9f-1\xc1r\xe8\#\x03\xb0\xfe\x9b\xbf\x9f\x1e\t\x89\n\u05ce\xbcZ\xc6$

 $$$ \x00\x00\u07d4\xb2\u0777\x86\xd3yN'\x01\x87\xd0E\x1a\xd6\u0237\x9e \x0e\x87E\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xb2\xe0\x85\xfd\xdd\x14h\xba\aA['NsN\x11 +\u007f\xb2\xa9\x89\x05k\xc7^-$

u07d4\xb2\u066b\x96d\xbc\xf6\xdf <4o\u0192\xfd\x9c\xba\xb9

 $\xf9\xd2\x19\xf5y\x80\x00\u07d4\xb3*\xf3\xd3\xe8\xd0u4I\&To.2\x88\xf9;\x16\xbd\x89\n\u05ce\xbc\\ Z\xc6$

\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xb3\x88\xb5\xdf\xec\xd2\xc5\u4d56W|d%V\xdb\xfe'xU\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xb3\x8cNS{]\xf90\xd6Zt\xd0C\x83\x1dkH[\xbd\xe4\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\x00\x94\xb3\x919Wa\x94\xa0\x86a\x95\x15\x1f3\xf2\x14\n\xd1\u0306\u03ca\x15-

 $\label{thm:linear_continuous} $$ \end{align*} $$ \end{align*$

 $\label{thm:converse} $$ \x00\x00\u07d4\xb3\xfc\x1dh\x81\xab\xfc\xb8\xbe\xcc\v\xb0!\xb8\xb7;r3\u0751\x89\x02\xb5\xe3\xaaf\x16\xb1\x88\x00\x00\u07d4\xb4\x05\x94\xc4\xf3fN\xf8l\u0326\"{\x8a\%\xaai\t\%\xee\x89\xd8\xd7\&} $$$

 $4\x14\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xb4F\x05U\$q\xa6\xee\xe4\u06abq\xff;\xb4\x13\&\xd4s\xe0\x89-$

~=Q\xbaS\xd0\x00\x00\u07d4\xb4GW\x1d\xac\xbb>\u02f6\xd1\xcf\v\f\x8f88\xe5#\$\xe2\x89\x01\xa 3\x18f\u007f\xb4\x05\x80\x00\u07d4\xb4G\x83\xc8\xe5{H\a\x93\xcb\u059aE\xd9\f{O\fH\xac\x89\x 01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xb4H\x15\xa0\xf2\x8eV\x9d\x0e\x92\x1aJ\u078f\xb2d%&Iz\ x89\x03\x027\x9b\xf2\xca.\x00\x00\u07d4\xb4H\x15\xa0\xf2\x8eV\x9d\x0e\x92\x1aJ\u078f\xb2d%&Iz\ x89\x03\x027\x9b\xf2\xca.\x00\x00\u07d4\xb4Im\xdb'y\x9a\"\$\W\xd79y\x11g(\u8844[\x89\x8d\x81\x 9e\xa6_\xa6\x80\x00\x00\x00\u07d4\xb4RL\x95\xa7\x86\x0e!\x84\x02\x96\xa6\x16\$@\x19B\x1cJ\xba\x8 a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\xb4\\\xca\r6\x82fbh<\xf7\u0432\xfd\xach\u007f\x02\xd0\ u010965\u026d\xc5\u07a0\x00\x00\u007d4\xb4d@\u01d7\xa5V\xe0L}\x91\x04f\x04\x91\xf9k\xb0v\ xbf\x88\xce\xc7o\x0eqR\x00\x00\u007d4\xb4m\x11\x82\xe5\xaa\xca\xff\r&\xb2\xfc\xf7\<\x9f\xfb\xcd\xd9}\ x89\xaa*`<\xdd\u007f\,x00\x00\u007d4\xb4\x89!\xc9h}U\x10tE\x84\x93n\x88\x86\xbd\xbf-

 $\x 6\x 9b\x 8965\u 026d\x c5\u 07a0\x 00\u 07d4\x b4\x 98\x bb\x 0fR\x 00\x 05\x b6! jD\%\x b7Z\x a9\x ad\x c5-$

 $b+\x89\xd8\xd7\&\xd7\x80\x00\x00\xe0\x94\xb4\xb1\x1d\x10\x9f\x8f\xa8\xed\xd3\xfe\xa9\xf8\xc3\x15d\x9a\xeb=\x11\x8a\x01\x0f\f\xf0d\xddY$

:\xe1(\x8d\xc3\u0549\n\u05ce\xbcZ\xc6

@^\x00\x00\x94\xb5\b\xf9\x87\xb2\xde4\xaeL\xf1\x93\u0785\xbf\xf6\x13\x89b\x1f\x88\x8a\x01 EB\xba\x12\xa37\xc0\x00\u07d4\xb5\tU\xaan4\x15q\x98f\b\xbd\u0211\xc2\x13\x9fT\f\u07c9j\x cb=\xf2~\x1f\x88\x00\x00\u07d4\xb5\f\x14\x9a\x19\x06\xfa\xd2xo\xfb\x13Z\xabP\x177\xe9\xe5o\x8 9\x15\b\x94\xe8I\xb3\x90\x00\u07d4\xb5\f\x9fW\x89\xaeD\xe2\xdc\xe0\x17\xc7\x14\xca\xf0\f\x 83\x00\x84\u0089\x15[\xd90\u007f\x9f\xe8\x00\x00\u07d4\xb5\x14\x88,\x97\x9b\xb6B\xa8\r\u04c7 T\u0578\xc8)m\x9a\a\x893\xc5I\x901r\f\x00\x00\u07d4\xb5\x14\xb5\x1d\u0734\xddN\x8a\xe6\xbe3m\xd9eI q\xd9\xfe\xc8kA\x89\x16\xd4d\xf8=\u2500\x00\u07d4\xb5\x1eU\x8e\xb5Q/\xbc\xfa\x81\xf8\u043d\

 $x93\x8cy\xeb\xb5$+\x89\&\u009eG\u0104L\x00\x00\u07d4\xb5\#\xff\xf9t\x98q\xb3S\x88C\x887\xf7\xe6\xe0\u07a9\xcbk\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xb5-\xfbE\xde]t\xe3\xdf$

6E\x96Fk\xa3\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xb5I>\xf1srDE\xcf4\\\x03]"\x9b\xa7Y\xf2\x8dQ\ x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xb5S\xd2]kT!\xe8\x1c*\xd0^\v\x8b\xa7Q\xf8\xf0\x10\xe 3\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xb5Tt\xbaX\xf0\xf2\xf4\x0el\xba\xbe\xd4\xea\x17n\x01\x1f\x ca\u0589j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xb5U\xd0\x0f\x91\x90\xcc6w\xae\xf3\x14\xac\xd7?\xd c99\x92Y\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xb5W\xab\x949\xefP\xd27\xb5S\xf0%\b6JFj\\\x03\x 89\n\u05ce\xbcZ\xc6 \x00\x00\u07d4\xb5j\x00(\x03\x9c\x81\xca\xf3\gu\xc6

\u7195Gd\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xb5j\u04ae\xc6\xc8\xc3\xf1\x9e\x15\x15\xbb\xb7\u 0751(RV\xb69\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xb5t\x13\x06\n\xf3\xf1N\xb4y\x06_\x1e\x9d\x19\xb3uz\xe8\u0309\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xb5ul\xbf\xb5ul\xbf\xbc\x9b\xdd\x18\xf76\xb2& P\xe4\x8as`\x1f\xa6\\\x89\x18-

?\xae\x06\x1e\xacEB\xcb`\xf3\xa5v7\x89\nZ\xa8P\t\xe3\x9c\x00\x00\u07d4\xb5\x87\f\xe3B\xd43C 36s\x03\x8bGd\xa4n\x92_>\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xb5\x87\xb4J,\xa7\x9eK\xc1\u 074b\xfd\xd4:

 $qP\xf2\xe7\xe0\x89\,\x8e\xb3\xfff@\x00\x00\u07d4\xb5\x89gm\x15\xa0DH4B0\xd4\xff'\xc9^\xdf\x12,I\x8965\u026d\xc5\u07a0\x00\x00\u0794\xb5\x8bR\x86^\xa5]\x806\xf2\xfa\xb2\x98\xb3R\u0283 \ ~\x18\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xb5\x90k\n\u9881X\xe8\xacU\x0e9\xda\bn\xe3\x15 \ ~\x89\n\u05ce\xbcZ\xc6$

\x00\x00\u07d4\xb5\xca\xc5\xed\x03G}9\v\xb2g\xd4\xeb\xd4a\x01\xfb\xc2\xc3\u0689\n\xad\xec\x98?\xcf\xf4\x00\x00\u07d4\xb5\u037cA\x15@oR\u5a85\xd0\xfe\xa1p\u0497\x9c\u01fa\x89Hz\x9a0 E9D\x00\x00\u0794\xb5\u0653M{}+\xcf`;(\x80t\x1e\xb7`(\x83\x83\xa0\x88\xe7\xc2Q\x85\x05\x06\x 00\x00\u07d4\xb5\xddP\xa1]\xa3Ih\x89\nS\xb4\xf1?\xe1\xaf\b\x1b\xaa\xaa\x89\xd8\xd7&\xb7\x17z \x80\x00\x00\u07d4\xb5\xfa\x81\x84\xe4>\xd3\u0e2b\x91!da\xb3R\x8d\x84\xfd\t\x89\x91Hx\xa8\xc 0^\xe0\x00\x00\u07d4\xb5\xfb~\xa2\xdd\xc1Y\x8bfz\x9dW\xdd9\xe8Z8\xf3]V\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xb6\x00B\x97R\xf3\x99\xc8\r\a4tK\xae\n\x02.\xcag\u0189\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xb6\x00\xfe\xabJ\xa9ISu\x04\xd9`W\"1Ai,\x19:\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xb6\x04|\u07d3-

 $\label{thm:converse} $$ \parbox{12Z3wIJ\xfa\x8a\b7Z*\xbc\xca$@\x00\x00\u07d4\xb65\xa4\xbcq\xfb(\xfd\xd2\xc3\)"\x98:V\u0084Bni\x89\t79SM(h\x00\x00\u07d4\xb6F\u07d8\xb4\x94BtkaR\)\x81\xa3\xb0K\xa3\x10bP\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xb6F\xd4LP\xd2Ffg\r6Gf\xe9\x91\xc0.\x11\u0089\x86\xac5\x10R\x00\x00\xe0\x94\xb6f\u005c0\xc7CA\x15\x16$$

'VR#\xf4NT\x98\xff\x8c\x8a\x04<0\xfb\b\x84\xa9I\x00\x00\u07d4\xb6d\x11\xe3\xa0-

 $c\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\xb6\xceM\xc5`\xfcs\xdci\xfbzb\xe3\x88\xdb\xr\xeavO\x894]\xf1i\xe9\xa3X\x00\x00\u07d4\xb6\xde\u03c2\x96\x98\x19\xba\x02\xde)\xb9\xb5\x93\xf2\x1b d\xee\xda\x0f\x89(\x1d\x90\x1fO\xdd\x10\x00\x00\xe0\x94\xb6\xe6\xc3\"+ko\x9b\xe2\x87]\x89\xf1 '\xfbd\x10\x0f\xe2\x8a\x01\xb2\x1dS\#\xcc0$

 $\label{thm:convoluo7d4} $$ \xo0\xo0\u07d4\xb6\xe3\u07eb\x89\xo1Z\xf1\u05cbX\xc4\xo0\xo0\xe0\x94\xb6\xf7\x8d\xa4\xf4\xd0A\xb3\xbc\x14\xbc[\xa5\x19\xa5\xba\f2\xf1(\x8a$)\xd3,?\xe1\x95\x04\x80\x00\xe0\x94\xb6\xfb9\xbP\b\x14&\xa3B\xc7\rG\xeeR\x1e[\xc5c\x8a\xo3-$

7\xdb\x03\x98\xacrA\f\xf9\x81=\xe9\xf8\xe1\uc36d\x8966\xc2^f\xec\xe7\x00\x00\u07d4\xb7;O\xf9\x 9e\xb8\x8f\u061b\vmW\xa9\xbc3\x8e\x88o\xa0j\x89\x01\xbc\x16\xd6t\xec\x80\x00\x00\u07d4\xb7 $= |wU\x9c\x86\xcfet\$)\x039K\xac\xf9n5p\x89\x04\xf1\xa7|\xcd;\xa0\x00\x00\x00\x00\x00\x00\xfa\x$ 4\xd5\u06ea\xf8\xde\x17\x1bN\x95\x1d\u0464W\x89\x04V9\x18\$O@\x00\x00\u07d4\xb7I\xb5N\x0 4\u0571\x9b\xdc\xed\xfb\x84\xdaw\x01\xabG\x8c'\xae\x89\x91Hx\xa8\xc0^\xe0\x00\x00\u07d4\xb 7N\xd2f`\x01\xc1c3\xcfz\xf5\x9eJ=H`6;\x9c\x89\n~\xbd^Cc\xa0\x00\x00\u07d4\xb7QI\xe1\x85\xf6\ xe3\x92pWs\x90s\xa1\x82*\xe1\xcf\r\xf2\x89\xd8\xd8X?\xa2\xd5/\x00\x00\u07d4\xb7S\xa7 \x9e\x $d1\v!d:\n=\xc0Qz\xc9k\x1a@h\x89\x15\xc8\x18[,\x1f\xf4\x00\x00\x00\xe0\x94\xb7V\xadR\xf3\xbft\xa7\x$ d2LgG\x1e\b\x87Ci6PL\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\xb7Wn\x9d1M\xf4\x1e\xc5Pd\x9 4):\xfb\x1b\xd5\xd3\xf6]\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xb7X\x89o\x1b\xaa\x86O\x17\ xeb\xed\x16\xd9S\x88o\xeeh\xaa\xe6\x8965\u026d\xc5\u07a0\x00\u0794\xb7h\xb5#N\xba:\x9 9h\xb3Mm\xdbH\x1c\x84\x19\xb3e]\x88\xcf\xceU\xaa\x12\xb3\x00\x00\u07d4\xb7\x82\xbf\xd1\xe2\ $xdep\xf4gdo\x9b\xc0\x9e\xa5\xb1\xfc\xf4P\xaf\x89\x0e\xb0\xa3A\vt\x00\x00\xe0\x94\xb7\xa2\xc1$ \x03r\x8bs\x05\xb5\xaen\x96\x1c\x94\xee\x99\xc9\xfe\x8e+\x8a\n\x96\x81c\xf0\xa5{@\x00\x00\u0 7d4\xb7\xa3\x1a|8\xf3\xdb\t2.\xae\x11\xd2'!A\xea\"\x99\x02\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\x b7\xa6y\x1c\x16\xebN!b\xf1Ke7\xa0+=c\xbf\xc6\x02\x89*Rc\x91\xac\x93v\x00\x00\u07d4\xb7\xa7\ xf7|4\x8f\x92\xa9\xf1\x10\fk\xd8)\xa8\xacm\u007f\u03d1\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\x b7\xc0w\x94ft\xba\x93A\xfbLtz]P\xf5\xd2\xdad\x15\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xb7\xc 0\xd0\xcc\vM4-

 $@b\xba\xc6\xc2\xc7\f\xc6\xda?\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\xb7\xc9\xf1+\x03\x8esCm\x17\xc1\xc1/\xfe\x1a\xec\u0373\xf5\x8c\x89\x1dF\x01b\xf5\x16\xf0\x00\x00\u07d4\xb7\xcck\x1a\xcc2\u0632\x95\xdfh\xed\x9d^`\xb8\xf6L\xb6\{\x89\x10CV\x1a\x88)0\x00\x00\u07d4\xb7\xccehK\t\xab\xdaS8\x9a\x87Si\xf7\x19X\xae\xac;\u0749lk\x93[\x8b\xbd@\x00\x00\u07d4\xb7\xd1.\x84\xa2\xe4\u01264Z\xf1\xdd\x1d\xa9\xf2PJ*\x99n\x89\n\u05ce\xbcZ\xc6$

\x00\x00\\u07d4\xb7\xd2R\xee\x94\x02\xb0\xee\xf1D)_\x0ei\xf0\xdbXl\bq\x89#\xc7W\a+\x8d\xd0\x 00\x00\xe0\x94\xb7\u0541\xfe\n\xf1\xec8?;<Ag\x83\xf3\x85\x14jv\x12\x8a\x04<3\xc1\x93ud\x80\x 00\x00\u07d4\xb7\xf6s\x14\u02c3.2\xe6;\x15\xa4\f\xe0\xd7\xff\xbd\xb2\i\x85\x899\x82y&J\x81\x8d\x 00\x00\x00\xe0\x94\xb8\x04\x056\x95\x8dY\x98\xceK\xec\f\xfc\x9c\"\x04\x98\x98H\xe9\x8a\x05.\xa7\r\x8f\xd5\n\x00\x00\u07d4\xb81\n\x16\xccj\xbcFP\aiK\x93\x0f\x97\x8e\xce\x190\xbd\x89\x88\x06\u078a\x00\x16\x00\x00\x00\xe0\x94\xb84\xac\xf3\x01S\"\u0143\x82\uecb7\x968\x90n\x88\xb6\u078a\x05\x15\n\xe8J\x8c\xdf\x00\x00\x00\xe0\x94\xb8KS\u043b\x12VV\xcd\xdcR\xeb\x85*\xb7\x1drY\xf3\u054a\x03c\\x9a\xdc]\xea\x00\x00\x00\x00\u07d4\xb8L\x8b\x9f\xd3>\xce\x00\xaf\x91\x99\xf3\xcf_\xe0\xcc\xe2\x8c\xd1J\x89\xcf\x15&@\xc5\xc80\x00\x00\u07d4\xb8L\x8B\x18\xf3B\xf8\x01.\u069f'Nc\xce!R\xb2\xdc\xfd\xab\x89\xa8\r\$g~\xfe\xf0\x00\x00\u07d4\xb8UP\x10\wn<\\\xb3\x11\xa5\xad\xee\xfe\x9\xb\x92\xbb\x9ad\xb9\x88\xd7&\xb7\x17z\x80\x00\x00\x00\x00\u07d4\xb8_\x89\xd6\x02\x1b\xd3\@\xcf&R\xf6\x97\xa8\xaf\wG,+X\xb5\x8a\x02\x85\x19\xac\xc7\x19\fp\x00\x00\x00\u07d4\xb8_\x8f\a\x02\x1b\xd3\@\xcf&R\xf3\x94\xda\xcb\u06bau\x89\x2\x85\x19\xac\xc7\x19\fp\x00\x00\x00\u07d4\xb8_\x8f\a\x02\x1b\xd3\@\xcf&R\xf3\xf9_\xd2\xdcgi\x8b\u07ca\x01\x0f\f\xf0\xddY

 $C\x8db\x0fS\xc1\x144\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xb8\xbe\xddWjKL$

\xcb\xf4\x84\x0e\xca\x00\x00\x00\x00\u07d4\xb8\u04c9\xe6\$\xa3\xa7\xae\xbc\xe4\xd3\xe5\xdb\xdfl\xd c)\x93*\xed\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\xb8\xd51\xa9d\xbc\xea\x13\x82\x96 \xc0\xce\xd7\$\"\xda\xdbL\u0289\t7\x15\xccZ\xb8\xa7\x00\x00\x00\xe0\x94\xb8\xd5\xc3\$\xa8 \x9d\x80\xd0\u052e\xde\x02\xba\x80\xabW\x8b\x8a\x03\x93\x92\x86)\xff\xf7^\x80\x00\x00\xe0\x94\x b8\xf2\x00\x00\x05\xb6\x13R\xff\xa7i\x9a\x1bR\xf0\x1fZ\xb3\x91g\xf1\x8a\x02\x1e\x19\xe0\u027a\xb2 @\x00\x00\u07d4\xb8\xf3\aX\xfa\xa8\b\xdb\xc9\x19\xaa{B^\xc9\"\xb9;\x81)\x8966\u05ef^\u024e\x 00\x00\u07d4\xb9\x01<Q\xbd\a\x8a\t\x8f\xae\x05\xbf*\xce\bI\u01be\x17\xa5\x89\x04V9\x18\$O@\x 00\x00\u07d4\xb9\x14Kg\-\xc6\x14\xce\xef\xdfP\x98 \x11\x83

\x8e\xa6L\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xb9\x16\xb1\xa0\x1c\xdcNV\xe7ew\x15\xea7\xe2\x\a0\xf0\x87\xd1\x06\x89\x82n1\x81\xe0'\x06\x80\x00\u07d4\xb9\x1d\x9e\x91I\xd4\r\x19=\xb6\x0ey\x\a0\bw\x16\xfc\x89\x15\xf1\xba\u007fG\x16

 $\label{thm:colored} $$ \x00\x00\u07d4\xba\x1f\xca\xf2\#\x93~\xf8\x9e\x85gU\x03\xbd\xb7\xcaj\x92\x8bx\x89\"\xb1\xc8\xc1\"z\x00\x00\x00\x00\x00\x94\xba\xfcCgS\xa79\xdb,\x8d@\xe6\xd4\xd0LR\x8e\x86\xfa\x8a\x02\xc0\xbb=\xd3\fN $$$

 $\label{thm:convolu07d4} $$\x00\x00\u07d4\xbaB\xf9\xaa\xceL\x18E\x04\xab\xf5BWb\xac\xa2oq\xfb\u0709\x02\aa}\u0627\x9 $$ c\x00\x00\u07d4\xbaF\x9a\xa5\u00c6\xb1\x92\x95\u0521\xb5G;T\x03S9\f\x85\x89lk\x93[\x8b\xbd @\x00\x00\x00\u07d4\xbad@\xae\xb3s{\x8e\xf0\xf1\xaf\x9b\f\x15\xf4\xc2\x14\xff\xc7\u03c965\u026d\xc5\u07a0\x00\x00\x00\x00\x94\xbam1\xb9\xa2a\xd6@\xb5\u07a5\x1e\xf2\x16,1\t\xf1\uba0a\x01\x0f\f\xf0d\xddY$$$

BF\xfdp\xbc\xbd\x86\xe4\xa9*\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xba\u0212,J\xcc},\xb 6\xfdY\xa1N\xb4\\\xf3\xe7\x02!K\x89+^:\xf1k\x18\x80\x00\x00\u07d4\xba\xd25\xd5\b]\u01f0h\xa6| A&w\xb0>\x186\x88L\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xba\xd4B^\x17\x1c>r\x97^\xb4j\xc0\xa 0\x15\xdb1Z]\x8f\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\xba\xdc*\xef\x9fYQ\xa8\u05cak5\xc3\u04 33\xa4\xe6\xe2\xe79\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\xba\xdeCY\x9e\x02\xf8OL0\x14 W\x1c\x97k\x13\xa3le\xab\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xba\xe9\xb8/r\x99c\x14\be\ x9d\xd7N\x89\x1c\xb8\xf3\x86\x0f\xe5\x89j\xcb=\xf2~\x1f\x88\x00\x00\x00\u07d4\xbb\x03f\xa7\u03fd 4E\xa7\r\xb7\xfeZ\xe3H\x85uO\xd4h\x8a\x01M\xef,B\xeb\xd6@\x00\x00\u07d4\xbb\aj\xac\x92 \x80i\xea1\x8a1\xff\x8e\xeb\x14\xb7\xe9\x96\xe3\x89\b\x13\xcaV\x90m4\x00\x00\u07d4\xbb\bW\xf 1\xc9\x11\xb2K\x86\u0227\x06\x81G?\u6aa1\xcc\xe2\x89\x05k\xc7^-

\xec>A\xfe\xb4\xc6y\xe4\x95vA\x16O\x89\xcf\x15&@\xc5\xc80\x00\x00\u07d4\xbbKJKT\x80p\xffA

 $\label{lem:convalue} C, & \ensuremath{\text{loon}} & \ensuremath{\text{loo$

\x00\x00\u07d4\xbb\x99;\x96\xee\x92Z\xda}\x99\u05c6W=?\x89\x18\f\u3a89lk\x93[\x8b\xbd@\x00\u07d4\xbb\xa3\u0180\x04\$\x8eH\x95s\xab\xb2t6w\x06k\$\u0227\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xbb\xa4\xfa\xc3\xc4

 $T(\x04\xf1\xce\x00\x00\u07d4\xbb\xb6C\xd2\x18\{6J\xfc\x10\xa6\xfd6\x8d\}U\xf5\r\x1a<\x8965\u026\xd2\x18\{6J\xfc\x10\xa6\xfd6\x8d\}U\xf5\r\x1a<\x8965\u026\xd2\x10\x00\x00\u07d4\xbb\xb8\xff\xe4?\x98\u078e\xae\x18F\#\xaeRd\xe4\u0438\u05c9\x05\xd5?\xfd\xe9(\b\x00\x00\u07d4\xbb\xbdn\u02f5u(\x91\xb4\u03b3\xcc\xe7:\x8fGpY7o\x89\x01\xf3\x99\xb1C\x8a\x10\x00\x00\u07d4\xbb\xbf9\xb1\xb6y\x95\xa4\"APO\x97\x03\u04a1JQV\x96\x89U\xa6\xe7\x9c\xcd\x1d0\x00\x00\u07d4\xbb\xc8\xea\xffc\xe4\xfc\u014d\x91\xep\u020f\x9bG\x92w\x89\n\u05ce\xbcZ\xc6$

 $x92;\x8f\x1e\xb0t\xa9\xfd\x89\n\u05ce\xbcZ\xc6$

 $e7\xdc\x11\xa1Y^*) = \xd2T!P\xd7Q\x8965\u026d\xc5\u07a0\x00\u07d4\xbci\xa0\u04a3\x1c = \xbfz\x91\"\x11i\x01\xb2\xbd\xfe\x98\x02\xa0\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xbckX6K\xf7\xf1\x95\x1c0\x9e\f\xba\x05\x95$

\xc2~E\xc9\x10\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xbc\xa3\xff\xd4h?\xba\n\u04fb\xc9\a 4\xb6\x11\u069c\xfbE~\x89\n\u05ce\xbcZ\xc6

 $c \x 10 \x 00 \$

 $\label{thm:condition} $$ \a6\xdf_4\xd7\x1b\x1a\xa3\x8d\xac\xf8v\xf9[\x88\x89\x01\x15\x8eF\t\x13\xd0\x00\u07d4\xbc\xd9^\xf9bF+n\u07e1\x0f\u0687\xd7\"B\xfe>\xdb\\\x89\x12\x1d\x06\xe1/\xff\x98\x80\x00\u07d4\xbc\u0065e\xdc!\xf2\x10\xa0^:\x1f\xa0\xb0CL\xed\x00C\x9b\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xbc\u007ec\xb9\xd9\x02<4\x17\x18.\x91\x00\xe8\xea\x1d73\x93\xa3\x89\x034-$

 $\label{thm:convoluo7d4} $$ \x00\x00\u07d4\xbd\x04\u007f\xf1\xe6\x9c\u01b2\x9a\xd2d\x97\xa9\xa6\xf2z\x90?\xc4\u0749.\xe4 IU\b\x98\xe4\x00\x00\u07d4\xbd\b\xe0\xcd\xde\xc0\x97\xdby\x01\ua05a=\x1f\xd9\u0789Q\xa2\x89 \x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xbd\t\x12\x89\x1cJ\x83\x06\x80Y\xfe\x0e\x15\yIFa\xa9\xf4 \x89+^:\xf1k\x18\x80\x00\x00\u07d4\xbd\f\u05d9\xeb\u0106B\xef\x97\xd7N\x8eB\x90d\xfe\u4489 \x11\xac(\xa8\xc7)X\x00\x00\u07d4\xbd\x17\xee\xd8+\x9a\%\x92\x01\x9a\x1b\x1b\x1b\x\x0f\xba\xd4\u@ \x8d\x00\x00\u07d4\xbd\x18\x037\v\u0771)\xd29\xfd\x16\xea\x85\&\xa6\x18\x8a\x589\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xbd+p\xfe\xcc7d\x0fiQO\xc7\xf3@IF\xaa\xd8k\x11\x89A\rXj $$$

 $\label{thm:convoluo7d4} $$ \xa4\xc0\x00\x00\u07d4\xbd0\x97\xa7\x9b<\r.\xbf\xf0\xe6\xe8j\xb0\xed\xad\xbe\xd4p\x96\x89Z\x89$ $$ \xe7\xd7\xf5\xf6X\x00\x00\u07d4\xbd2]@)\xe0\xd8r\x9fm9\x9cG\x82\xae\x9ez\xe4\x1e\x89\xd2$ $$ \U\xd1\x12\xe1\x03\xa0\x00\x00\u07d4\xbdC^*9\x16\x9bG\$):\xf9\x14nl\xb8(\n\u007f^*\x89\xd8\xd7$ \xb7\x17z\x80\x00\x00\u07d4\xbdG\xf5\xf7n;\x93\x0f\xd9HR\t\xef\xa0\xd4v=\xa0\uh\x8965\u026d$

\x86\xac5\x10R`\x00\x00\u07d4\xbdQ\xee.\xa1C\u05f1\u05b7~~D\xbd\xd7\xda\x12\U00105b09G \\x06\u0332\xb9(\x00\u07d4\xbdY\tN\aO\x8dy\x14*\xb1H\x9f\x14\x8e2\x15\x1f

 $< M\x 8\%0\x 89\x 04\ V9\x 18\$O@\x 00\x 00\u 07d4\x bdf\x ff\x ed\x b50\x ea\v.\x 85m\x d1*\x c2) I1\x fe)\x e0 \x 89\n\u 05ce\x bc\Z\x c6\x 00\x 00\u 07d4\x bdg\x d2\x e2\x f8-$

 $\label{lem:convention} x93\x00\u0509lk\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\xbe+2nx\xed\x10\xe5P\xfe\xe8\xef\xa8\xf8\a\x03\x96R/Z\x8a\bW\xe0\xd6\xf1\xdav\xa0\x00\x00\xe0\x94\xbe0Zyn3\xbb\xf7\xf9\xae\xaee\x12\x95\xeq90f\xef\xda\x10\x10\x8a\x02M\xceT\xd3J\x1a\x00\x00\x00\u07d4\xbeG\x8e\x8e=\xdek\xd4\x03\xbb-6$

\xbfZ\xd17<;F:\x13\x1e\x86\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convoluo7d4} $$\x00\x00\u07d4\xbeZ^h\x99\x98c\x9a\xd7[\xc1\x05\xa3qt>\xef\x0fy@\x89\x1b2|s\xe1\%z\x00\x00\u07d4\xbe\x8d7By\x86\xe8\xca&\x00\xe8X\xbb\x03\xc3YR\x0f\x89\xa00\xdc\xeb\xbd/L\x00\x00\u07d4\xbe^\x03~\x90qJK\x91~a\xf1\x93\xd84\x90g\x03\xb1:\x89\(=A\x03\x94\x10\x00\x00\u07d4\xbec:77\xf6\x849\xba\xc7\xc9\nR\x14$

X\ue38ao\x894\n\xad!\xb3\xb7\x00\x00\x00\x00\x94\xbee\x9d\x85\xe7\xc3O\x883\xea\u007fH\x8d \xe1\xfb\xb5\xd4\x14\x9b\xef\x8a\x01\xeb\xd2:\xd9\u057br\x00\x00\u07d4\xbes'M\x8cZ\xa4J<\xbe \xfc\x82c\xc3{\xa1!\xb2\n\u04c9\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xbe\x86\u0430C\x84\x1 9\u03b1\xa081\x927\xbaR\x06\xd7.F\x8964\xfb\x9f\x14\x89\xa7\x00\x00\u07d4\xbe\x8d\u007f\x18 \xad\xfe]I\xc7u9I\x89\xe1\x93\f\x97\x9d\x00}\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xbe\x91\x86\ xc3JRQJ\xbb\x91\a\x86\x0fgO\x97\xb8!\xbd[\x89\x1b\xa0\x1e\xe4\x06\x03\x10\x00\x00\u07d4\xbe $\x93W\x93\xf4[p\xd8\x04]\&T\xd8\xdd:\xd2K[a7\x89/\xb4t\t\x8fg\xc0\x00\x00\u07d4\xbe\x98\xa7\u0$ 07f\xd4\x10\x97\xb3OY\xd7X\x9b\xaa\xd0!e\x9f\xf7\x12\x890\xca\x02O\x98{\x90\x00\u07d4\x be\x9b\x8c4\xb7\x8e\xe9G\xff\x81G.\xdaz\xf9\xd2\x04\xbc\x84f\x89\b!\xab\rD\x14\x98\x00\x00\u0 7d4\xbe\xa0\r\xf1pg\xa4:\x82\xbc\x1d\xae\xca\xfbl\x140\x0e\x89\xe6\x89b\xa9\x92\xe5:\n\xf0\x00\ x00\u07d4\xbe\xa0\xaf\xc9:\xae!\b\xa3\xfa\xc0Yb;\xf8o\xa5\x82\xa7^\x89\\(=A\x03\x94\x10\x00\x0 0\u07d4\xbe\xb35\x8cP\u03dfu\xff\xc7mD<,\u007fU\aZ\x05\x89\x89\x90\xf54`\x8ar\x88\x00\x00\u 07d4\xbe\xb4\xfd1UYC`E\u0739\x9dI\xdc\xec\x03\xf4\fB\u0709lk\x93[\x8b\xbd@\x00\x00\u07d4\x be\xc2\xe6\xde9\xc0|+\xaeUj\u03fe\xe2\xc4r\x8b\x99\x82\xe3\x89\x1f\x0f\xf8\xf0\x1d\xaa\xd4\x00\ x00\u07d4\xbe\xc6d\x0fI\t\xb5\x8c\xbf\x1e\x80cB\x96\x1d`u\x95\tI\x89Ij\xccq\u05f1\xd4\x00\x00\u0 7d4\xbe\xc8\xca\xf7\xeeIF\x8f\xeeU.\xff:\xc5#N\xb9\xb1}B\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xb e\xce\xf6\x1c\x1cD+\xef|\xe0Ks\xad\xb2I\xa8\xba\x04~\x00\x896;V\u00e7T\xc8\x00\x00\u0794\xb e\xd4d\x9d\xf6F\u2052)\x03-

 $\label{thm:convention} $$ \x85\u055a\xf1\x19V\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xbe\xef\x94!8y\xe0&\"\x14+\xeaa)\tx\x93\x9a\u05ca\x016\x85{2\xad\x86\x04\x80\x00\xe0\x94\xbe\xf0}\x97\xc3H\x1f\x9dj\xee\x1c\x98\xf9\xd9\x1a\x18\n2D+\x8a\x15-$

 $\label{thm:convolu07d4} $$ \x86\xac5\x10R`\x00\x00\u07d4\xbfh\u048a\xaf\x1e\xee\xfe\xf6F\xb6^\x8c\xc8\u0450\xf6\xc6\u069 c\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xbfi%\xc0\aQ\x00\x84@\xa6s\x9a\x02\xbf+l\u06ab^:\x8965\u026d\xc5\u07a0\x00\u07d4\xbfw\x01\xfcb%\u0561x\x15C\x8a\x89A\xd2\x1e\xbc]\x05\x9d\x89e\xea=\xb7UF`\x00\x00\u07d4\xbf\x8b\x80\x05\xd66\xa4\x96d\xf7Bu\xefBC\x8a\xcde\xac\x91\x89h\u05ce\xbcZ\xc6$

 $c\x10\x00\x00\u07d4\xbf\xfbi) $\x1fx\x86\x93'>p\''\xe6\x0e>\xab\x1f\xe8O\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xc0\x06O\x1d\x94l\xab\x91]V\x90l\x9f\xb3$

c\x10\x00\x00\u07d4\xc0[t\x06

\xab\xc4yD\xb2r3H\$\x89\x06\x81U\xa46v\xe0\x00\x00\u07d4\xc0I\xeb\xbb\xf7\xf5\x14\x9af\xf7\xeb\x97k>G\xd5e\x16\xda/\x89Ik\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\xc0r^\u00bd\xc3:\x1d\x82`q\u07a2\x9db\xd48Z\x8c%\x8a\b\xa0\x85\x13F:\xa6\x10\x00\x00\u07d4\xc0~8g\xad\xa0\x96\x80z\x05\x1aI\x9c4\xcc;?J\xd3J\x89`\xf0f

c\x10\x00\x00\u07d4\xc0\xa3\x93\b\xa8\x0e\x9e\x84\xaa\xaf\x16\xac\x01\xe3\xb0\x1dt\xbdk-\x89\afM\xddL\x1c\v\x80\x00\u07d4\xc0\xa6\u02edwi*=\x88\xd1A\xefv\x9a\x99\xbb\x9e<\x99Q\x89\x05k\xc7^-

c\x10\x00\x00\x94\xc0\xa7\xe8C]\xff\x14\xc2Uws\x9d\xb5\\\$\u057fW\xa3\u064a\nm\xd9\f\xae Q\x14H\x00\x00\u07d4\xc0\xae\x14\xd7\$\x83.\xce'x\xde\u007f\x8d\xaf\{\x12\xa9>\x89\x01\x15\x8 eF\t\x13\xd0\x00\x00\u07d4\xc0\xaf\xb7\u0637\x93p\xcf\xd6c\u018c\u01b9p*7\u035e\xff\x8965\u0 26d\xc5\u07a0\x00\x00\u07d4\xc0\xaf\xb7\u0637\x93p\xcf\xd6c\u018c\u01b9p*7\u035e\xff\x8965\u0 26d\xc5\u07a0\x00\x00\u07d4\xc0\xb0\xb7\xa8\xa6\xe1\xac\xdd\x05\xe4\u007f\x94\xc0\x96\x88\x aa\x16\u01ed\x8d\x89\x03\m\x02\xacvq\x00\x00\x00\u07d4\xc0\xb3\xf2D\xbc\xa7\xb7\xde[H\xa5>\u 06dc\xbe\xab\vm\x88\xc0\x8a\x01;\x80\xb9\x9cQ\x85p\x00\x00\u07d4\xc0\xc0M\x01\x06\x81\x0e >\xc0\xe5J\x19\U000ab157\xe6\x9aW=\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\u07d4\xc0\u02ed<\xcd\xf6T\xda\\"\xcb\xcf\\xe\x97\xca\x19U\xc1\x15\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\xc0\xcb\xf6\x03\xa3\x9e|F\xffw\x8a\x94\xf7\xd4E\xfe\\"\xcf0\x89\x10\xce\x1d=\x8c\xb3\x18\x00\x00\u07d4\xc0\xe0\xb9\x00\xb9\x03\b\x8e\fc\xf2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xc0\xed\rJ\xd1\r\xe045\xb1S\xa0\xfc%\xde;\x93\xf4R\x04\x89\xabM\xcf9\x9a:`\x00\x00\u07d4\xc0\xc0\xf2\x9e\xd0\af\x11\xb5\xe5^\x13\x05G\xe6\x8aH\xe2m\xf5\u4262\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xc1\x13(x#\]\u06e5\xd9\xf3\"\x8bR6\xe4p

\xdco\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xc1\x17\r\xba\xad\xb3\xde\xe6\x19\x8e\xa5D\xba\xe

c\x93%\x18`\xfd\xa5\x89A\rXj

\xa4\xc0\x00\x00\xe0\x94\xc1&W=\x87\xb0\x17ZR\x95\xf1\xdd\a\xc5u\u03cc\xfa\x15\xf2\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xc1'\xaa\xb5\x90e\xa2\x86D\xa5k\xa3\xf1^.\xac\x13\xda)\x95\x89

\x86\xac5\x10R`\x00\x00\xe0\x94\xc1+\u007f@\u07da/{\xf9\x83f\x14\"\xab\x84\xc9\xc1\xf5\bX\x8a \x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\xc1,\xfb{=\xf7\x0f\xce\xca\x0e\xde&5\x00\xe2xs\xf8\xed\x 16\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xc1/\x88\x1f\xa1\x12\xb8\x19\x9e\xcb\xc7>\xc4\x18W\ x90\xe6\x14\xa2\x0f\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\xc18Lnq~\xbeK#\x01NQ\xf3\x1c\x9d\xf7 \xe4\xe2[1\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xc1C\x8c\x99\xddQ\xef\x1c\xa88j\xf0\xa 3\x17\xe9\xb0AEx\x88\x89\f\x1d\xaf\x81\u0623\xce\x00\x00\u07d4\xc1c\x12(\xef\xbf*.:@\x92\xee\x89\x00\xc69\xed4\xfb\u02093\xc5|\x901r\f\x00\x00\u07d4\xc1u\xbe1\x94\xe6iB-

\x15\xfe\xe8\x1e\xb9\xf2\xc5\g\xd9\u0249\n\u05ce\xbcZ\xc6

 $\label{thm:convoluo7d4} $$\x00\x00\u07d4\xc1\x82v\x86\xc0\x16\x94\x85\xec\x15\xb3\xa7\xc8\xc0\x15\x17\xa2\x87M\xe1\x89\x02+\x1c\x8c\x12\xa0\x00\x00\u07d4\xc1\x8a\xb4g\xfe\xb5\xa0\xaa\xdf\xff\x91\#\x0f\xf0\VFMx\xd8\x00\x89\|k\x93[\x8b\xbd@\x00\x00\u0794\xc1\x95\x05CUM\x8aq0\x03\xf6b\xbba,\x10\xadL\xdf!\x88\xfc\x93c\x92\x80\x10\xa0\x00\u07d4\xc1\x92\xe4\xc7\xeb\x19\x8b\x03\x1b\x12\x19\x92\xe4\xc7\xeb\x19\x8b\x03\x1b\x12\x19\x92\xe4\xc7\xeb\x19\x8b\x03\x1b\x12\x88\x1b\x19\x20\xa0\xfb\x9c\xadE\xcdi\x91\x92\xcd'T\v\x88\xd38By\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xc1\xb2\xaa\x8c\xb2\xbfb\xcd\xc1\cG\xec\xc4e\u007f\xac\xaa\x99\x98\x8967\x93\xfa\x96\u6980\x00\u07d4\xc1\xb5\x00\x01\x1c\xfb\xa9]\xd6\xe9\x89\n\u05\xe0\xbcZ\xc6$

\x00\x00\u07d4\xc1\xb9\xa5pM5\x1c\xfe\x98?y\xab\xee\xc3\u06fb\xae;\xb6)\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xc1\xcb\xd2\xe23*RL\xf2\x19\xb1\r\x87\x1c\xcc

\xfbrs\x89\x01\xdd\x1eK\xd8\xd1\xee\x00\x00\u07d4\xc1\xeb\xa5hJ\xa1\xb2L\xbac\x15\x02c\xb7\x a9\x13\x1a\xee\u008d\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xc1\xec\x81\xdd\x12=K|-\u0674\xd48\xa7\a,\x11\u0707L\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xc1\xf3\x9b\xd3]\xd9\xce\xc3 7\xb9oG\xc6w\x81\x81`\xdf7\xb7\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u0794\xc1\xff\xad\a\u06d6\x 13\x8cK*S\x0e\xc1\xc7\xde)\xb8\xa0Y,\x88\xf4?\xc2\xc0N\xe0\x00\x00\xe0\x94\xc2\x1f\xa6d:\x1f\ x14\xc0)\x96\xadqD\xb7Y&\xe8~\xcbK\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\xc24\nL\xa9L\x9 6x\xb7IL<\x85%(\xed\xe5\xeeR\x9f\x89\x02\xa3k\x05\xa3\xfd|\x80\x00\u07d4\xc29\xab\u07ee>\x9 a\xf5E\u007fR\xed+\x91\xfd\n\xb4\xd9\xc7\x00\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xc2;/\x92\x1c\ xe4\xa3z%\x9e\u4b4b!X\xd1]fOY\x89\x01`\x89\x95\xe8\xbd?\x80\x00\u07d4\xc2C\x99\xb4\xbf\x86 \xf73\x8f\xbfd^;\"\xb0\u0dd79\x12\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xc2L\u03bc#D\xcc\xe5d\x1 2\x9b\xe4U\ud50a\xdd\v\x92\x89Hz\x9a0E9D\x00\x00\u07d4\xc2\\\xf8&U\f\x8e\xaf\x10\xaf\"4\xfe \xf9\x04\u0779R\x13\xbe\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xc2f?\x81E\xdb\xfe\xc6\xc6F\xfc \\I\x96\x13E\xde\x1c\x9f\x11\x89%g\xacp9+\x88\x00\x00\u07d4\xc2pEh\x854+d\vL\xfc\x1bR\x0e\x 1aTN\xe0\xd5q\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\xc2sv\xf4]!\xe1^\xde;&\xf2e_\xce\xe0,\xcc\ x0f*\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\xe0\x94\xc2w\x97q\xf0Smy\xa8p\x8fi1\xab\xc4K05\u964

 $\label{thm:convoluo7d4} $$\x00\x00\u07d4\xc2\xc1>r\xd2h\xe7\x15\r\u01d9\xe7\xc6\xcf\x03\u0209T\xce\u05c9\%\xf2s\x93=\xb5p\x00\x00\u07d4\xc2\xcb\x1a\xda]\xa9\xa0B8s\x81G\x93\xf1aD\xef6\xb2\xf3\x89HU~;p\x17\xdf\x00\x00\u07d4\xc2\xd1w\x8e\xf6\xee_\xe4\x88\xc1E\xf3Xkn\xbb\xe3\xfb\xb4E\x89>\x1f\xf1\xe0;U\xa8\x00\x00\xe0\x94\xc2\xd9\xee\xdb\xc9\x01\x92c\xd9\xd1\u016e\a-$

)\xb6#\v\x92\u06f1\x16\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xc2\xe2\u0518\xf7\r\xcd\bY\xe5\v\x02:q\nmK!3\xbd\x8989\x11\xf0\f\xbc\xe1\x00\x00\u07d4\xc2\xed_\xfd\u046d\xd8U\xa2i\xe0b\xb5\xd6\x18t#`\u0509A\rXi

 $\label{thm:convoluo7d4} $$ \a4\xc0\x00\x00\u07d4\xc2\xfa\xfd\xd3\n\xcbmg\x06\xe9\<\xb0&A\xf9\xed\xbb\x89Q\x00\x86\vC\x0fH\x00\x00\u07d4\xc2\xfd\v\xf7\xc7\%\xef>\x04~Z\xe1\u009f\xe1\x8f\x12\xa7)\x9c\x89Hz\x9a0E9D\x00\x00\u07d4\xc2\xfe\us\x1fcm\xcd\t\xdb\xda\x06q9;\xa0\xc8*\x89wC\''\x17\xe6\x83\'\x00\x00\u07d4\xc3\x10z\x9a\xf32-$

 $R8\xdf\x012A\x911b\x959W\x89\x1a\xb4\xe4d\xd4\x141\x00\x00\xe0\x94\xc3\x11\v\xe0\x1d\xc9s$ $L\xfcn\x1c\xe0\u007f\x87\xd7\x13E\xb7\xe1\x8a\x01\x0f\f\xe9I\xe0\x0f\x93\x00\x00\u07d4\xc3$ $8\xcaR\xe1\x97E\xbe\11\xfc\xdcT\x14\x8b\xb2\xc4\u0409\x02\xb5\xaa\xd7,e$

\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\xc3N;\xa12.\xd0W\x11\x83\xa2O\x94

 $N\xe4\x9c\x18fA\x89\x03'\xaf\uf927\xbc\x00\x00\xe0\x94\xc3[\x95\xa2\xa3s]\xb8\xf0\xf5\x96\xb3E $$ \x87+\xd3\r\xa24\x8a\x01\x98\xbe\x85\#^- $$

/6\xf5\x80\x83\"\xa0\xa8\x89\xb4{Q\xa6\x9c\xd4\x02\x00\x00\u07d4\xc4\b\x8c\x02_>\x85\x01?T9\xfb4@\xa1s\x01\xe5D\xfe\x89~\t\xdbM\x9f?4\x00\x00\u07d4\xc4\x14a\xa3\u03fd2\u0246UU\xa4\x8117\xc0v1#`\x8965\xc6 G9\u0640\x00\u07d4\xc4

8\x8f\xbe\xe8J\xd6V\xddh\xcd\xc1\xfb\xaa\x93\x92x\v4\x89\n-

 $j \times 00^{x}$

\x16\">\xa2G\x1b\x12\x1c\xa4\x89 .h\xf2\u00ae\xe4\x00\x00\u07d4\xc4h\x1es\xbb\x0e2\xf6\xb7& H1\xffi\xba\xa4\x87~2\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\xc4k\xbd\xefv\xd4\xca`\xd3\x16\xc0 \u007f]\x1ax\x0e;\x16 ~\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xc4}a\v9\x92P\xf7\x0e\xcf\x13\x89\x ba\xb6),\x91&O#\x89\x0f\xa7\xe7\xb5\xdf<\xd0\x00\x00\u07d4\u0100;\xb4\a\xc7b\xf9\vu\x96\xe6\x fd\u1513\x1ev\x95\x90\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4\u0106Q\xc1\xd9\xc1k\xffL\x95 T\x88I??&C\x1foh\x89#\xab\x95\x99\xc4?\b\x00\x00\u07d4\u0109\xc8?\xfb\xb0%*\xc0\xdb\xe3R\x 12\x17c\x0e\x0fl\x1f\x14\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4\u010bi<\xac\xef\xdb\xd6\xcb] x\x95\xa4.1\x962~&\x1c\x8965\u026d\xc5\u07a0\x00\x00\u07d4\u0113H\x9eV\u00fd\xd8)\x00}\xc 2\xf9VA)\x06\xf7k\xfa\x89\x02\xa7\x91H\x8eqT\x00\x00\u07d4\u0116\u02f0E\x9aj\x01`\x0f\u0149\ xa5Z2\xb4T!\u007f\x9d\x89\x0e\u0683\x8cI)\b\x00\x00\u07d4\u011c\xfa\xa9g\xf3\xaf\xbfU\x03\x10 a\xfcL\xef\x88\xf8]\xa5\x84\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\u0136\xe5\xf0\x9c\xc1\xb9\r\xf0 x\x03\xce=M\x13vj\x9cF\xf4\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\xe0\x94\u013e\xc9c\b\xa2\x0f\x 90\u02b1\x83\x99\u0113\xfd=\x06Z\xbfE\x8a\x02\xf6\xf1\a\x80\xd2.\xc0\x00\x00\x00\x94\xc4\xc0\ x1a\xfc>\x0f\x04R!\xda\x12\x84\u05c7\x85tD/\xb9\xac\x8a\x01\x92<h\x8b\xab\x04\x00\x00\u07d 4\xc4\xc1S\x18\xd3p\xc73\x18\xcc\x18\xbd\xd4f\u06eaLf\x03\xbf\x89\x01\x11du\x9f\xfb2\x00\x00\ u07d4\xc4\xc6\xcbr=\u05ef\xa7\xebSV\x15\xe5?<\xef\x14\xf1\x81\x18\x89lk\x8f\xce\r\x18y\x80\x0

 $0 \u07d4 \xc4 \xcE \xa2 \xb6 < '\xc0 \xb4B \x9eX \xcdB \xdaY \xbes \x9b \u058965 \u026d \xc5 \u07a0 \x00 \x00 \u07d4 \xc4 \u03d3 \x0e] \x11j \xb8 \xd1; \x9f \x9a \u012bP \x03 \xa6 \xab \u0789 \x11X \xe4 \x91 = \x00 \x00 \x00 \u07d4 \xc4 \xd9 \x16WNh \u011f \xf9 \xd3 \xd8 -$

 $\label{thm:linear} $$ \xb0\xedpWb.\xee\u0480\x94\xad\x89\xcd\xff\x97\xfa\xbc\xb4\x00\x00\x00\x94\xc5\x17\xd01\x88\x13\xc7\x17\u132f\xa1\xea\xb2eN\x01\u068a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xc5\x18\x96\xe0S\x9a\xbb\x85\xb0Z\xe3\x8965\u026d\xc5\u07a0\x00\x00\x00\x00\x00\x00\x00f\xbf\x04\xed\u007fk\x05\xa3\{G\x18\xd6\xfc\xe0\x14.\x1a\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\xc5\bmF\xc8\x11+\x12\x8b\xafo\xafo\x12\x88\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xc5-$

 $\label{thm:cond} $$ \end{tabular} $$ \$

\x00\x00\xe0\x94\xc65^\xc4v\x8cp\xa4\x9a\xf6\x95\x13\u0343\xa5\xbc\xa7\xe3\xb9\u034a\x01EB\ xba\x12\xa37\xc0\x00\x00\u07d4\xc6:\xc4\x17\x99.\x9f\x9b`8n\xd9S\xe6\xd7\xdf\xf2\xb0\x90\xe8\x 89\xd8\xd8X?\xa2\xd5\x00\x00\u07d4\xc6<\u05c8!\x18\xb8\xa9\x1e\aML\x8fK\xa9\x18Q0;\x9a\x8 9\x0e\x189\x8ev\x01\x90\x00\x00\u07d4\xc6R\x87\x1d\x19\$\"\u01bc#_\xa0c\xb4J~\x1dC\u3149\b g\x0e\x9e\xc6Y\x8c\x00\x00\x00\x00\u07d4\xc6gD\x1e\u007f)y\x9a\xbaadQ\xd5;?H\x9f\x9e\x0fH\x8a\x02\xf2\x9a\xceh\xad\u0740\x00\x00\u07d4\xc6j\xe4\xce\xe8\u007f\xb352\x19\xf7\u007f\x1dd\x86\u0 140\(x032\x89\x01\x9a\x16\xb0o\xf8\xcb\x00\x00\x00\u07d4\xc6t\xf2\x8c\x8a\xfd\a?\x8by\x96\x91\xb2\xf0XM\xf9B\xe8D\x89|k\x93[\x8b\xbd@\x00\x00\x00\u07d4\u019b\x85U9\xce\x1b\x04qG(\xee\xc2Z7\xf3g\x95\x1d\xe7\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\u019b\xe4@\x13Mb\x80\x98\x01D\xa9\xf6M\x84t\x8a7\xf3|\x89\x1aJ\xba\"\\

\xf4\r\xc5\xe9\x81#\rR\xae:\xc1\x93\"\x89\t\xdd\xc1\xe3\xb9\x01\x18\x00\x00\u07d4\u01ae(}\xdb\x

 $e1\x14\x9b\xa1m\xdc\xcaO\xe0j\xa2\uaa48\xa9\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xc6\xc7\xc1\x917\x98\x97\u075c\x9d\x9a3\x83\x9cJ_b\xc0\x89\r\x89\xd8\xd8T\xb2$0h\x80\x00\xe0\x94\xc6\xcdh\xec56,Z\xd8L\x82\xadN\xdc#!\%\x91-$

 $\label{thm:colved} $$ \x00\x00\xe0\x94\xc7=\x12(\''\x15\xdc\ab\xf3+~\x80)\xcd\x1az\xae>\x8a\x01v\f\xbcb;\xb3P\x00\x00\x00\x00\x94\xc7If\x80B\xe7\x11\#\xa6H\x97^b\xedc\x82\xf8>\x05\xe2\x8a\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d4\xc7J9\x95\xf8\a\xde\x1d\xb0\x1a.\xb9\xc6.\x97\xd0T\x8fio\x8965\u026d\xc5\u07a 0\x00\x00\u07d4\xc7PI\x10\x19\x12\x1f\xf0\x8a,\x8c\x15\x91\xa6^\xb4\xbd\xfbJ?\x89 \x86\xac5\x10R^\x00\x00\u07d4\xc7\xce-$

\xa0k\xbc@\b\x11Y\u01ba\x0f\x97n9\x93\xb1\x89:y#\x15\x1e\xcfX\x00\x00\u07d4\xc7]\"Y0j\xec}\xf 0\"v\x8ci\x89\x9ae!\x85\xdb\u0109\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xc7`\x97\x1b\xbc\x18\x 1cjj\xf7tA\xf2BG\u045c\xe9\xb4\u03c9lk\x93[\x8b\xbd@\x00\x00\u07d4\xc7a0\xc7<\xb9!\x028\x02\\\x9d\xf9]\v\xe5J\xc6\u007f\xbe\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4\xc7e\xe0\x04v\x81\tG\ x81j\xf1B\xd4m.\u7f28\xccO\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xc7g^\VG\xb9\xd8\xda\ xf4\xd3\xdf\xf1\xe5R\xf6\xb0qT\xac8\x89\t\xc2\x00vQ\xb2P\x00\x00\u07d4\xc7{\x01\xa6\xe9\x11\x fa\x98\x8d\x01\xa3\xab3dk\xee\xf9\xc18\xf3\x89'\x1bo\xa5\xdb\xe6\xcc\x00\x00\u07d4\u01c3z\u0 420\xbf\x14\x18i7\xac\xe0lUF\xa3j\xa5OF\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\u01d8\x06\x 03+\xc7\xd8(\xf1\x9a\u01a6@\u018e=\x82\x0f\xa4B\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\u01d7d4\u01d6\xddwa\xf1\xf1>U\x8ds\xa5\x9f\x82\xf3\x8b\x8a\x01\xb1\xaeMn.\ xf5\x00\x00\u007d4\u01e0\x18\xf0\x96\x8aQ\xd1\xf6`<\\\\xdcT|\xdcT|\xcb\x0f\xf2\x93\x89\xd8\xd7&\x

 $b7\x17z\x80\x00\x00\u07d4\u01ef\xf9\x19)yt\x89UZ\xf1\xd1M\iZ\x10\x83U\x8965\u026d\xc5\u07a0\x00\x00\u0794\u01f1\xc8>c$

 $\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\u01ff\x17\xc4\xc1\x1f\x98\x94\x1fP~w\bO\xff\xbd-$

 $\label{thm:condition:con$

 $\label{thm:linear_continuous_co$

\xd0t\x1eX^\x98{\xb8\f!.\x89T\x06\x923\xbf\u007fx\x00\x00\u007d4\xc8S%\uaca5\x9b>\xd8c\xc8i

04c2\xd4\xfba\x00\x00\xe0\x94\u021c\xf5\x04\xb9\xf3\xf85\x18\x1f\xd8BO\\\xcb\xc8\xe1\xbd\xdf}\x 8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\u0222\xc4\xe5\x9e\x1c\u007f\xc5H\x05X\x048\x ae\xd3\xe4J\xfd\xf0\x0e\x89\x02b\x9ff\xe0\xc50\x00\x00\u07d4\u022al\u301f\b\x99\xf2\x8a\xb5~g Cp\x9dXA\x903\x89\xb4t\t\x8fg\xc0\x00\x00\u07d4\u022b\x1a<\xf4l\xb8\xb0d\xdf.\"-9`s\x94 2w\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u0231\x85\x05%\xd9F\xf2\xae\x84\xf3\x17\xb1Q\x88\xc5 6\xa5\u0706\x89\x91\x8d\xdc:B\xa3\xd4\x00\x00\u07d4\xc8\xd4\xe1Y\x9d\x03\xb7\x98\t\xe0\x13\n \x8d\u00c4\b\xf0^\x8e\u04c9\x9f\xad\xo6\x12\x16\x00\x00\u07d4\xc8\xdd'\xf1k\xf2\p\xf5w\x1b\x 9f\xe4\xedO\xfc\xb3\t6\xf4\x89\n\xad\xec\x98?\xcf\xf4\x00\x00\u07d4\xc8\xdezVL\u007f@\x12\xa6 \xf6\xd1\x0f\u04ofG\x89\x0f\xbf\a\u0509\x10CV\x1a\x88)0\x00\x00\u07d4\xc8\xe2\xad\xebT^\l\x9d\x98,\fx11sc\u03b4\x89\u0171\x1f\x895e\x9e\xf9?\x0f\xc4\x00\x00\x00\x00\x00\x00\u07d4\xc8\xe5X\xa3\xc5i~o\x b2:%\x94\u0200\xb7\xa1\xb6\x8f\x98`\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xc8\xf2\x

x1d0\x00\x00\x00\x94\xc9\x12{\u007ff)\xee\x13\xfc?`\xbc/Dg\xa2\aE\xa7b\x8a\x03|\x9a\xa4\xe7\x ceB\x1d\x80\x00\u07d4\xc9\x1b\xb5b\xe4+\xd4a0\xe2\u04eeFR\xb6\xa4\ub1bc\x0f\x89\x1dF\x01 b\xf5\x16\xf0\x00\x00\x94\xc90\x88y\x05m\xfe\x13\x8e\xf8

\x00\x00\xe0\x94\xc9JXR\x03\xda{\xba\xfd\x93\xe1X\x84\xe6`\u0531\xea\xd8T\x8a\x01{x\x83\xc0i \x16`\x00\x00\u07d4\xc9O|5\xc0'\xd4}\xf8\xefO\x9d\xf8Z\x92H\xa1}\xd2;\x89\x01\x9f\x8euY\x92L\ x00\x00\u07d4\xc9Q\x90\f4\x1a\xbb\xb3\xba\xfb\xf7\xee

)7pq\xdb\xc3j\x89\x11\xc2]\x00M\x01\xf8\x00\x00\u07d4\xc9S\xf94\xc0\xeb-

 $\label{thm:condition} $$ \x0f\x14K\u06b0\x04\x83\xfd\x81\x94\x86\\xe7\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xc9f&r\x8a\xaaLO\xb3\xd3\x1c&\xf3\x10\b\x17\x10\u0449\xb5\x0f\u03ef\xeb\xec\xb0\x00\x00\u07d4\u0240\hh\u007d4\xc9gQel\n\x8e\xf45{sD2!4\xb9\x83PJ\u0289lk\x93[\x8b\xbd@\x00\x00\u07d4\u0240\hh\u007f+\xfc\u027d\x90\xed\x18slW\xed\xd3R\xb6]\x8965\u026d\xc5\u07a0\x00\x00\u07d4\u0241\xd3\x12\u0487\xd5\xx87\x1e\u0757:\xbbv\xb9\xe5\xc3^\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\u0242\xmc\xb0\xd7L\x1b\x1a\xf8A\x83r\xe3\fv\x16\xbe\x89\x05k\xc7^-$

R\xd5\"\xcd//\x95}\$\x81S@\x9f\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xcaB\x88\x01N\xdd\xc5c/_\x ac\xb5\xe3\x85\x17\xa8\xf8\xbc]\x98\x89\x12nr\xa6\x9aP\xd0\x00\x00\u07d4\xcaB\x88c\xa5\xca0 6\x98\x92\xd6\x12\x18>\xf9\xfb\x1a\x04\xbc\xea\x89Rf<\u02b1\xe1\xc0\x00\x00\u07d4\xcal\xa5\xf 5\x8a\xdb\xef\xae\xeeY\xee\xa2A\xcf\x04\x82b.\xaa\x89M\x85<\x8f\x89\b\x98\x00\x00\u07d4\xca L\xa9\xe4w\x9dS\x0e\u02ec\xd4~j\x80X\xcf\xdee\u064f\x89+^:\xf1k\x18\x80\x00\x00\u07d4\xcae~ x0f\xa2\x82\u0176v1\xceU+b\xeeU\xad\x84t\x89j\xc4\"\xf54\x92\x88\x00\x00\xe0\x94\xcal\x81\x8b \xef\xd2Q6\x1e\x02t@h\xbe\x99\u062a`\xb8J\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\xcap\xf 4\u077f\x06\x9d!C\xbdk\xbc\u007fikRx\x9b2\u7262\xa1]\tQ\x9b\xe0\x00\x00\xe0\x94\xcatuvDjL\x8 f0\xb0\x83@\xfe\xe1\x98\xdec\xec\x92\u03ca\x01|\x8e\x12\x06r*0\x00\x00\u07d4\xca{\xa3\xffSl~_ \x0e\x158\x00\xbd8=\xb81)\x98\xe0\x89\t1\xac=k\xb2@\x00\x00\xe0\x94\u0282v\xc4w\xb4\xa0{\x 80\x10{\x845\x94\x18\x96\a\xb5;\xec\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\u0284\t\b>\x01\ xb3\x97\xcf\x12\x92\x8a\x05\xb6\x84U\xceb\x01\u07c9V\xbcu\xe2\xd61\x00\x00\x00\u07d4\u0298 \u01d8\x8e\xfa\b\xe9%\uf719ER\x03&\xe9\xf4;\x99\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\u0 29a\x04*j\x80o\xfc\x92\x17\x95\x00\xd2D)\xe8\xabR\x81\x17\x89;\xa1\x91\v\xf3A\xb0\x00\x00\u07 d4\u029d\xec\x02\x84\x1a\xdf\\\xc9

 $\x 898E \xccp\xb7x\x00\x00\u07d4\xcb=vI\x98?\x19+\xce\xca\xc7\x0fN\xe0=\xd9\xffqMQ\x89\x05k\xc7^-$

\x8964\xbf9\xab\x98x\x80\x00\u07d4\xcbh\xaeZ\xbe\x02\xdc\xf8\xcb\u016aq\x9c%\x81FQ\xaf\x8b\x85\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xcbty\x10\x9bC\xb2fW\xf4F_M\x18\xc6\xf9t\xb\e_B\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\xcbty\x10\x9bC\xb2fW\xf4F_M\x18\xc6\xf9t\xb\e_B\x89b\xa9\x92\xe5:\n\xf0\x00\x00\x00\u07d4\u02c6\xed\xbc\x8b\xbb\x1f\x911\x02+\xe6IV^\xbd\xb\b0\x9e2\xa1\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\u02c6\xed\xbc\x8b\xbb\x1f\x911\x02+\xe6IV^\xbd\xb\b0\x9e2\xa1\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\u02c6\xed\xbc\x8b\xbb\x1f\x911\x02+\xe6IV^\xbd\xb\b0\x9e2\xa1\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\u02c6\xed\xbc\x8b\xbb\x1f\x90\xbd\x85\x9e=B\x86m\xc8\xc1\x87I\x89\f\x90\xdf\a\xde\xf7\x8c\x00\x00\u07d4\u02d4\xe7o\xeb\xe2\b\x11g3\xe7n\x80]H\xd1\x12\xec\x9f\u02df\xaa\\\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\u02e2\\zP<\xc8\xe0\xd\01q\xca\x05\xc7b\xf9\xb7b\xb4\x8b\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\u02e2\\zP<\xc8\xc0\xd\x1e\xb4\u055d\xdb\x06\xa6B\x1c\x14\xc3E\xa4{\$\x89\xd8\xd7\xb7\x17z\x80\x00\x00\u07d4\u02f7\xbe\x17\x95?\u0313\u1f19\x80[\xf4U\x11CNL\x8a\n\xae[\x9d\xf5m/

]7\xb8\xd3w\xcf\x13\x80\xda\x03\x17\x89M\x85<\x8f\x89\b\x98\x00\x00\u07d4\xcc\x03I\x85\xd3\xf 2\x8c-

 $9\xb1\xa3K\xce\xd4\u04f2\xb6\xca\#N\x89\t\xdd\xc1\xe3\xb9\x01\x18\x00\x00\u07d4\xcc\x04\< C\x88\xd3E\xf8\x84\u0185^q\x14*\x9fA\xfdi5\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xcc\x1dn\xad\x01\xaa\xda>\x8d\u01f9]\xca\%\xdf\&\xee\xfac\x9d\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xcc+_D\x8f5(\xd3\xfeA\xcc)\x1f\xa9\xc0\xdcv\xf1\xb7v\x89\x03@\xaa\xd2\x1b;p\x00\x00\u07d4\xcc-$

|u\xe8\x89.\xe4\U\b\x98\xe4\x00\x00\u07d4\xccHAM*\xc4\xd4*Yb\xf2\x9e\xeeD\x97\t/C\x13R\x89 \b\xbaR\xe6\xfcE\xe4\x00\x00\u07d4\xccJ/,\xf8l\xf3\xe43u\xf3`\xa4sF\x91\x19\x14\x90\x89l\x15\x 05;\xd1)\t\x80\x00\u07d4\xccO\x0f\xf2\xae\xb6}T\xce;\xc8\xc6Q\v\x9a\xe8>\x9d2\x8b\x89\x15\xaf\ x1dx\xb5\x8c@\x00\x00\u07d4\xccO\xaa\xc0\v\xe6b\x8f\x92\xefk\x8c\xb1\xb1\xe7j\xac\x81\xfa\x1 8\x89\v\"\xa2\xea\xb0\xf0\xfd\x00\x00\x00\x00\x00\xe0\x94\xccO\xebr\u07d8\xff5\xa18\xe0\x17a\xd1

 $\label{thm:color$

xb7^\xf9\x80\$\u0509\x9f\xad\x06\$\x12y\x16\x00\x00\u07d4\xcd\x10,\xd6\xdb=\xf1J\u05af\x0f\x87\ xc7\$y\x86\x1b\xfc=\$\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xcd\x1ef\xedS\x9d\xd9/\xc4\v\xba\xa1\xf a\x16\u078c\x02\xc1ME\x89\fw\xe4%hc\xd8\x00\x00\u07d4\xcd\x1e\xd2c\xfb\xf6\xf6\xf6\xf7\xb4\x8a\x ef\x8fs=2\x9dC\x82\xc7\u01c9\x01\x00\xbd3\xfb\x98\xba\x00\x00\u07d4\xcd*6\xd7S\xe9\xe0\xed\ $x01*XMqh\aX{A\xd5j\x89\x0e+\xa7[\v\x1f\x1c\x00\x00\u07d4\xcd2\xa4\xa8\xa2\u007f\x1c\xc69T\x1c\$ aacOxW\x05s4\u01e3\x89:\xd1fWlr\xd4\x00\x00\u07d4\xcd5\xff\x01\x0e\xc5\x01\xa7!\xa1\xb2\xf0 z\x9c\xa5\x87\\xfc\xf9Z\x89\xd9o\u0390\u03eb\xcc\x00\x00\u07d4\xcdC\x06\xd7\xf6\x94z\xc1tMN\ x13\xb8\xef2\xcbe~\x1c\x00\x89\x1b\x1a\xb3\x19\xf5\xecu\x00\x00\u07d4\xcdC%\x8bs\x92\xa90\ x83\x9aQ\xb2\xef\x8a\xd24\x12\xf7Z\x9f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xcdl\xbf\x18^p\xd0E \a\x99\x9f\x92\xa4\xdeDU1('\u040965\u026d\xc5\u07a0\x00\x00\u07d4\xcdU\x10\xa2B\u07f0\x18 =\xe9%\xfb\xa8f\xe3\x12\xfa\xbc\x16W\x89\x82\x1a\xb0\xd4AI\x80\x00\x00\u07d4\xcdVj\u05f8\x8 3\xf0\x1f\u04d9\x8a\x9aX\xa9\xde\xe4rM\u0725\x89\x030\xae\x185\xbe0\x00\x00\xe0\x94\xcdY\xf 3\xdd\xe7~\t\x94\v\xef\xb6\xeeX\x03\x19e\xca\xe7\xa36\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x0 0\u07d4\xcdr]p\xbe\x97\xe6w\xe3\xc8\xe8\\\v&\xef1\xe9\x95PE\x89Hz\x9a0E9D\x00\x00\xe0\x94\ xcd~G\x90\x94d\xd8q\xb9\xa6\xdcv\xa8\xe9\x19]\xb3H^z\x8a\x02\x15\xf85\xbcv\x9d\xa8\x00\x00\ u07d4\xcd~\xce\bkKa\x9b;6\x93R\xee8\xb7\x1d\xdb\x06C\x9a\x89\n\u05ce\xbcZ\xc6 \x00\x00\u07d4\xcd\u007f\t\xd7\xedf\xd0\u00cb\u016dN2\xb7\xf2\xb0\x8d\xc1\xb3\r\x89>;\xb3M\x $a2\xa4p\x00\x00\u07d4\u0355)I+\)\xe4u\xac\xb9A@+=;\xa5\x06\x86\xb0\x89j\xcb=\xf2~\x1f\x88\x$ 00\x00\u07d4\u0355\xfaB=o\xc1 'J\xac\xde\x19\xf4\xee\xb7f\xf1\x04 \x89\n\u05ce\xbcZ\xc6 \x00\x00\u07d4\u035bL\xefs9\f\x83\xa8\xfdq\u05f5@\xa7\xf9\u03cb\x8c\x92\x89\x04\xe1\x00;(\xd 9(\x00\x00\u07d4\u0361t\x11\t\xc0&[?\xb2\xbf\x8d^\xc9\u00b8\xa34kc\x89\x01\x15\x8eF\t\x13\xd0 \x00\x00\u07d4\u0361\xb8\x86\u39d5\u027aw\x91N\n/\xe5go\x0f\\\u03c9\x05\xbf`\xeaB\xc2\x04\x 00\x00\u07d4\u0364\$\x0fK\x9b\xc5\t\x05\xb7\x9d\x17\u008f\xc4o\x954\x9b\u07c93\x10\xe0I\x11\ xf1\xf8\x00\x00\u07d4\u036bF\xa5\x90 \x80do\xbf\x95B\x04

c\x10\x00\x00\u07d4\xcd\xe3m\x81\xd1(\u015d\xa1Ee!\x93\xee\u00bf\xd9e\x86\xef\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4\xcd\xea8o\x9d\x0f\xd8\x04\xd0(\x18\xf27\xb7\xd9\xfavF\xd3^\x89\xa3l\xd3m\x80\xec\W\x80\x00\u07d4\xcd\xec\xf5gT3\u0370\xc2\xe5Zh\xdb]\x8b\xbexA\x9d\u0489\x01\x15\x8eF\t\x13\xd0\x00\x00\x00\xe0\x94\xcd\xfd\x82\x173\x97%\xd7\xeb\xac\x11\xa66U\xf2e\xef\xf1\xcc=\x8a\x01\x0f\fid\x10\xe3\xa9\x00\x00\u07d4\xce\a\x9fQ\x88wt\xd8\x02\x1c\xb3\xb5u\xf5\x8f\x18\xe9\xac\xf9\x84\x89\t\xc2\x00vQ\xb2P\x00\x00\u07d4\xce\x18\x84\u077b\xb8\xe1\x0eM\xbanD\xfe\xee\u00a7\xe5\xf9/\x05\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xce\x1b\f\xb4j\xae\xcf\u05db\x88\f\xad\x0f-

\u068a\x8d\xed\u0431\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xce&\xf9\xa50_\x83\x81\tCT\xdb\xfc\x92fN\x84\xf9\x02\xb5\x89\fz\xaa\xb0Y\x1e\xec\x00\x00\u07d4\xce-

\xea\xb5\x1c\n\x9a\xe0\x9c\xd2\x12\xc4\xfaL\xc5+S\xcc\r\xec\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xce.\r\xa8\x93F\x99\xbb\x1aU>U\xa0\xb8\\\x16\x945\xbe\xa3\x8a\x01\x0f\fid\x10\xe3\xa9\x00\x

 $00\u07d4\xce:a\xf0F\x1b\x00\x93^\x85\xfa\x1e\xad\x82\xc4^Zd\u0508\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xceK\x06]\xbc\xb20G$

 $2b\xfbH\xc1\x18\x83d\x97tp\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xceS\xc8\xcd\xd7B\x96\xac\xa9\x87\xb2\xbc\x19\u00b8u\xa4\x87\u0409\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xce^\x04\xf0\xbc\xfa\x06\xac\xa6o\xfa\x91\xbfY\xfa\x0f\xb9\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xce^\xb6:{xf4\xfb\xc2\xf6\u4ea0\u018a\xb1\xcbL\xf9\x8f\xb4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xceb\x12Z\xde\xc37\n\xc5!\x10\x95:Nv\xe9E\x1e;\x89\b=|z\xabc`\x00\x00\x00\x94\xceq\bmL`%T\xb8-\xcb\xfc\x8d$

cMS\xccM\x8a\t(\x96R\x9b\xad\u0708\x00\x00\u07d4\u038akmP3\xb1I\x8b\x1f\xfe\xb4\x1aAU\x0 4\x05\xfa\x03\xa2\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\u0397\x86\xd3q/\xa2\x00\xe9\xf6\x8 57\xee\xaa\x1a\x06\xa6\xf4ZK\x89a\t=|,m8\x00\x00\u07d4\u039d!\u0192\xcd<\x01\xf2\x01\x1fP_\ x87\x006\xfa\x8fI\u0489\x15\xaf\x1dx\xb5\x8c@\x00\x00\x00\xe0\x94\u03a2\x89f#\xf4\x91\x02\x87\xa 2\xbd\u017e\x83\xae\xa3\xf2\xe6\xde\b\x8a\x01\xfbZ7Q\xe4\x90\xdc\x00\x00\u07d4\u03a3JM\xd9 =\u066e\xfd9\x90\x02\xa9\\x99z\x1bK\x89\u0349QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4\u03a8t3AS<\xb2\xf0\xb9\xc6\xef\xb8\xfd\xa8\rw\x16(%\x89\x05k\xc7^-

 $c\x10\x00\x00\u07d4\u03b0\x89\xec\x8ax3\x8e\xf8\x8d\xe1\x1bl\xe3\u0751\x0ft\x8f\x8965\u026d \\ \xc5\u07a0\x00\x00\u07d4\u03b3=x\xe7Tz\x9d\xa2\xe8\Q\xae\xc5\xf3D\x1c\x87\x92:\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\u03b3\x898\x1dH\xa8\xaeO\xfcH:\u043b^$

 $| \x00\x00\x00\x04\xcf\x15v\x12vN\x0f\u0596\xc8\xcb_\xba\x85\xdfL\tr\xdc<\xb0\x8a\x06ZM\xa2]0\x 16\xc0\x00\x00\u0794\xcf\x1b\xdby\x9b.\xa6<\xe14f\x8b\xdc\x19\x8bT\x84\x0f\x18v\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xcf\"\x88\xefN\xbf\x88\xe8m\xb1=\x8a\x0e\v\xf5*\x05e\x82\u00c9\x89 Po\xbf\x97@t\x00\x00\u07d4\xcf&Ni%\x13\t\x06\xc4\xd7\xc1\x85\x91\xaaA\xb2\xa6\u007foX\x89lk \x93[\x8b\xbd@\x00\x00\u07d4\xcf&\xb4{\xd04\xbcP\x8elK\xcf\xd6\xc7\xd3\x004\x92Wa\x89a\x94 \x04\x9f0\xf7 }$

 $00\x00\u07d4\xcf^\x0e\xac\u0473\x9d\x06U\xf2\xf7u5\xeff\b\xeb\x95\v\xa0\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xcfhM\xfb\x83\x04r\x93U\xb5\x83\x15\xe8\x01\x9b\x1a\xa2\xad\x1b\xac\x89\x17r\x\xad\x1b\xac\x89\x17r\x\xaa\x84\Lr\x00\x00\u07d4\xcfi@\x81\xc7m\x18\xc6L\xa7\x13\x82\xbe\\\xd6;<\xb4v\xf8\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xcfnR\xe6\xb7t\x80\xb1\x86~\xfe\xc6Dm\x9f\xc3\xcc5w\xe8\x89\ft\x01\x86\xb2\x00\x00\x00\u07d4\u03c8:$

 $2 \times 96g \times 2^{j} \times 1e < v] \times 1e < v$

 $\label{thm:colored} $$ \u0269\times14\x03Sr\xff\u0189\x15\xbeat\xe1\x91.\x00\x00\u07d4\xcf\xc4\xe6\xf7\xf8\xb0\x11AK\xfb\xa4/\#\xad\xfa\xa7\x8dN\xcc^\x89dI\xe8NG\xa8\xa8\x00\x00\u07d4\xcf\xd2r\x8d\xfb\x8b\xdb\xf3\xbfsY\x8an\x13\xea\xf40R\xea+\x89\t79SM(h\x00\x00\u07d4\xcf\xd4t\x93\xc9\xf8\x9f\u603d\xa5uM\xd7\xc9\xcf\xe7\xcb[\xbe\x89\x02\xf4sQ4H\xfe\x00\x00\u07d4\xcf\xde\x0f\xc7]o\x16\xc4C\xc3\x03\x82\x177-$

 $\label{thm:condition} $$ \x99\xf5\xd9\a\xf7\x89\x83\"^c\x96\xb5\xec\x00\x00\x00\x94\xcf\xe2\u02af<\xec\x97\x06\x1d\t9t\x88\x99\xf6\xp1f\x88\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xcf\xea\u02ae\xd5r\x85\xe0\xacrh\xcejN5\xec\xfd\xb2B\u05c9:\xe4\xd4$\x01\x90\\x00\x00\u07d4\xcf\ucfa0\|'\x00\/e\xfeSK\xb8\x84-$

 $Aa\xfd\x1f\xaew\x1d\x0e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd01\x919\xfb\xab.\x8e*\xcc\xc1\xd9\u0531\x1d\xf6ilZ\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:linear} $$ \a4\x1e\x86\x8e\xd3\xfe\xf5t[\x96\xf5\xec\xa4b\xffo\u0689\xa2\xa1]\tQ\x9b\xe0\x00\x00\x00\x94\xd0?\xc1e\Wj\xae\xd5\%\xe5P,\x8e\x14\x0f\x8b.\x86\x969\x8a\x01sV\u0633\%\x01\xc8\x00\x00\u07d\4\xd0C\xa0\x11\xecBp\xee~\u0239\hsu\x15\xe5\x03\xf80(\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u007d\xd0K\x86\x1b=\x9a\xccV:\x90\x16\x89\x94\x1a\xb1\xe1\x86\x11a\xa2\x89\x01\x15\x8eF\tx1$

 $3\xd0\x00\x00\u07d4\xd0ZD\x91\x1d\xbb'\[\xfb.Z7\xe5\xa7\x03\xa5o\x99\x97\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\xd0_\xfb+t\xf8g$

 $p\xde\x1b\xe0\xcaC\x1c^\xea\$\x82\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd0w]\xba*\xf4\xc3\n:x6Y$ $9\xcdq\xc2\xf9\u0795\u0489i^\xe8\x89p\x81\xd0\x00\x00\u07d4\xd0{\xe0\xf9}\tx97\xca\xf9\x03\u02$ $2c\x1dS\xcd\xe9\x04\xfb\x19\aA\x8968\x908\xb6\x99\xb4\x00\x00\u07d4\xd0\sim Q\x18d\xb1\u03d9i\xe3V\x06\x02\x82\x9e2\xfc\nq\xf5\x89\x02\xb5\xe3\xaf\x16\xb1\x88\x00\x00\x00\u07d4\u0400\x94\x98$ $\xc5H\x04z\x1e^{**}\xa6\xa2\x9c\xd6\x1a\x0e\xe2h\xbd\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u0402'_tZ,\xac\x02v\xfb\xdb\x02\u0532\xa3\xab\x17\x11\xfe\x89\x01\xa0\Ui\r\x9d\xb8\x00\x00\u07d4\u040$ $\tf\xc0\x9a\x000\xfd\t(\xcd2\x11\x98X\x01\x82\xa7j\xae\x9f\x8965\u026d\xc5\u07a0\x00\x00\u07d4\u040$ $\tu0413\xe8)\x81\x9f\xd2\xe2[\x978\x00\xbb=XA\xdd\x15-$

\x05\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\u0414J\xa1\x85\xa13pa\xae

\u071d\xd9l\x83\xb2\xbaF\x02\x89\n\u05ce\xbcZ\xc6

o\\D0\xfe\x00Pc\x90<=zI\xa7\x89&I\x1eE\xa7S\xc0\x80\x00\u07d4\xd0\xe1\x94\xf3K\x1d\xb6\t(\x8 5\t\xcc\xd2\xe7;a1\xa2S\x8b\x8965f3\xeb\xd8\xea\x00\x00\u07d4\xd0\xe3^\x04vF\xe7Y\xf4Qp\x93 \xd6@\x86BQ\u007f\bM\x89\u054f\xa4h\x18\xec\u02c0\x00\u07d4\xd0\xeeM\x02\xcf\$8,0\x90\xd3\xe9\x95`\xde6xs\\\u07c9\x82\x1a\xb0\xd4AI\x80\x00\x00\u07d4\xd0\xf0OR\x10\x9a\xeb\xec\x9a{\x 1e\x932v\x1e\x9f\xe2\xb9{\xb5\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xd0\xf9Yx\x11\xb0\xb9\x92\xbb}7W\xaa%\xb4\xc2V\x1d2\xe2\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xd1\x10\r\xd0\x0f\x

 $e2\xdd\xf1\x81c\xad\x96M\vi\xf1\xf2\xe9e\x8a\x8a\x01C\x12\tU\xb2Pk\x00\x00\u07d4\xd1\x16\xf3\xdc\xd5\xdbtK\xd0\b\x88v\x87\xaa\x0e\xc9\xfdr\x92\xaa\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xd1\x19A\Fs,\xf3M\x1a\x1a\xfby\xc3\xe7\xe2\u034e\xec\xe4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd1-w\xae\x01\xa9-$

5\x11{\xacpZ\xac\u0642\xd0.t\xc1\x8965\u026d\xc5\u07a0\x00\x00\x00\x94\xd15yK\x14\x9a\x18\x e1G\xd1nb\x1ai1\xf0\xa4\n\x96\x9a\x8a\x04<3\xc1\x93ud\x80\x00\x00\x00\xe0\x94\xd1C\%8\xe3[vd\x95]\u4563*\xbd\xf0A\xa7\xa2\x1c\x8a\x04+\xf0kx\xed;P\x00\x00\u07d4\xd1C\x82g#\x17\x04\xfcr\x80\xd5c\xad\xf4v8D\xa8\a\"\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convoluo7d4} $$\x8e\x9a\x87\u5729\xec\x8eX\&\xa5\xb7\x93\xf9\x9f\x96\xc4\u00c965\u026d\xc5\u07a0\x00\x00\x94\xd1d\x85\x03\xb1\xcc\u0178\xbe\x03\xfa\x1e\xc4\xf3\xee\&_j\xdf\{\x8a\x01;\xef\xbfQ\xee\xc0\x90\x00\x00\x00\x00\x00\x01\x8d\xc3\xd0\u007f\b\n\x8c\m\xafe\xf8\xe1\x8a^2\x05\x8f\u0095\xed\x00\x00\x00\u07d4\xd1q\xc3\xf2\%\x8a\xef5\xe5\x99\xc7\xda\x1a\xa0s\x00\#M\xa9\xa6\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\xd1\w\x8c\x13\xfb\xd9\xd9\xbc\xb7\xd1\x020\xfe\x1f\xd0\xaa\x89\xd9\xec\xb4\xfd$

 $\label{thm:linear_continuous} $$ \times e^x00\x00\u07d4\xd1\u007f\xbe'''xd9\x04b\xed7(\x06p\xa2\xea\v0\x86\xa0\xd6\u0589\n\xd6\xeq)$$ ee\xdd\x17\xcf;\x80\x00\u07d4\u0441\x1cU\x97i\x80\xf0\x83\x90\x1d\x8a\r\xb2i\"-$

 $\label{thm:linear} $$ \left(\frac{x}{x}\right) \times 6\left(\frac{x}{x}\right) \times 6\left(\frac{x}{x}\right)$

 $\label{thm:linear} $$ \x8c|x84|xde|x00k|u02db|xe9|x89|x1b|x1a|xe4|xd6|xe2|xefP|x00|x00|u07d4|xd1|xc4|xd6+|x91|x1a|xd7|x01|xff.|x90|x13|x1e|x8c|xeb|x89|xc9||x89|x|x91|xa2|xdeE~|x88|x00|x00|u07d4|xd1|xc9np|xf0Z|xe0|xe6|xcd||xb2|xe7||xdeV|x89|x1b|x1a|xe4|xd6|xe2|xefP|x00|x00|u07d4|xd1|u0571|u007f|xfe-$

00\u07d4\xd2\x06\xaa\u07736\xd4^yr\xe9<\xb0uG\x1d\x15\x89{]\x89

R\xb6\\\xbbl\x8a\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\xe0\x94\xd2Q\xf9\x03\xae\x18rrY\xee\xe8A\x a1\x89\xa1\xf5i\xa5\xfdv\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xd2R\x96\v\v\xf6\xb2\x 84\x8f\u07ad\x80\x13m\xb5\xf5\a\xf8\xbe\x02\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xd2X\x1aU\x ce#\xab\x10\u062d\x8cD7\x8fY\a\x9b\xd6\xf6X\x8a\x01\xdd\f\x88_\x9a\r\x80\x00\x00\u07d4\xd2Z\ xec\xd7\xeb\x8b\xd64[\x06;]\xbd'\x1cw\xd3QD\x94\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\xd2]#O \xf7\xac\xca\xce=\x99g\b\xf8\xf9\xb01p\xf9\6\x89Hz\x9a0E9D\x00\x00\u07d4\u0482\x98RM\xf5\xe cK\$\xb0\xff\xb9\u07c5\x17\n\x14Z\x9e\xb5\x89\x0f\x98\xa3\xb9\xb37\xe2\x00\x00\x00\x00\u07d4\u0483\ xb8\xed\xb1\n%R\x8aD\x04\xde\x1ce\xe7A\r\xbc\xaag\x8a\x02\x8a\x85t%Fo\x80\x00\x00\u07d4\u0484\xa5\x03\x82\xf8:am9\xb8\xa9\xc0\xf3\x96\xe0\ubfe9]\x8966\xc2^f\xec\xe7\x00\x00\u07d4\u0488\xe7\xcb\{\xa9\xf6}

\xa4\xc0\x00\x00\u07d4\u04ab\xd8J\x18\x10\x93\xe5\xe2)\x13oB\xd85\xe8#]\xe1\t\x89\x05k\xe0<\xa3\xe4}\x80\x00\u07d4\u04ac\r:X`^\x1d\x0f\x0e\xb3\xde%\xb2\xca\xd1)\xed`X\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4\u04bfg\xa7\xf3\xc6\xceV\xb7\xbeAg]\xbb\xad\xfe~\xa9:3\x89\x15\xaf\x1d x\xb5\x8c@\x00\x00\u07d4\xd2\xdb\xeb\xe8\x9b\x03W\xae\xa9\x8b\xbe\x8e\tG\x92z\xda\xf2\x9f#\xe b\xadl\x89\x15\x17z\x80\x00\x00\u07d4\xd2\xe2\x1e\xd5hh\xfa\xb2\x8e\tG\x92z\xda\xf2\x9f#\xe b\xadl\x89\x13U\xd0\xe8\x00\x00\u07d4\xd2\xe8\x17s\x8a\xbf\x1f\xb4\x86X?\x80\xc3P1\x8 b\xed\x86\f\x80\x89\r\x02\xce\xcf_]\x81\x00\x00\u07d4\xd2\xed\xd1\xd0\x00\u07d4\xd2\xf1\x99\x8e\x1c\x

b1X\f\xecOl\x04\\xcd=\xce\xc5L\xf7<\x89\n\u05ce\xbcZ\xc6

 $Sz> \x 01\x 15\x 8eF\t x 13\x d0\x 00\x 00\u 07d4\x d3\x 11\x bc\u 05eaN\x 9bO 8?\x f3\x d0\u 05b6\x e0~!\x e3p\x 89\n\u 05ce\x bcZ\x c6$

\x00\x00\u07d4\xd3\x15\xde\xea\x1d\x8c\x12q\xf9\xd11\x12c\xabG\xc0\a\xaf\xb6\xf5\x89\x03\xc8\x1dNeK@\x00\x00\u07d4\xd3+,y\xc3dx\xc5C\x19\x01\xf6\xd7\x00\xb0M\xbe\x9b\x88\x10\x89\x15\x\neq \x\neq \x\

 $\label{thm:label$

 $x99\xa4\x9b\x01\u024d\x1c>\f\x98\xe1\xe1\x89\x0f-$

\xb6\xaci\xf0\u019e\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\u07d4\xd3\xdf;S\xcb;GU\xdeT\xe1\x80 E\x1c\xc4L\x9e\x8a\u0a89#\u0114\t\xb9w\x82\x80\x00\u07d4\xd3\xf8s\xbd\x99V\x13W\x89\xab\x 00\xeb\xc1\x95\xb9\"\xe9K%\x9d\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd4\x02\xb4\xf6\xa0\x99\xe b\xe7\x16\xcb\x14\xdfOy\xc0\xcd\x01\xc6\a\x1b\x89lk\x93[\x8b\xbd@\x00\x00\x00\x00\xe0\x94\xd4\r\x00U \xfd\x9a8H\x8a\xff\x92?\xd0=5\xecF\xd7\x11\xb3\x8a\x01\x0f\b\xed\xa8\xe5U\t\x80\x00\u07d4\xd4\xd6\xe2\xefP\x00\x00\u07d4\xd4\x18\x837\v\xc2\xe4\xfa{\x8a!\xae\br\xd5RG\xb6%\x01\x89U\xa6\xe7\x9c\xcd\x1d0\x00\x

 $00\u07d4\xd4\x1d\u007f\xb4\x9f\xe7\x01\xba\xac\%qpBI\u0273\x8c\xa3\xa9\xb2\x89\t\x8a\x9b\x8a\x3\x14\xc0\x00\u07d4\xd4$

 $\xbd\x03\x11^\x8bf\xf8\xa6\xd1[*\x95\xe6\xde'\u017f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd44O]\xade\xd1\sim\-$

\x00\x00\u07d4\u0502\xe7\xf6\x8eA\xf28\xfeQx)\xde\x15G\u007f\xe0\xf6\xdd\x1d\x89\x1b\x1a\xe4 \xd6\xe2\xefP\x00\x00\u07d4\u0507\x9f\xd1+\x1f:'\xf7\xe1\tv\x1b#\xca4<H\xe3\u0609\$\x1a\x9bOa z(\x00\x00\u07d4\u050e?\x93W\xe3\x03Q8A\xb3\xf8K\u0683\xfc\x89ru\x87\x8965\u026d\xc5\u07 a0\x00\x00\xe0\x94\u051au\xbb\x93?\xca\x1f\u029a\xa10:d\xb6\xcbD\xea0\xe1\x8a\x02\x1e\x19\x e0\u027a\xb2@\x00\x00\u07d4\u0530\x85\xfb\bo=\rh\xbf\x12\x92k\x1c\xc3\x14,\xae\x87p\x89\u02 13\u041c\x8fQP\x00\x00\u07d4\u0532\xff;\xae\x19\x93\xff\xeaM;\x18\x021\xdaC\x9fu\x02\xa2\x89 lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\u0533\x8a_\xdbc\xe0\x17\x14\xe9\x80\x1d\xb4\{\u0250\xbdP\x 91\x83\x8a\x01E4\xd9[\xef\x90\\\x00\x00\u07d4\u0538\xbd\xf3\u07daQ\xb0\xb9\x1d\x16\x85\{/_\a\x e8\xfa\xceh\x05m\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd4\u01act.|\x85}J\x05\xa0L3\xd4\xd0\\\x1 4gW\x1d\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convoluo7d4} $$\x00\x00\u07d4\xd4\xd9,b\xb2\x80\xe0\x00fbm\x86W\xf1\xb8af\xcb\x1ft\x0f\x89\n\xd7\xf264\xcb\xd6\x00\x00\u07d4\xd4\ubc52\x9a\#\x87\x1c\xf7\u007f\xe0l\xab\x96\x02\xbe\b\xbe\ns\x89g\x8a\x93 b\xe4\x18\x00\x00\xe0\x94\xd4\xeel\x19\xfb7\xf2\xbb\x97\f?\xffT\xaa\xf1\xf3\u0766\xc0?\x8a\x9x 83\&\xea\xc9\x00\x00\x00\u07d4\xd4\xfe\xed\x99\xe8\x91\|\TXc_6\x03\xec\xb7\xe8\x17\xa7\u0409 $$$

\x10C\xc4<\xde\x1d9\x80\x00\u07d4\xd4\xffF

89\x0e~\xeb\xa3A\vt\x00\x00\xe0\x94\u0550>\x99x\xee

 $\x 9e(\x8f\x8a\xbb(\x00\x00\u07d4\xd5\u02e5\xb2k\xea]s\xfa\xbb\x1a\xba\xfa\xcd\xef\x85\xde\xf3h\u0309\n\u05ce\xbcZ\xc6$

 $7d4\xd6\x06Q\xe3\x93x4\#\xe5\xcc\x1b\xc5\xf8\x89\xe4N\xf7\xea$>\x89\x15\x9ev7\x11)\xc8\x00\x00\u07d4\xd6\t\xbfO\x14n\xeak\r\xc8\xe0m\xdc\xf4D\x8a\x1f\xcc\xc9\xfa\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd6\t\xec\v\xe7\r\n\xd2\ng\xc9\xd4v+R\xeeQ\x12,\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xd6\nRX\a(R\r\xf7Tk\xc1\xe2\x83)\x17\x88\u06ee\f\x8964\x89\xef?\xf0\xd7\x00\x00\u07d4\xd6\x92\xd0$ $6\v$s!\xa3*Z\xff\xb9k\x1e'\x99'\xccXM\xe9C\x89z\xd0$

 $\label{thm:cond} $$ \d(xdd)xd7v(x00)x00(x00)x00(x04)xd6(x11)x02v(xcf)xe3(x1eB)x82ZW(u007fkC])xbc(xc1)f(xf7d)x8965(u026d)xc5(u07a0)x00(x00)x94(xd6)x12Y{(xc3)x17C(u01c63)xf63)xf29(xb1)xe9Bk(xd9%)x8a(x10)x17(xf7)u07d6(xbe)x17(x80)x00(u07d4)xd6#J(xafE)xc6(xf2.f(xa2%)xff(xb9):(xddb)x9bN(xf8)x0f(x8965)u026d(xc5)u07a0(x00)u07d4(xd6.)u06d6(xfc)u259a(xafIT^(x96)xf1)xc0(xbc)x80R(x05)x89(x04)xa5eSjZ(u0680(x00)u07d4(xd60)v2)x15(xb1)x1d(xe7b)xec(xdeKp)xb7(x92)x01)(x15)x82(x89)kx93[(x8b)xbd@(x00)x00(u07d4)xd69](xb5)xa4(xbbf)xe6(x0fL)xfb(xcd)xf0(x05)(xb4)xd9xb(xe2)x891T(xc9r)x9d(x05x)x00(x00)xe0(x94)xd6J-$

 $\label{thm:convenience} $$ \lambda e1^xd^f] \times 5\x8965\u026d\xc5\u07a0\x00\x00\u0794\xd6f\xcc\r\x11\xb6\x89\u03a6\xd9\xea_\xf4\x01L\J]\xc7\u0108\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xd6m\xdf\x11Y\xcf\"\xfd\x8czK\xc8\u0540\wV\xd43\xc4>\x89\wC\"\x17\xe6\x83\\x00\x00\u07d4\u0587\xce\xc0\x05\x90\x87\xfd\xc7\x13\xd4\xd2\xd6\w\xd2\xd6\w\xd2\xd2\x1b;p\x00\x00\u07d4\u0588\xe7\x85\u024f\x00\xf8K:\xa1S3U\u01e2X\xe8yH\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\u05a2.Y\x8d\xab\u04ce\xa6\xe9X\xbdy\u050d\u0756\x04\xf4\u07c965\u026d\xc5\u07a0\x00\x00\u07d4\u05a7\xac\M\xe7\xb5\x10\xf0\xe8\xdeQ\x9d\x97?\xa4\xc0\x1b\xa84\x00\x89e\xea=\xb7UF\x00\x00\u07d4\u05ac\xc2$

 $\label{thm:condition} $$ \sum_{x \in \mathbb{N}(x) \in \mathbb{N}(x)} (x) - ($

 $\label{thm:c3n} $$ \left(\frac{1}x1d^\pi 19Ey(u054c'f(xa7)xef(x16)xc3(n))x89lk(x93[\x8b)xbd@\x00(x00)u07d4\xd7\x05\%\x19uj(xf4\%)x90\xf1S\x91\xb7\#\xa0?\xa5d\xa9Q\x89\xfa61H\r\x01\xfd\x80\x00\u07d4\xd7\na+\xd6\u0769\xe3\xb0\xdd\xdc\xffJ\xafA\"\u04cf\xea\xe4\x89\x1dF\x01b\xf5\x16\xf0\x00\x00\u07d4\xd7\n\xd2\xc4\xe9\uefe67\xefV\xbdHj\u04a1\xe5\xbc\xe0\x93\x89\n\u05ce\xbcZ\xc6$$

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\xd7\x14\fx8eZC\a\xfa\xb0\xcc'\xba\u0752\x95\x01\x8b\xf8yp\x89\x05\xf1\x01\kPv\xd0\x00\x00\u07d4\xd7\x16J\xa2a\xc0\x9a\u0672\xb5\x06\x8dE>\xd8\xebj\xa10\x83\x89\xa2\xa1]\ tQ\x9b\xe0\x00\x00\u07d4\xd7\x1eC\xa4Qw\xadQ\xcb\xe0\xf7!\x84\xa5\xcbP9\x17(Z\x89\n\u05ce\xbcZ\xc6$

\x00\x00\u07d4\xd7\x1f\xb10\xf0\x15\fVRi\xe0\x0e\xfbC\x90+R\xa4U\xa6\x89\n\u05ce\xbcZ\xc6 \x00\x00\u07d4\xd7\"W8\xdc\xf3W\x848\xf8\xe7\u0233\x83~B\xe0J&\x89\x18+\x8c\ubec3\xaa\x0 0\x00\u07d4\xd7'MP\x80M\x9cw\u0693\xfaH\x01V\xef\xe5{\xa5\x01\u0789i*\xe8\x89p\x81\xd0\x0 0\x00\u07d4\xd71\xbbk_<79^\t\u03ac\xcd\x14\xa9\x18\xa6\x06\a\x89\x89\u0556{\xe4\xfc?\x10\x0 0\x00\xe0\x94\xd7>\xd2\u0645\xb5\xf2\x1bU\xb2td;\xc6\xda\x03\x1d\x8e\u074d\x8a\nm\xd9\f\xae Q\x14H\x00\x00\u07d4\xd7D\xac~S\x10\xbeijc\xb0\x03\xc4\v\xd097\x05a\u0189Z\x87\xe7\xd7\xf5 \xf6X\x00\x00\xe0\x94\xd7Jn\x8dj\xab4\u0385\x97h\x14\xc12{\xd6\xea\a\x84\u048a\x15-

\x00\x00\u07d4\u05d4\x83\xf6\xa8DO%I\xd6\x11\xaf\xe0,C-

Y\x048\xb8,>\x95\x15\xbe.\xb6\xedz\x8b\x1a\x8a\f\xb4\x9bD\xba`-

\x80\x00\x00\u07d4\xd7\xd7\xf2\u02a4b\xa4\x1b;0\xa3J\xeb;\xa6\x10\x10\xe2bo\x89lk\x93[\x8b\xb

 $\label{thm:converse} $$d@\x00\x00\u07d4\xd7\xef\xd5^\x96\u03bcZ7O,\x8bv\x86\x80\xf2\xb0\x89\x05]\xe6\xa7 y\xbb\xac\x00\x00\xe0\x94\xd7\xeb\x901b'\x1c\x1a\xfa5\xfei\xe3s\"\u0224\u049b\x11\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xd7\xeb\u0779\xf99\x87w\x9bh\x01U7T8\xdbe\xaf\xcbj\x89\x005t\x1a\xfe\xff\x94L\x00\x00\u07d4\xd7\xef4\x0ef\xb0\u05ef\xcc\xe2\n\x19\xcb{\xc}\xfc\x81\xda3\xd9N\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xd7\xf3p\u053e\xd9\xd5\ol\u0259\xder\x9e\xe5i\xd3\xf4\xe4\xe4\x89\n\u05ce\xbcZ\xc6$

1({\x96q\xe8\x1c\x88\xb9\x8b\xc8}\xa6\xf9\x00\x00\u07d4\xd8K\x92\xA\xfcWt\xf0\x0e\x14`J\xe0\xdfB\xc8U\x1e\x89\xd9o\u0390\u03eb\xcc\x00\x00\u07d4\xd8U\xb0<\xcb\x02\x9awG\xb1\xf0s\x03\xe0\xa6dy59\u0209lk\x93[\x8b\xbd@\x00\x00\u07d4\xd8_\u07af*a\xf9]\xb9\x02\xf9\xb5\xa5<\x9b\x8f\x92f\u00ec\x89|\xf6Z~\x90G(\x00\x00\u07d4\xd8q^\xf9\x17o\x85\v.0\xeb\x8e8'\a\xf7w\xa6\xfb\xe9\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\xd8t\xb9\u07eeEj\x92\x9b\xa3\xb1\xa2~W,\x9b,\xec\u07f3\x89\t79SM(h\x00\x00\u07d4\u0613\n9\xc7sW\xc3\n\u04e0`\xf0\v\x06\x04c1\xfdb\x89,s\xc97t,P\x00\x00\u07d4\u061b\xc2q\xb2{\xa3\xabib\xc9JU\x90\x06\xae8\xd5\xf5j\x89|k\x93[\x8b\xbd@\x00\x00\x00\u07d4\u0637}\xb9\xb8\x1b\xbe\x90B{b\xf7\x02\xb2\x01\xff\u009f\xf6\x18\x892m\x1eC\x96\xd4\\\x00\x00\u07d4\xd8\xd6C\x84\$\x9bwg\x94\x06;\v\x98x\xd5\xe3\xb50\xa4\xb2\x89\t\xa0C\u0432\xf9\v\x80\x00\u07d4\xd8\xd6T

 $E|!x\x94m\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xd9\x13\xf0w\x19\lu<G&\xac\xaa+\xd3a\x9c\xffw\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xd9\x1d\x88\x91dG\x9c\xe46\xec\xe5\x17c\xe2,\xda\x19\xb2-$

k\x89\xb6m\x88\x12h\x00\x88\x00\x00\u07d4\xd9)\xc6]i\u057b\xae\xa5\x97bf.\xf4\x18\xbc!\xad\x9 2J\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xd90\xb2zx\x87d\x85\xd0\xf4\x8bp\xddS6T\x96y\u028f \x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xd91\xac&h\xbaj\x84H\x1a\xb19sZ\xec\x14\xb7\xbf\xb a\xbf\x89|k\x93[\x8b\xbd@\x00\x00\u07d4\xd98=Km\x17\xb3\xf9\xcdBn\x10\xfb\x94@\x15\xc0\xd4 K\xfb\x89+^:\xf1k\x18\x80\x00\x00\x00\u07d4\xd9B\xdeG\x84\xf7\xa4\x87\x16\xc0\xfdK\x9dT\xa6\xe 5L_/>\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\xd9D\u0226\x9f\xf2\xca\x12|i\f\x12)\xc7\x19\6%\x 10b\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xd9J\W\x88*Rs\x9b\xbe*\x06G\xc8\f\$\xf5\x8a+O\x1c\x8 9H\xb5N*\xdb\xe1+\x00\x00\xe0\x94\xd9SB\x95<\x8a!\xe8\xb65\xee\xfa\u01c1\x9b\xea0\xf1pG\x8 a\x13\xf0\\u007f\xfe\xf0]@\x00\x00\u07d4\xd9\\\x90\xff\xbeT\x84\x86G\x80\xb8gJJ\x83\u0212V\xd 6\xe4\x89X\xe7\x92n\xe8X\xa0\x00\x00\u07d4\xd9g\x11T\x0e.\x99\x83C\xd4\xf5\x90\xb6\xfc\x8f\x ac;\xb8\xb3\x1d\x89_Z@h\xb7\x1c\xb0\x00\x00\u07d4\xd9j\xc2Pt\t\u01e3\x83\xab.\xee\x18\"\xa5\xd78\xb3kV\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\xd9m\xb3;{Z\x95\f>\xfa-

 $c\x10\x00\x00\x00\x04\xd9\xd4\xd1>\xbdK\xf6\x9c\xac^\x9c~\x82H:\xb4m\xd7\xe9\x8a\x01!\xeah\xc1\x14\xe5\x10\x00\x00\u07d4\xd9\xe2~\xb0}\xfcq\xa7\x06\x06\f\u007f\a\x928\u0293\xe8\x859\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xd9\xe3\x85~\xfd\x1e$

 $\begin{tabular}{ll} $$ D\x17p\xa7w\xa4\x9d\xcE\xe2\xe0\u04c9\f\x1d\xaf\x81\u0623\xce\x00\x00\u07d4\xd9\xec.\xfe\x99\xff\\xf0\r\x03\xa81\x92\xa2J\xefD\x1f~\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xd9\xec\x8f\xe6\x9bw\x16\xc0\x86Z\xf8\x88\xa1\x1b+\x12\xf7 \end{tabular}$

 $\label{thm:linear} $$ \u05f1^\times00\x00\u07d4\xd9\xf5G\xf2\xc1\xde\x0e\u064aS\xd1a\xdfWc]\xd2\x1a\x00\xbd\x89\x05\V xf6L\x1f\xe7\xfa\x00\x00\u07d4\xd9\xff\x11]\x01&l\x9fs\xb0c\xc1\xc28\xef5e\xe6;6\x89\xdc\xe5M 4\xa1\xa0\x00\x00\u07d4\xda\x06\x04N)\xe,F\u007f\xe7AF\xbf\x18[!3\x8a\x1c\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xda\vH\xe4\x89\xd3\x02\xb4\xb7\xbf $$$

O\x95|\x1c\x9b\u30f0\u07c9lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xda\rK~\xf9\x1f\xb5Z\xd2e\xf2Q\x14

 $g\xf1\x03v\xce\u058a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\xda\x10\x97\x8a9\xa4o\U0003b10c\xf6]\xd9\xc7u\t\xa6\xd7\x0e\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xda\x16\xdd\=\x1a'\x145\x8f\xe3u,\xaeS\u06eb+\u930a\x04\x1b\xad\x15^e\x12$

 $\label{thm:continuous} $$ \left(\frac{3}{2}\right) \times \frac{3}{2} \times \frac{3}$

\x91\n\xbcKAI\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\u06bc\"PB\xa6Y,\xfa\x13\xeb\xe5N\xfaA\x04\bx\xa5\xa2\x89\x0e\x11\xfa\xd5\xd8\\\xa3\x00\x00\u07d4\xda\xc0\xc1w\xf1\x1c\\>>x\xf2\xef\xd6c\xd12!H\x85t\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xda\xd16\xb8\x81x\xb4\x83zIx\x0f\xeb\xa2&\xb9\x85i\xa9L\x89\n\u05ce\xbcZ\xc6

 $\label{thm:convolu07d4} $$\xo0\xo0\u07d4\xda\xdb\xfa\xfd\x8bb\xb9*\\\xef\xd7RV\u0743\xab\xdb\u05fb\u06c9\x01\x11du\x9f\xfb2\x00\x00\u07d4\xda\xdc\x00\xaby'`</\xcf1\xce\xe3R\xf8\x0elMcQ\x89lf\xe9\xa5Sx\xb8\x00\x00\u07d4\xda\xe0\xd3>\xaa4\x15i\xfa\x9f\xf5\x98\&\x84\x85JJ2\x8an\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xda\xe7$

\x1e\xab\x8c\x063\x02\x93\ri9)\xd0\u007f\x95\xe7\x19b\x89\x91\xae\xc0(\xb4\x19\x81\x00\x00\u007d4\xda\xed\u052d\x10{'\x1e\x89Hl\xbf\x80\xeb\xd6!\u0757Ex\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xdb\x04\xfa\xd9\u011f\x9e\x88\v\xeb\x8f\xcf\x1d:8\x90\u4cc4o\x89CZ\xe6\xcc\fX\xe5\x00\x00\u007d4\xdb\f\u01cft\u0642{\u070ads'n\xb8O\u0717b\x12\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xdb\x12\x93\xa5\x06\xe9\f\xad*Y\xe1\xb8V\x1f^f\x96\x1ag\x88\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xdb\x19\xa3\x98\"06\x8f\x01w!\x9c\xb1\f\xb2Y\u0372%|\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xdb#\xa6\xfe\xf1\xaf{X\x1ew,\xf9\x18\x82\u07b2Qo\xc0\xa7\x89\n\u05ce\xbcZ\xc6}

\x00\x00\u07d4\xdb\$O\x97\xd9\xc4K\x15\x8a@\xed\x96\x06\xd9\xf7\xbd8\x9131\x89\x05\x87\x88\u02d4\xb1\xd8\x00\x00\u07d4\xdb(\x8f\x80\xff\xe22\u00baG\u0314\xc7c\xcfo\u0278+\r\x89\x04\x

 $9b\x9c\xa9\xa6\x944\x00\x00\u07d4\xdb*\f\x9a\xb6M\xf5\x8d\u07f1\u06ec\xf8\xba\r\x89\xc8[1\xb4\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\xdb4t^\u0785\v\xb4\x99\xdb\x01\xbe\xb7\xc1\xec\u068\\ 5\xcfJ\xbe\x89\x04\V9\x18$O@\x00\x00\u07d4\xdb?\%\x8a\xb2\xa3\xc2\xcf3\x9cD\x99\xf7ZK\xd1\xd3G.\x9e\x89QP\xae\x84\xa8\xcd\xf0\x00\x00\u07d4\xdbK\xc8;\x0ek\xaa\xdb\x11\V\xc5\xcf\x06\xe0\xf7!\x80\x8cR\u01c9/\xb4t\t\x8fg\xc0\x00\x00\u07d4\xdbc\x12-$

 $\label{twomas} $$ 7\times 2^x e^x e^ru\xc7\x03\x89\r\x8drkqw\xa8\x00\x00\u07d4\xdb\xc1\xd0\xee+\xabS\x11@\xde\x13w\"\xcd6\xbd\xb4\xe4q\x94\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:convoluo} $$ \x00\x00\u07d4\xdb\u015e\u0609s\u07ad1\b\x84\":\xf4\x97c\xc0P0\xf1\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u0794\xdb\xc6ie\xe4\&\xff\x1a\xc8z\xd6\xebx\xc1\xd9Rq\x15\x8f\x9f\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xdb\xcb\xcdzW\ua7724\x9b\x87\x8a\xf3K\x1a\xd6B\xa7\xf1\u0449\n\u05ce\xbcZ\xc6$$

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\xdb\xd5\x1c\xdf,;\xfa\xcd\xff\x10b!\xde.\x19\xadmB\x04\x14\x89_h\xe8\x13\x1e\u0 $$ 3c0\x00\x00\u07d4\xdb\xd7\x1e\xfaK\x93\u0209\xe7e\x93\xde\x9c;\x04\u02ef\xbe\b\x89\x01\x15\x8eF\tx13\xd0\x00\x00\u07d4\xdb\xf5\xf0a\xa0\xf4\x8e^ia\x879\xa7}.\xc1\x97h\xd2\x01\x89\b=lz\xabc\x00\x00\u07d4\xdb\xf8\xb19g\xf5Q%'-$

 $q\x1e\xd4u\xf5\x15n\xf7\xe7\x1a\x80\xd94\xb9\x8a\x02\x05\xb4\u07e1\xeetx\x00\x00\u07d4\xdc\b \u007f\x93\x90\xfb\x9e\x97j\xc2:\xb6\x89TJ\tB\xec$

!\x89b\xa9\x92\xe5:\n\xf0\x00\x00\u07d4\xdc\x1e\xb9\xb6\xe6CQ\xf5d\$P\x96E\xf8>y\xee\xe7l\xf4\x89\xd8\xd7&\xb7\x17z\x80\x00\u07d4\xdc\x1f\x19ya_\b!@\xb8\xbbx\xc6{"\xa1\x94"\x13\xb1\x89\x03@\xaa\xd2\x1b;p\x00\x00\u07d4\xdc#\xb2`\xfc\xc2n}\x10\xf4\xbd\x04J\xf7\x94W\x94`\xd9\u0689\x1b\x1bk\u05efd\xc7\x00\x00\u07d4\xdc)\x11\x97E\xd23s

\xdaQ\xe1\x91\x00\xc9H\u0640\xb9\x15\x89\b\xacr0H\x9e\x80\x00\x00\u07d4\xdc-

c\x10\x00\x00\xe0\x94\xdc?\x0evr\xf7\x1f\xe7R[\xa3\v\x97U\x18:

\xb9\x16j\x8a\x02\b\x9c\xf5{[>\x96\x80\x00\xe0\x94\xdcCE\u0581.\x87\n\xe9\fV\x8cg\xd2\xc5g\u0

3f4\xf0<\x8a\x01k5-

\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\xdcv\xe8[\xa5\v\x9b1\xec\x1e&

\xbc\xe6\xe7\xc8\x05\x8c\x0e\xaf\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\u0703\xb6\xfd\rQ!1 G\a\xea\xf7.\xa0\xc8\u027e\xf9v\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u070c)\x12\xf0\x84\xa6\u04 44\xaasc\x85\x13\u033c2n\x01\x02\x89F3\xbc6\xcb\xc2\xdc\x00\x00\u07d4\u0711\x1c\xf7\xdc]\u0 4016\Vg\x05(\xe93\x8eg\x03G\x86\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u0730;\xfal\x111#NV\xb7\ xea|Or\x14\x87Tkz\x89Hz\x9a0E9D\x00\x00\x00\x00\x00\x0736M\xf47X\xc7\u03d7O\xa6`HO\xbbq\x8 f\x8cq\xc1\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\xdc\xc5-

 $\label{thm:linear} E\xec>\x16P\x8b`?\xd96\xe7\xfd}\xe5\xf3j\x89\x01\x11du\x9f\xfb2\x00\x00\u07d4\xdc\xd1\fU\xbb\x85\u0D4\xf1!\x9c,\x9a\x98\xac\xe7\x9f\x03\x89\xd8\xd8\X?\xa2\xd5/\x00\x00\u07d4\xdc\u057c\xa2\x00S\x95\xb6u\xfd\xe5\x03\Y\xb2k\xfe\xfcl\xee\x89\n\xad\xec\x98?\xcf\xf4\x00\x00\u07d4\xdc\u06fdN&\x04\xe4\x0e\x17\x10\xccg0(\x9d\xcc\xfa\u04c9-$

 $\label{thm:cond} $$ \x89\xf9]\xd2\xec'\xcc\xe0\x00\x00\u07d4\xdc\xe3\f1\xf3\xcafr\x1e\xcb!<\x80\x9a\xabV\x1d\x9bR\xe4\x89]\x8b\xbd@\x00\x00\u07d4\xdc\xf39eS\x13\x80\x161h\xfc\x11\xf6~\x89\xc6\xf1\xbc\xe17\x8a\x89\x12'v\x854\x06\xb0\x80\x00\u07d4\xdc\xf6\xb6W\&n\x91\xa4\xda\xe6\x03=\xda\xc1S2\xo074d+4\x89_h\xe8\x13\x1e\u03c0\x00\x00\x00\x00\x00\x00\xo0\xo0\xo0\xe9\xe8\poFum\xb4\x89\x1d\xb9\xb6\xo11\xd2F\x9cP\x8965\u026d\xc5\u07a0\x00\x00\x00\xe0\x94\xdc\xff\xf3\xe8\xd2<*4\xb5k\u0473\xbdE\u01d3tC\y9\x8a\x01\x0f\fxf0d\xddY$

\x00\x00\u07d4\xdd\x04\xee\xe7N\v\xf3\f?\x8dI,\u007fR\xe0Q\x92\x10\u07d3\x89\x04V9\x18\$O@\x00\x00\x90\x94\xdd&\xb4)\xfdC\xd8N\xc1y\x82S\$\xba\u057f\xb9\x16\xb3`\x8a\x01\x16\xbf\x95\xbc\x842\x98\x00\x00\x00\u07d4\xdd*#:\xde\xdef\xfe\x11&\xd6\xc1h#\xb6*\x02\x1f\xed\u06c9lk\x93[\x8b\xbd@\x00\x00\u07d4\xdd+\u07e9\x17\xc1\xf3\x10\xe6\xfa5\xaa\x8a\xf1i9\xc23\xcd}\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xdd5\xcf\xdb\u02d93\x95Sz\xec\xc9\xf5\x90\x85\xa8\xd5\u0776\xf5\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xddG\x18\x9a>d9qg\xf0b\x0eHEe\xb7b\xbf\xbb\xf4\x89dl\xe8NG\xa8\xa8\x00\x00\u07d4\xddM\xd6\xd3`3\xb0co\u030d\t8`\x9fM\xd6OJ\x86\x89\x03@\xaa\xd2\x1b;p\x00\x00\u07d4\xddO_\xa2\x11\x1d\xb6\x8fk\xde5\x89\xb60)9[i\xa9-

 $\label{thm:linear} $$ \x00\x00\u07d4\u075bHZ;\x1c\xd3:j\x9cb\xf1\xe5\xbe\xe9'\x01\x85m\%\x89\f3\x83\xe6\x03\x1b~\x80\x00\xe0\x94\u0763q\xe6\x00\xd3\x06\x88\xd4q\x0e\b\x8e\x02\xfd\xf2\xb9RM_\x88\x01\w''J\x88D\xc7\x00\x00\u07d4\u0764\xed^X\x88\xdd$

(\xd9.\x9f:\xa8\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\u077e\xe6\xf0\x94\xea\xe64

 $\label{thm:condition} $$ \xd0]2F\xd6\x1f\x06\xe0\x83\x89\x01s\x17\x90SM\xf2\x00\x00\x00\x94\xdd\xe7zG@\xba\b\xe7\xf7 ?\xbe:\x16t\x91)1t.\xeb\x8a\x044\xfeMC\x82\xf1\u0500\x00\u07d4\xdd\xe8\xf0\xc3\x1bt\x15Q\x1d\xce\xd1\xcd\F2>K\xd1\"2\x89WG=\x05\u06ba\xe8\x00\x00\u07d4\xdd\xe9i\xae\xf3N\xa8z\u0099\xb7\xe0+J\x01U\u030a\x89\x102\xf2YJ\x01s\x80\x00\u07d4\xdd\xf0\xcc\xe1\xfe\x99m\x91v5\xf0\a\xb2\xf2\xf4\x05$$

9eZ\xb3\x13!M/\x01\u072b\u0389@\xb8\x1b\x1cv\x89\n\xad\xec\x98?\xcf\xf4\x00\x00\u07d4\xde3 \xd7\b\xa3\xb8\x9e\x90\x9e\xafe;0\xfd\u00e5\xd5\u0334\xb3\x89\t\x9c\x88\"\x9f\xd4\xc2\x00\x00\u07d4\xde7B\x99\xc1\xd0}\ySs\x85\x19\x0fD.\xf9\xca\$\x06\x1f\x89\a?u\u0460\x85\xba\x00\x00\u07d4\xdeB\xfc\xd2L\xe4#\x93\x830CgY_\x06\x8f\fa\a@\x89\x02r*p\xf1\xa9\xa0\x00\x00\u07d4\xdeP\x86\x8e\xb7\xe3\xc7\x197\xecs\xfa\x89\u074b\x9e\xe1\rE\xaa\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xdeU\xde\x04X\xf8P\xb3~Mx\xa6A\xdd.\xb2\u074f8\u0389\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xde[\x00_\xe8\u06ae\x8d\x1f\x05\xde>\xda\x04

f\xc6\xc4i\x1c\x89;\xa1\x91\v\xf3A\xb0\x00\u07d4\xdea-

 $\as \xe8N\xa4\xa7\xfe\xaa=!B\xbd^\xe8-$

2\x01\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\xe0\x94\xdem61\x06\xccb8\xd2\xf0\x92\xf0\xf07!6\xd1\ xcdP\u018a\x01!\xeah\xc1\x14\xe5\x10\x00\x00\u07d4\xde}\xee\"\x0f\x04\W\xa7\x18}\V\xc1\xc4\x1f .\xb0\n\xc5`!\x89\"%\xf3\x9c\x85\x05*\x00\x00\u07d4\u0782\u030dJ\x1b\xb1\xd9CC\x92\x96[>\x80\ xba\xd3\xc0=O\x89P\x18nu\u0797\xa6\x00\x00\u07d4\u0797\xf43\a\x00\xb4\x8e\mc|\x91\xca\x1 d\xe9\u0130\x1b\xa4\x89\x9d\xcc\x05\x15\xb5n\f\x00\x00\u07d4\u0797\xf43\a\x00\xb4\u079e\xffLy\x88\x11\xd9h\xdc\xc bF\r\x9b\x06\x9c\xf3\x02x\xe0\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\u07b1\xbc4\xd8mJM\xd e%\x80\u063e\xaf\aN\xb0\xe1\xa2D\x89U\xa6\xe7\x9c\xcd\x1d0\x00\u07d4\u07b9\rTGL\r/Zyp\xdc\xdb/R\ xfb\x10\x98\xb8\x96\x965\u026d\xc5\u07a0\x00\x00\u07d4\u07b9\xa4\x9aC\x870 \xf0u\x91\x85\xe2\v\xbbL\U000c1ecf\x89\vx\xed\xb0\xbf.^\x00\x00\u07d4\u07b9\u07d4\u07bb\u0743\x1e\x0f \xaen7\x82R\xde\xcd\xf9/|\xf0\xc6X\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xde\xc3\xee\xc2d\nu,Fn+~\u616f\xe9\xacA\xf4\x89G\u0257SYk(\x80\x00\u07d4\xde\xc8#s\xad\xe8\xeb\xcf*\xcbo\x8b\xc2 AM\u05eb\xb7\rw\x89\n\u05ce\xbcZ\xc6

 $\label{thm:linear_label} $$ \x 16\x 9\x 141y\x d8i\x 11\x 02\x 00\x 00\u 07d4\x de\x e9B\x d5\x ca\x f5\x fa\x c1\x 14!\x d8k\x 01\v E\x 8e\) \x 90\x 08\x d8\x d7\x 17z\x 80\x 00\x 00\u 07d4\x de\x ee\&\x 89\x fa\x 90\x 06\x b5\x 9c\x f2\x 85\#\x e5\x 140\x 07f\x d0\x 148\x 89\x 18ey\x f2\x 9e$

 $%\x00\x00\u07d4\xde\xfd\xdf\u055b\x8d,\x15N\xec\xf5\xc7\xc1g\xbf\v\xa2\x90] > \x89\x05\x12\xcb^{8}GB\x00\x00\u07d4\xde\xfe\x91A\xf4pE\x99\x15\x9d{"=}\xe4+\xff\xd8\x04\x96\xb3\x89\x05k\xc7^-c\x10\x00\x00\u07d4\xdf\t\x8f^N=\xff\xa5\x1a\xf27\xbd\xa8e,Os\ud726\x89\x1b6\xa6DJ>\x18\x00\x00\x00\x94\xdf\r\ba{\x02\x10\x00\x00\x96\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xdf\x0f\xf1\xf3\xd2z\x8e\xc9\xfb\x8fk\f\xb2T\xa6;\xba\x82\xa5\x89\xec\xc5\xb2\xb2\x00\x00\x00\u07d4\xdf\x1f\xa2\xe2\x0e1\x98^\xbe,\x0f\f\x93\xb5L\x0f\xb6z&K\x89\n\u05ce\xbcZ\xc6$

 $\x 89 \x 95 \u 0754 \x 9e \x 6a \x 00 \x$

 $\label{thm:condition} $$\x9e^x89\x01\x15G8\$4N\x00\x00\u07d4\xe0\x01\xab\xa7\x02\xe1r\bl\x19P\xff\xfb\u02a3\t\x83H\x8f\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xe0\x04\x84x\x8d\xb5\x0f\u01a4\x8e7\x9d\x12>P\x8b\x0f\xb1\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xe0\x06\x04b\xc4\u007f\xf9g\x9b\xae\xf0qY\xca\xe0\x8c)\xf2t\xa9\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe0\r\x15;\x106\x91C\xf9\u007fT\xb8\xd4\xca\"\x9e\xb3\x8e\xf3\x89\xb=\xl2\xabc\x00\x00\u07d4\xe0\x12\xdbE8'\xa5\x8e\x16\xc16\V\b\xd3n\xd6\xrx05\xaf\x89\x89\x8b\xbd@\x00\x00\u07d4\xe0\x15G\xbaB\xfc\xaf\xaf\x89\x89\x8b\xec\xf7i\x9ft\xb2\xe1\x05bO\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xe0\x18Y\xf2B\xf1\xa0\xec\xa8\xa3\xb0\xb5v@\xec\x89\x1e\x16\x17\{\xe5\xcc\x00\x00\x00\xe0\x94\xe0}$

 $\label{thm:linear} $$ \xe8cb\xb4\x87u(6\xa6\xde\v\xc0,\xd8\u061a\x8bj\x8a\x01EB\xba\x12\xa37\xc0\x00\u07d4\xe00)$$ $$ 0\#\xf0\x9b(\x87a,|\x9c\xf1\x98\x8e::\x94\u0249|k\x93[\x8b\xbd@\x00\x00\u07d4\xe0'\"\x13\xe8\xd2\xfd>\x96\xbdb\x17\xb2KK\xa0\x1bapy\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xe0+t\xa4v($

 $\label{thm:color$

J\xe1al\\a(\u06c9\x0e\x81\xc7\u007f)\xa3\\x00\x00\u07d4\xe0O\xf5\xe5\xa7\u2bd9]\x88W\xce\x02\ x90\xb5:+\x0e\xda]\x8965\u026d\xc5\u07a0\x00\x00\xe0\x94\xe0P)\xac\xeb\axg[\xef\x17A\xab,\u0 493\x1e\xf7\xc8K\x8a\x01\x0f\r\xba\xe6\x10\tR\x80\x00\u07d4\xe0V\xbf?\xf4\x1c&%o\xefQqf\x12\ xb9\u04da\u0799\x9c\x89\x05k\xe7W\xa1.\n\x80\x00\u07d4\xe0a\xa4\xf2\xfcw\xb2\x96\u045a\xda #\x8eI\xa5\u02ce\xcb\xfap\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xe0f>\x8c\xd6q\x92\xa6A\xf 5nP\x03f\x01G\x88\x0f\x01\x8e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe0f\x8f\xa8,\x14\xd6\xe8\xd 9:S\x11>\xf2\x86\\xa8\x15\x81\xbc\x89//9\xfcIT\x00\x00\x00\u07d4\xe0i\xc0\x173R\xb1\v\xf6\x83G \x19\xdb[\xed\x01\xad\xf9{\xbc\x89\x01\x064\xf8\xe52;\x00\x00\u07d4\xe0I)\xa8\x15\x17\xe0\u050 7\xb6\u007f\xb0\xb6\xaa\xbcOW6\x83\x88\x89\x15\xbeat\xe1\x91.\x00\x00\u07d4\xe0I\xb6)G\x04\ xee\xa7C|/\xc3\xd3\as\xb7\xbf8\x88\x9a\x89\x01\x16\xdc:\x89\x94\xb3\x00\x00\u07d4\xe0q7\xae\r $\x11m\x0353\xc4\uad16\xf8\xa9\xfb\tV\x9c\x89K\xe4\xe7\&{j}\xe0\x00\x00\xe0\x94\xe0\xdb0\xabH$ oy\x19N\xbb\xc4]\x8f\xab\x9a\x92B\xf6T\x8a\x01\x06`~4\x94\xba\xa0\x00\x00\u07d4\xe0~\xbb\xc 7\xf4\xdaAnB\xc8\xd4\xf8B\xab\xa1b3\xc1%\x80\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xe0\x81\xca \x1fH\x82\xdb`C\u0569\x19\a\x03\xfd\xe0\xab;\xf5m\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\x e0\x83\xd3Hc\xe0\xe1\u007f\x92ky(\xed\xff1~\x99\x8e\x9cK\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\ u07d4\xe0\x8b\x9a\xbak\xd9\u048b\xc2\x05gy\xd2\xfb\xf0\xf2\x85Z=\x9d\x89lk\x93[\x8b\xbd@\x0 0\x00\u07d4\xe0\x8b\u009c+H\xb1i\xff+\xdc\x16qLXnl\xb8\\\u03c9\x01\x15\x8eF\t\x13\xd0\x00\x0 0\u07d4\xe0\x8c\11\x06\xe3\xf93O\xe6\xf7\xe7bM!\x110\xc0w\x89\x02+\x1c\x8c\x12'\xa0\x00\x00 \u07d4\xe0\x9ch\xe6\x19\x98\xd9\xc8\x1b\x14\xe4\xee\x80+\xa7\xad\xf6\xd7L\u06c9\xd8\xd7&\xb 7\x17z\x80\x00\x00\u07d4\xe0\x9f\xeauZ\xee\x1aD\xc0\xa8\x9f\x03\xb5\u07b7b\xba3\x00o\x89;\x 8a\x01EB\xba\x12\xa37\xc0\x00\x00\xe0\x94\xe0\xaai6UU\xb7?(#3\xd1\xe3\f\x1b\xbd\a(T\xe8\x8a \x01{x\x83\xc0i\x16`\x00\x00\u07d4\xe0\xba\u064e\ue598\xdb\xf6\xd7`\x85\xb7\x92=\xe5uN\x90m \x89\t\r\x97/22<\x00\x00\u07d4\xe0\u012b\x90r\xb4\xe6\xe3eJI\xf8\xa8\xdb\x02jK3\x86\xa9\x89Ik\ x93[\x8b\xbd@\x00\x00\u07d4\xe0\u0380\xa4a\xb6H\xa5\x01\xfd\v\x82F\x90\u0206\x8b\x0eM\xe 8\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xe0\xcfi\x8a\x053'\xeb\xd1k\y\x00\t/\xe2\xe8T\$F\ x89\x05*4\u02f6\x1fW\x80\x00\xe0\x94\xe0\xd21\xe1D\xec\x91\a8||\x9b\x02\xf1p,\xea\xa4\xf7\x00 $\x8a\x01\x0f\r\xba\xe6\x10\tR\x80\x00\u07d4\xe0\xd7\kqf\xb1\xf3\xa1+@\x91\xee+)\u078c\xaa}\a\u$ 06c9lk\x93[\x8b\xbd@\x00\x00\u07d4\xe0\xe0\xb2\xe2\x9d\xdes\xafu\x98~\xe4Dl\x82\x9a\x18\x9c 89\xae\xfeE\x1b\x8a\x02\r\u058a\xaf2\x89\x10\x00\x00\u07d4\xe0\xf3r4|\x96\xb5_}C\x06\x03K\xe b\x83&o\xd9\tf\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xe0\xf9\x03\xc1\xe4\x8a\xc4!\xabHR\x8 f=J&H\b\x0f\xe0C\x897\b\xba\xed=h\x90\x00\x00\u07d4\xe0\xff\v\xd9\x15D9\u0125\xb7#>)\x1d}\x 86\x8a\xf5?3\x89\x15y!jQ\xbb\xfb\x00\x00\xe0\x94\xe1\n\xc1\x9cTo\xc2T|a\xc19\xf5\xd1\xf4Zff\u0 570\x8a\x01\x02\xdao\xd0\xf7:<\x00\x00\xe0\x94\xe1\fT\x00\x88\x11?\xa6\xec\x00\xb4\xb2\u0202

 $O\x87\x96\xe9n\u010a2\x0fE\t\xab\x1e\xc7\xc0\x00\x00\xe0\x94\xe1\x17:\$})\xd8\#\x8d\xf0\x92/M\xf2\xo5\xf2\xaf\wu00ca\bx\xc9]V\x0f0G\x80\x00\xe0\x94\xe1 > \xb3\xa7\#\xe9\x9c\"$

 $\label{thm:linear} $$ \x00\x00\u07d4\xe1\xe1\xe5\xe6^*\xcA\xd4\xe2\xdc2\x8d\u1089i^\timesxe8\x89p\x81\xd0\x00\x00\xe0\x94\xe1T\xda\xea\xdbTX8\xcb\u01aa\fUu\x19\x02\xf5(h^*\x8a\x01\n\xfc\x1a\xde;N\xd4\x00\x00\u07d4\xe1\xe3\Ya\xcdt\xbdY\r\x04\u012dJ\x19\x89\xe0\V\x91\u0189\a\xea(2uw\b\x00\x00\u07d4\xe1\xe3\xf8\f\xd1\xf8\u03459\xdc\&\b$

 $\x04\x1dpZ, \x00\x00\x94\xe1\x92H\x9b\x85\xa9\x82\xc1\x882F\xd9\x15\xb2)\xcb\x13\x007f8\x8a\x01\x0f\f\xf0d\xddY$

\x1a\x14\xca\xc4\xe1\x19\x89\x05kU\xaeX\xca@\x00\x00\u07d4\u1cac\xa1T\xb8\xe0vIN\xba0\xbc \x10\xc7\xf3P6\xf3h\x89\x01\x15G8\$4N\x00\x00\u07d4\u1cdb\x88\u0650\r\xbcJI\xdcH\x1e\x10`\b\n\x8a\xec<\x89Ik\x93[\x8b\xbd@\x00\x00\x00\xe0\x94\xe1\xb62\x01\xfa\xe1\xf1)\xf9\\z\x11k\xd9\xdd\x e5\x15\x9cI\u068a\x04\xd6\x05s\xa2\xf0\xc9\xef\x00\x00\u07d4\u1feaZE\xc5\x04B\x89#\u0126\x11\x92\xa5[\x14\x00\xb4]\x89\x90\xf54`\x8ar\x88\x00\x00\u07d4\xe1\xc6\a\xc0\xa8\xa0`\u068f\x02\xa8\xeb8\xa0\x13\xea\x8c\xda[\x8c\x89+\xa3\x9e\x82\xed]f\x00\x00\x00\x00\x00\x00\x00\x00\u07d4\xe1\u02c3\xec^\xb6\x f1\xee\xb8^\x99\xb2\xfcc\x81\\u0795q\x84\x8a\x04<3\xc1\x93ud\x80\x00\x00\u07d4\xe1\u07f5\u0309\x0e\u8c87~\x88]&|\%a\x87\xd0\x19\xe6\x89\x05k\xc7^-

 $c\x10\x00\x00\u07d4\xe1\xe8\xc5\v\x80\xa3R\xb2@\xcesB\xbb\xfd\xf5i\f\xc8\xcb\x14\x89\x15[\xd90\u007f\x9f\xe8\x00\x00\u07d4\xe1\xf6>\xbb\xc6,{tD\x04\x0e\xb9\x96\#\x96O\vg\xb3v\x89\x01\x15} $$ x8eF\t\x13\xd0\x00\u07d4\xe2\x06\xfbs\xe9\u07b7\x9e\x19\x904\x96\u0596\x1b\x9b\xe5f\x03\x89\x05k\xc7^-c\x10\x00\x00\u07d4\xe2\aW\x8e\x1fM\u06cf\xf6\u0546{9X-}$

q\xb9\x81*\u0149\xd2U\xd1\x12\xe1\x03\xa0\x00\x00\u07d4\xe2\b\x81*h@\x98\xf3\xdaN\xfej\xba %b\V\xad\xfe?\xe6\x89lk\x93[\x8b\xbd@\x00\x00\x00\x00\x94\xe2\tT\xd0\xf4\x10\x8c\x82\xd4\u0732\x 14\x8d&\xbb\xd9\$\xf6\xdd\$\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xe2\v\xb9\xf3\x96d\ x19\xe1K\xbb\xaa\xaag\x89\xe9\$\x96\u03e4y\x89\xbb\xd8%\x03\aRv\x00\x00\u07d4\xe2\r\x1b\xc bq(m\xc7\x12\x8a\x9f\xc7\xc6\xed\u007fs8\x92\xee\xf5\x896d\xf8\xe7\xc2J\xf4\x00\x00\u0794\xe2\x19\x12\x15\x98?3\xfd3\xe2,\u0522I\x00T\xdaS\xfd\u0708\xdbD\xe0I\xbb,\x00\x00\u07d4\xe2\x19\x8c\x8c\xa1\xb3\x99\xf7R\x15a\xfdS\x84\xa7\x13\xbaHk\x897\b\xba\xed=h\x90\x00\x00\x00\x00\x9

 $4\xe2\x1cw\x8e\xf2\xa0\xd7\xf7Q\xea\x8c\aM\x1f\x81\"C\x86>N\x8a\x01\x1f\xc7\x0e,\x8c\x8a\xe1\x80\x00\xe0\x94\xe2)\xe7F\xa8?,\xe2S\xb0\xb0>\xb1G\x11\xb5~W\x00\x8a\x016\x9f\xb9a(\xacH\x00\x00\u07d4\xe2+$

\x00\x00\u07d4\xe3\bCR\x04y7d\xf5\xfc\xbee\xebQ\x0fZtJeZ\x89\n\u05ce\xbcZ\xc6
\x00\x00\u07d4\xe3\t\x97L\xe3\x9d`\xaa\xdf.ig2Q\xbf\x0e\x04v\n\x10\x89\r\xc5_\xdb\x17d{\x00\x0
0\u07d4\xe3\x1bN\xef\x18L\$\xab\t\x8e6\xc8\x02qK\xd4t=\xd0\u0509\n\u05ce\xbcZ\xc6
\x00\x00\u07d4\xe3!\xbbJ\x94j\xda\xfd\xad\xe4W\x1f\xb1\\\x00C\u04de\xe3_\x89Udu8+L\x9e\x00\x00\u07d4\xe3\x\ext{xe8\xafm\xb3\xe4gXE\x02\xedq\t\x12^\xae\"\xa5\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\xe3+\x1cG%\xa1\x87TI\u93d7\x0e\xb3\xe5@b\xd1X\x00\x89\n\u05ce\xbcZ\xc6
\x00\x00\u07d4\xe3\x95vmW\xb5\xcdK\x172\x89\u0587o\x9edU\x81\x94\x89\x05k\xc7^-c\x10\x00\x00\u07d4\xe38@\u063c\xa7\u0698\xa6\xf3\u0416\xd8=\xe7\x8bp\xb7\x1e\xf8\x89lk\x9
3[\x8b\xbd@\x00\x00\u07d4\xe38\xe8Y\xfe.\x8c\x15UHH\xb7\\\xae\u0368w\xa0\xe82\x89a\xac\xff

\x81\xa7\x8a\xd4\x00\x00\u07d4\xe3=\x98\x02

 $\label{thm:convention} $$ \left(\frac{x_0e}{x_0e}\right) x_0e^{x_0}$

@\u04af\xce.\x91\a\xc6py\xacz&`\bl\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xe3TS\xee\xf2\xcc<\z\x04M\n\xc14\xbaaY\b\xfa\x82\xee\x89\a\xff\x1c\xcbua\xdf\x00\x00\u07d4\xe3j\x8e\xa8\u007f\x1e\x99\xe8\xa2\xdc\x1b&\b\xd1ff\x9d\xfa\x01\x89\x05k\xc7^-

\xfb\x87\xf3\x97\xdf\u0189\a\xc0\x86\x0eZ\x80\xdc\x00\x00\u07d4\xe3\x92U\t\xc8\u0432\xa6s\x8c _jr\xf3S\x14I\x12H\u03896\xe9\xa8f\x9aDv\x80\x00\xe0\x94\xe3\x93=a\xb7}\xcd\xc7\x16@\u007f\ x82P\xbc\x91\xe4\xff\xae\xb0\x9d\x8a\x12V\x98I\x95\x89\x1c

#\xd5\xf8I\xe6\xf9-

\x9cW\x95\xc4:\x8a\x89\x90\xf54`\x8ar\x88\x00\x00\u07d4\xe4\x06\xf5\xddr\u02b6m\x8an\xcb\u0

5bf\xb4\x94\xa7\xb6\xb0\x9a\xfe\x89\x05k\xc7^-

\xe2@\xf7OE\x91\xf1\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe4\x82\xd2U\xed\xe5k\x04\xc3\xe8\xd f\x15\x1fV\xe9\xcab\xaa\xa8\u0089\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xe4\x8ee\x12T!\x88\ rB\xbd\xf1\x01\x8a\xb9w\x8d\x96\x92\x8f?\x89\u3bb5sr@\xa0\x00\u07d4\u4481\x8a\xa6\x84\ xe5\xa6vV\x1br]B\xf3\xccV\xaeQ\x98\x89+^:\xf1k\x18\x80\x00\x00\u07d4\xe4\x996\xa9*\x8c\xcfq\ x0e\xaa\xc3B\xbcEK\x9b\x14\xeb\ucc49lk\x93[\x8b\xbd@\x00\x00\u07d4\xe4\x9a\xf4\xf3J\u06a23 \v\x0eI\xdct\xec\x18\xab/\x92\xf8'\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\u46e0\u0356\x81IF\aw<\xf 8\xa5\x97\v\xb5\xbc\x16\xa1\xe6\x89Z\x87\xe7\xd7\xf5\xf6X\x00\x00\u07d4\xe4\xa4~93\$I?\xd6)y\ xa1\xea\x19\xff\u07ccr\xef7\x89\b\t\xb3\x83\xea}~\x80\x00\u07d4\u4dae\"\xc7s [\x89\xf3M\xd7z\u 0417_\n\u0311\x81\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xe4\xca\nR8VM\xfc\x91\xe8\xbf\"\xba\ xde)\x01a\x9a\x1c\u050965\u026d\xc5\u07a0\x00\x00\u07d4\xe4\xca\xfbr\u007f\xb5\u01b7\v\xb2 u3\xb8\xa9\xcc\xc9\xefh\x88\xe1\x89\x10I{\xf4\xafL\xaf\x80\x00\u07d4\xe4\xdc\"\xedY[\xf0\xa37\x c0\x1e\x03\xcck\xe7D%_\xc9\xe8\x89\nZ\xa8P\t\xe3\x9c\x00\x00\u07d4\xe4\xfb&\xd1\xca\x1e\xec \xba=\x82\x98\xd9\xd1H\x11\x9a\u00bb\xf5\x80\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xe4\xf c\x13\xcf\u02ec\x1b\x17\xcew\x83\xac\xd4#\xa8E\x94?k:\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07 d4\xe5\vFJ\xc9\xde5\xa5a\x8b|\xbf%Ft\x18+\x81\xb9~\x89\xdeB\xee\x15D\u0750\x00\x00\u07d4\ xe5\x10,;q\x1b\x81\x03D\x19t\x19\xb1\u034apY\xf1>2\x89\x10CR\x8d\t\x84i\x80\x00\xe0\x94\xe5\ x10\xd6y\u007f\xba=f\x93\x83Z\x84N\xa2\xadT\x06\x91\x97\x1b\x8a\x03\xae9\xd4s\x83\xe8t\x00\ x00\u07d4\xe5\x14!\xf8\xee\"\x10\xc7\x1e\xd8p\xfea\x82v\u0215J\xfb\xe9\x89Hz\x9a0E9D\x00\x0 0\u07d4\xe5\x1e\xb8~\u007f\xb71\x1fR(\xc4y\xb4\x8e\u0247\x881\xacL\x89lk\x93[\x8b\xbd@\x00\ x00\u07d4\xe5!V1\xb1BH\xd4Z%R\x96\xbe\xd1\xfb\xfa\x030\xff5\x89G\x03\xe6\xebR\x91\xb8\x00 $\x00\xe0\x94\xe5(\xa0\xe5\xa2g\xd6g\xe99:e\x84\xe1\x9b4\u071b\xe9s\x8a\x01/x93\x9c\x99\xed\xe0$ xab\x80\x00\x00\u07d4\xe54%\xd8\xdf\x1f\x11\xc3A\xffX\xae_\x148\xab\xf1\xcaS\u03c9\x11t\xa5\ xcd\xf8\x8b\xc8\x00\x00\u07d4\xe5<hyb\x12\x03>No\x9c\xffV\xe1\x9cF\x1e\xb4T\xf9\x8965\u026 d\xc5\u07a0\x00\x00\u07d4\xe5A\x02SM\xe8\xf2>\xff\xb0\x93\xb3\x12B\xad;#?\xac\xfd\x89\xd8\x d7&\xb7\x17z\x80\x00\x00\u07d4\xe5E\xee\x84\xeaH\xe5d\x16\x1e\x94\x82\u055b\xcf@i`.\xa2\x8 9dl\xe8NG\xa8\xa8\x00\x00\u07d4\xe5H\x1a\u007f\xedB\xb9\x01\xbb\xed

x\x9b\u052d\xe5\r_\x83\xb9\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe5Y\xb5\xfd3{\x9cUr\xa9\xbf\x9

e\x0f%!\xf7\xd4F\xdb\xe4\x89\n\u05ce\xbcZ\xc6

 $\label{thm:linear} $$ \x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe5\xaa\v\x83;\xb9\x16\xdc\x19\xa8\xddh?\x0e\xde$\x1d\x98\x8e\x89\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\u5def\x14i\x86\xc0\xff\x8f\x85\xd2.I\xc34\a}\x84\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe5\xb8\&\x19l\x0e\x1b\xc1\x11\x9b\x02\x1c\xf6\xd2Y\xa6\x10\u0256p\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:convolu07d4} with the convolunt of the convolution of the$

xaf | xaf

 $\label{thm:colx6} $$ \x00\x00\xe0\x94\xe6\x9a\xe1\xf3\flx8b\x84\xcds\xba\xe0+\xc0\xf8\x8a\xo3\x94\xfd\xc2\xe4R\xf6q\x80\x00\u07d4\xe6\x9d\x1c7\x8bw\x1e\x0f\xef\xf0Q\xdbi\xd9f\xacgy\xf4\xed\x89\x1d\xfg\xaa\x14\x97\x04\x00\x00\u07d4\xe6\x9f\xcc&\xed\"_{.7\x984\xc5}\xd7\flx175\u5f09lk\x93[\x8b\xbd@\x00\x00\u07d4\xe6\x30\x01\xbc\x94\xffg\xa2\xf6\x99\xdf\xc2\x06\xf9\xe7gB\x89\xa7\xcb\xf6dd\x98\x00\x00\u07d4\xe6\xa6\xf6\xddop\xa4V\xf4\xec\x15\xefz\xd5\xe5\u06f6\x8b\xd7\u0709\n\u05ce\xbcZ\xc6$

 $\label{thm:linear} $$ \xb0\x00\u07d4\xe7\\x1f\xb1w\b\x9f>X\xb1\x06y5\xa6Yn\xf1s\u007f\xb5\x89\x05j\x87\x9f\xa7 uG\x00\x00\u07d4\xe7\;8\xa5\x8a?3\xd5V\x90\xa5\xa5\x97f\xbe\x18^\x02\x84\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xe7a\xd2\u007f\xa3P,\xc7k\xb1\xa6\bt\x0e\x14\x03\u03dd\xfci\x89\x0f u03dd\xfci\x89\x0f u03dd\xfci\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x0f\x89\x89\x0f\x8$

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@\x12\x02\xbb\x9b\xd18`\x91\r\xd6\u009a\xc0\xb6\x89C8t\xf62\xcc`\x00\x00\u07d4\xe7\x84\xdc\x c8s\xaa\x8c\x15\x13\xec&\xff6\xbc\x92\xea\xc6\xd4\xc9h\x89\n\u05ce\xbcZ\xc6 \x00\x00\u07d4\xe7\x91-

 $j \times a \times 0.01e9 \times 0.03 \times 9.00 \times 0.00 \times 0.00$

\xf4,^\u06f2\xed\xe6\xae\xc4=\xa4\xed\x9b\WW\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xe7\xda`\x 9d@\xcd\xe8\x0f\x00\xce[O\xfbj\xa9\u04304\x94\xfc\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xe7\x f0oi\x9b\xe3\x1cD\vC\xb4\xdb\x05\x01\xec\x0e%&\x16D\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xe7\xfd\xd7\xfeoV\x1f\u007f\xa1\xda0\x05\xfd6TQ\xad\x89\u07c9\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\xe7\xfd\x8f\xd9Y\xae\xd2v~\xa7\xfa\x96\f\xe1\xdbS\xaf\x80%s\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xe8\x0e\u007f\xef\x18\xa5\xdb\x15\xb0\x14s\xf3\xadkx\xb2\xa2\xf8\xac\u064\9\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xe8\x13\u007f\xc1\xb2\xec|\xc7\x10:\xf9!\x89\x9bJ9\xe1\xd9Y\xa1\x89P\xc5\xe7a\xa4D\b\x00\x00\u07d4\xe8\x1c-

4l\n\xdfL\xc5g\b\xf69K\xa6\xc8\u0226J\x1e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe8,X\xc5yC\x1b g5F\xb5:\x86E\x9a\xca\xf1\u079b\x93\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xe84\xc6C\x18 \\\xa7\xddJ!\xab\xcb\b&|\xb2\x1f\xf0,\x8965\xc6

\xc3Y\x9b9S\xfa|\xb1\xc9v\x1c\xc2F\x89a\x94\x04\x9f0\xf7

\xac\x9e\x85\xaf\xc1\f\xe7\vV\u0636\xba\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\xe9\n5L\xec\x04\u059e]\x96\xdd\xc0\xc5\x13\x8d=3\x15\n\xa0\x89\x1b\x1a}\u03c aD\u04c0\x00\xe0\x94\xe9\x13>}1\x84]_+f\xa2a\x87\x92\xe8i1\x1a\xcff\x8a\x05\x17\xc0\xcb\xf9\x a3\x90\x88\x00\x00\u07d4\xe9\x1d\xac\x01\x95\xb1\x9e7\xb5\x9bS\xf7\xc0\x17\xc0\xb29[\xa4L\x8 9e\xea=\xb7UF`\x00\x00\u07d4\xe9\x1f\xa0\xba\xda\u0779\xa9~\x88\xd3\xf4\xdb|U\u05bbt0\xfe\x 89\x14b\fW\xdd\xda\xe0\x00\x00\u07d4\xe9#\xc0aw\xb3B~\xa4H\xc0\xa6\xff\x01\x9bT\xccT\x8d\x 95\x89\x01\xf7\x80\x01Fg\xf2\x80\x00\xe0\x94\xe9=G\xa8\u0288]T\fNRo%\xd5\xc6\xf2\xc1\b\u01 38\x8a\x17\xda:\x04\u01f3\xe0\x00\x00\x00\u07d4\xe9E\x8fh\xbb',\xb5g:\x04\xf7\x81\xb4\x03Uo\u 04e3\x87\x89\x03N\x8b\x88\xce\xe2\xd4\x00\x00\x00\u07d4\xe9I[\xa5\x84'(\xc0\ud5fe7\xd0\xe4\"\xb9\x8di

 $\x0^{x0}/x0^{x1}dK\x8a\x04<3\xc1\x93ud\x80\x00\x00\u0794\xe9^\x92\xbb\xc6\xde\a\xbf:f\x0e\xbf_\xeb$

 $8\x13\xef\xd1\x16_\x12\xf6\x02\xf9\u007fJb\x90\x9d\xf\x89\|\xae\xe9v\x13\xe6p\x00\x00\u07d4\xe9\\\u007f\xde\vgqc\%\xcf\x0e\xcc\u8851\xa3v\x1b,y\x1d\x896w\x03n\xdf\n\xf6\x00\x00\u07d4\xe9\x82\\\xe6\xf2\x8cT\x8f_\x96\xf4\c\xf7\xabp\x87\xf5?\xa1\x89\x15z\xe8)\xa4\x1f;\x00\x00\u07d4\xe9\x86L\x1a\xfc\x8e\xaa\xd3\u007f;\xa5o\xcbtw\xccb$

\t\xb7\x89\x04HXap\xa7\xdc\x00\x00\u07d4\xe9\x87\xe6\x13\x9eaF\xa7\x17\xfe\xf9k\xc2I4\xa5D\u07f\xe0]\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xe9\x89s<\xa1\u054d\x9e{P}\xba]DHX\xbe\xc01r\x89\x1f\x87@\x83\x13\xdfO\x80\x00\u07d4\u9311\xca\u0752L\x92W\x9e\x11\xb4\x12\x17\xb2\x82\x95I\u06a1\x89\a\l\x9a\x84\x802\f\x00\x00\u07d4\u9311\xca\u0752L\x92W\x9e\x11\xb4\x12\x17\xb2\x82\x95I\u06a1\x89\a\l\x9a\x84\x802\f\x00\x00\u07d4\xe9\x9a\xec\xe9\x05A\xca\xe2\xb8}\xa6s\x96^\n\xeb)j\xfd\x891\u07d0\x95\xa1\x8f\x00\x00\u07d4\xe9\x9d\xe2X\xa4\x17<\xe9\xac8\xed\xe2I\v;\xea<\ts\u0549Y\u0438\x05\xe5\xbb0\x00\x00\u07d4\u98b4\x91N\x85S\xbf\r|\x00\xcaS#i\xb8\xb9\xf91\xbf\x89\x8b\xbd@\x00\x00\u07d4\u98da\x8b\xac\x0f\x01\xc3I\xc6L\xed\xb6\x98\x97\xf63#N\u0489\xd7\xc1\x98q\x0ef\xb0\x00\u007d4\u996e<\x9e\x05\x97\\xd1\x06\x9e\x9f\xd9\u04ee\xfb\xae\x04\xb8\u07c9j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xe9\xb1\xf1\xfc\xa3\xfaG\x9f!\xb0\x10\x9d@rc\axb2\xb1\xf1\xfc\xa3\xfaG\x9f!\xb0\xc3S\xb7\xf5\xe9m\x90Z\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\x00\x00\u07d4\u9da7\x90\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\x00\u07d4\u9da7\x90\x00\x00\u07d4\u9da7\x90\x00\x00\u07d4\u9da7\x90\x00\x00\u07d4\u9da7\x90\x00\x00\u07d4\u9da7\x90\x00\x00\u07d4\u9da7\x90\x00\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\x00\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u07d4\u9da7\x90\u

\x9e\x06X[N\xb5F\xc5\u007f\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xe9\u0559Ek%C\xe6\u06c0\xea \x9b!\x0e\x90\x80&\xe2\x14n\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\xeaN\x80\x9e&j\xe5\xf1<\xdb\u33dd\x04V\xe68m\x12t\x89\xf3\xf2\v\x8d\xfai\xd0\x 00\x00\xe0\x94\xeaS\xc9T\xf4\xed\x97\xfdH\x10\x11\x1b\u06b6\x9e\xf9\x81\xef%\xb9\x8a\x03\xa 9\u057a\xa4\xab\xf1\xd0\x00\x00\u07d4\xeaS\xd2ed\x85\x9d\x9e\x90\xbb\x0eS\xb7\xab\xf5`\xe0\ x16.8\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xea`Ci\x12\xdek\xf1\x87\u04e4r\xff\x8fS3\xa0\xf 7\xed\x06\x89\x01\x11du\x9f\xfb2\x00\x00\u07d4\xea`T\x9e\xc7U?Q\x1d!I\xf2\xd4fl\xbd\x92C\xd9 <\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xeaf\xe7\xb8M\u037f6\xee\xa3\xe7[\x858*u\xf1\xa1]\x96\x8 9]\xbc\x91\x91&o\x11\x80\x00\u07d4\xeahIPW\t<\x17\x1cf\u06d9\xe0\x1b\x0e\xce\xcb0\x86\x83\x 89\x14\u0768],\xe1G\x80\x00\u07d4\xeaj\xfe,\xc9(\xac\x83\x91\xeb\x1e\x16_\xc4\x00@\xe3t!\u72 62\u007f\xa0c\xb2\xe6\x80\x00\u07d4\xeay\x05}\xab\xef^d\xe7\xb4O\u007f\x18d\x8e~S7\x18\ u0489\n\u05ce\xbcZ\xc6 \x00\x00\u07d4\xea|Mm\xc7)\xcdk\x15|\x03\xad#|\xa1\x9a \x93F\u00c9lk\x93[\x8b\xbd@\x00\x00\u07d4\xea\x81h\xfb\xf2%\xe7\x86E\x9c\xa6\xbb\x18\xd9c\ xd2kPS\t\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xea\x81\u02868T\f\xd9\xd4\xd7=\x06\x0f,\ xeb\xf2\$\x1f\xfc>\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xea\x83\x17\x19yYB@A\xd9\xd7\xc6z>\x ce\x1d\xbbx\xbbU\x89\x15[\xd90\u007f\x9f\xe8\x00\x00\u07d4\xea\x85'\xfe\xbf\xa1\xad\xe2\x9e& A\x93)\u04d3\xb9@\xbb\xb7\u0709lj\xccq\u05f1\xd4\x00\x00\u07d4\xea\x8f0\xb6\xe4\xc5\xe6R\x 90\xfb\x98d%\x9b\u0159\x0f\xa8\ue289\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xea\x94\xf3(\b\xa2 \uf29b\xf0\x86\x1d\x1d\$\x04\xf7\xb7\xbe%\x8a\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xea\xa 4\\\xea\x02\xd8\,\xc8\xfd\xa9CN-

\x98[\xd4\x03\x15\x84\x89h\x1f\xc2\xccn+\x8b\x00\x00\xe0\x94\uac3d\x14\x83\t\x18l\xf8\xcb\xd1;r 2\xd8\tZ\u02c3:\x8a\x02C\x9a\x88\x1cjq|\x00\x00\u07d4\uaed0\xd3y\x89\xaa\xb3\x1f\xea\xe5G\xe 0\xe6\xf3\x99\x9c\xe6\xa3]\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\uaed0\xd3y\x89-\xff\fn?\xf2\x8a}]T\xf 6\\\xb7h\x9d\\x99\x89\x9a\xd9\u67ddGR\x00\x00\u07d4\xea\xc1H(&\xac\xb6\x11\x1e\x19\xd3@\x a4_\xb8QWk\xed`\x89\x01\xbe\x8b\xab\x04\u067e\x80\x00\x00\u07d4\xea\xc1{\x81\xedQ\x91\xfb\b\ x02\xaaT3s\x13\x83A\a\xaa\xa4\x8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\xea\u00fW\x84\x92\u007f\u9958\xfc\\xec8\xb8\x10/7\xbcX\x8965\u026d\xc5\u07a0\x00\x00\x00\x00\x04\xea\xc7h\xbf\x14\xb8\xf9C.i\xea\xa8*\x99\xfb\xeb\x94\xcd\f\x9c\x8a\x14\u06f2\x19\\\xa2(\x90\x00\x00\u07d4\xea\xd2\x2\x1c\x1d\xec\u03ff\x1e\xdd\x11@\x04\x06\xb2\x98\xfc\x89\xd2U\xd1\x12\xe1\x03\x a0\x00\x00\u07d4\xea\xd6Rb\xed]\x12-

\xf2\xb2u\x14\x10\xf9\x8c2\xd1#\x8fQ\x89\x05\x83\x17\xedF\xb9\xb8\x00\x00\u07d4\xea\xd7P\x16\u3801Pr\xb6\xb1\b\xbc\xc1\xb7\x99\xac\xf08>\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xea\xda#\xaa\x05r\x00\xe7\xc9\xc1^\x8f\xf1\x90\xd0\xe6l\f\x0e\x83\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xea\xea#\xaa\x05r\x00\xe7\xc9\xc1^\x8f\xf1\x90\xd0\xe6l\f\x0e\x83\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xea\xea\xea#\xaa\xda\xf5\u06ab[\xf0)^\a\a\u007fY\xfb\x82U\x90\v\x89\xd8\xd7&\xb7\x17z\x80\x00\u007d4\xea\xae\xea\xea\xde\xck\x8bib\xd5\xd9\(\x8c\x15\W\x9dG\xc0\xa9\xfc\xff\x89\x04\x9b\x9c\xa9\xa6\x94\x00\x00\x00\u07d4\xea\xf5#\x88Tn\xc3Z\xcaolc\x93\xd8\xd6\f\xde:K\xf3\x89\x01\x15\x8eF\f\x13\xd0\x00\x00\x00\u07d4\xeb\x10E\x8d\xac\xa7\x9eJk\$\xb2\x9a\x8a\x8a\xdaq\x1b\u007f.\xb6\x89\u063bel\xb0+\xb8\x00\x00\u07d4\xeb\x1c\xea{E\u047dM\x0e*\x00{\u04ff\xb3Tu\x9e,\x16\x89\n\xbb\xcdN\xf3\wX\x00\x00\u07d4\xeb\%H\x1f\u035c\"\x1f\x1a\xc7\xe5\xfd\x1e\u0353\a\xa1b\x15\xb8\x89\n\xad\xc2\u078a\f\x0f\$F\b\xa7\(\x80\x00\x00\x00\x00\x00\x00\xe0\x94\xeb;\xddY\xdc\u0765\xa9\xbb*\xc1d\x1f\xd0!\x80\xf5\xf3e`\x8a\x01e\xc9fG\xb3\x8a

 $\label{thm:convolu07d4} $$\x00\x00\u07d4\xeb<\xe7\xfc8\x1cQ\xdb}_\xbdi/\x8f\x9e\x05\x8aLp=\x89\n\u05ce\xbcZ\xc6 $$\x00\x00\u07d4\xebE?Z:\xdd\u074a\xb5gP\xfa\xdb\x0f\xe7\xf9M\x9c\x89\xe7\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xebO\x00\xe2\x836\xea\t\x94\%\x88\ueb12\x18\x11\xc5\"\x14<\x89lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\xebR\xab\x10U4\x922\x9c\x1cT\x83:\xe6\x10\xf3\x98\xa6[\x9d\x89\b=\l2\xabc\x00\x00\u07d4\xebW\r\xba\x97R'\xb1\xc4-n\x8d\xea,\Vu026d\x96\x06p\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xebc\x94\xa7\xbf\xa4\u0489\x1$

n\x8d\xea,V\u026d\x96\x06p\x89lk\x93\\x8b\xbd@\x00\x00\u07d4\xebc\x94\xa7\xbf\xa4\u0489\x1
1\u0565\xb2>\x93\xf3^4\f\"\x94\x89\x04:w\xaa\xbd\x00x\x00\x00\u07d4\xebh\x10i\x1d\x1a\xe0\u0
45eG\xbd\"\u03be\u0cfa'\xf8\x8a\x89\x87\x85c\x15\xd8x\x15\x00\x00\u07d4\xebvBL\x0f\u0557\xd
3\xe3A\xa9d*\xd1\xee\x11\x8b+W\x9d\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xeb|

 $+F+|u0145]t \times 4u_n \& (xa1)x15 \times 91 (x85)x \otimes (x00)x00 (u07d4)x \otimes (x83) (x1a)x91 (x18)x + F+|u0145]t \times 4u_n \& (x67)x \otimes (x85)x \otimes ($

 $\label{thm:condition} $$ \x94\x86\a\x00\x00\u07d4\xeb\xac+D\b\xefT1\xa1;\x85\b\xe8bP\x98!\x14\xe1E\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\xeb\xb6,\xf8\xe2,\x88K\x1b(\xc6\xfa\x88\xfb\xbc\x17\x93\x8a\xa7\x87\x89\x84\x03\u0278\x00\x00\u07d4\xeb\xb7\xd2\xe1\x1b\u01b5\x8f\n\x8dE\xc2\xf6\xde0\x10W\n\u0211\x89\x01s\x17\x90SM\xf2\x00\x00\u07d4\xeb\xbbO,=\x88\xbe>\xb6-$

 $\label{thm:linear_control_co$

c\x10\x00\x00\u07d4\xec\u0466(\x025\x1aAV\x8d#\x030\x04\xac\xc6\xc0\x05\xa5\u04c9\x02\xb5\ xe3\xaf\x16\xb1\x88\x00\x00\u07d4\xec\xd2v\xafd\u01dd\x1b\u0669+\x86\xb5\u835a\x95\xeb\x88\ xf8\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\xe0\x94\xec\u0506\xfc\x19g\x91\xb9,\xf6\x12\xd3HaO\x9 1VH\x8b~\x8a\x02\x8a\x85t%Fo\x80\x00\x00\x00\u07d4\xec\xda\xf92)\xb4^\xe6r\xf6]\xb5\x06\xfb^\xca \x00\xf7\xfc\xe6\x89W\x01\xf9m\xcc@\xee\x80\x00\u07d4\xec\xe1\x11g\vV<\u037e\xbc\xa5#\x84) \x0e\xcdh\xfe\\\x92\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xec\xe1\x15&\x82\xb7Y\x8f\xe2\xd 1\xe2\x1e\xc1U3\x88T5\xac\x85\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xec\xe1\x15\x\exxe1\)\bw\xb5\x83\ xe3a\xa2\xd4\x1b\x00\x93F\xe6'N\%8\x89\x10CV\x1a\x88)0\x00\x00\u07d4\xec\xf0]\a\xea\x02n~\x bfIA\x00#5\xba\xf2\xfe\xd0\xf0\x02\x89\n\u05ce\xbcZ\xc6

\x00\x00\u07d4\xec\xf2L\xdd|\"\x92\x8cD\x1eiM\xe4\xaa1\xb0\xfa\xb5\x97x\x89

 $\label{thm:label$

 $Q\xb34\xac\r\xe6\xe7q\xc7\xc0EF\x95\xea\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xed\x1f\x1e\x11Z\r'\xce\x02\xfb\%\xdf\x01M(\x9e:\f\xbe)\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xed10\1 \x9f\x92s\u04d3m\x8f[/q\u9c72)c\x89\x05k\xc7^-$

c\x10\x00\x00\u07d4\xed2z\x14\xd5\u03ed\u0641\x03\xfc\t\x99q\x8d~\xd7\x05(\xea\x89N\x10\x03\xb2\x8d\x92\x80\x00\x00\u07d4\xed<\xbc7\x82\u03bdg\x98\x9b0\\A3\xb2\xcd\xe3\"\x11\xeb\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xed@\x14S\x8c\xeefJ/\xbc\xb6\xdcf\x9fz\xb1m\v\xa5|\x89\n\

u05ce\xbcZ\xc6

\x00\x00\u07d4\xedA\u188f\\\xaa\x848\x80\xefN\x8b\b\xbdl3\x14\x1e\u07c9*\xd5\xdd\xfaz\x8d\x83\x00\x00\x00\x94\xedK\xe0J\x05-z\u0333\xdc\u03901\x9d\xba@

 $2\x11\x857\x85\xa0\x8b\xf8\xf3>\u049f\x89Hz\x9a0E9D\x00\x00\x00\x94\xedp\xa3|\xdd\x1c\xbd\xa9tm\x93\x96X\xae*a\x81(\x85x\x8a\x02\bj\xc3Q\x05\&\x00\x00\x00\u07d4\xedsFvn\x1agm\r\x06\xeq\x82\x18g\xa2v\xa0\x83\xbf1\x89\u064a\t1\xcc-$

 $\label{thm:condition} $$ \operatorname{thm:condition} $$$

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\xed\xf8\xa3\xe1\xd4\x0f\x13\xb7\x9e\xc8\xe3\xe1\xec\xf2b\xfd\x92\x11bc\x89\b\x90\x00\x00\x00\u07d4\xee\x05\u06d8\xf98\a\x14fMT\xb4\xee\x97\x1a\x1c\xae\e\x03\x89\x02+\xb8\xdd\xd6\y\xbe\x00\x00\u07d4\xee\x00\a\xb0\x96\x700\x90\x8a\x94C^*suW\x87j\xac\1\x89\x02\xe0B\x1ei\xc4\u0300\x00\u07d4\xee\x04\x9a\xf0\x05\x97M\xd1\u01f3\xa9\u028d\x9a\xa7\u0\xb8\xa2\xb9\xa2\xb$

c\x10\x00\x00\xe0\x94\xeeX\xfb=\xb2\x90p\xd0\x13\x01\x88\xceG+\xe0\xa1r\xb8\x90U\x8a\x02\x1

 $fB\xdc\xdcX\xe3\x9c\x00\x00\u07d4\xeee[\xb4\xee\x0e\x8dTxRo\xb9\xf1^@d\xe0\x9f\xf3\u0749\n\u05ce\xbcZ\xc6$

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\xeeiY\xde+g\x96{q\x94\x8c\x89\x1a\xb0\r\x8c\x8f8\xc7\u0709\x06hZ\xc1\xbf\xe3,\x00\x00\u07d4\xeel\x03B\x99i\xca\x12b\xcb?\nJT\xaf\xa7\xd3H\xd7\xf5\x89\r\xe2\x19\xf9\x1f\xc1\x8a\x00\x00\u07d4\xeeqy>:\xcf\x12\xa7'OV9a\xf57R\x9d\x89\xc7\u0789lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\xeer\x88\xd9\x10\x86\xd9\xe2\xeb\x91\x00\x14\u066b\x90\xa0-$

 $x \u00a0\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xee|=\xed|(\xf4Y\xc9/\xe1;M\x95\xba\xfb\xab\x026)\x89\%\xf2s\x93=\xb5p\x00\x00\xe0\x94\xee\x86)$

 $\label{thm:convenience} $$ \x91k\xd2\xe9\xc9\xe0\x8a\xa0C\x85\xdbf\x91.\x8a\n\x96\x81c\xf0\xa5{@\x00\x00\u007d4\ue2} $$ 5b\x02\xcb\xcb9\xcda\xde\x13B\xd5\x04\x82\xab\xb6\x852\x89_h\xe8\x13\x1e\u03c0\x00\x00\u007d4\xee\x90m\x90m\x17H\%\x81t\xbeL\xbc8\x93\x03\x02\xab\B\x89\n\u05ce\xbcZ\xc6$$

 $A \times d9 \times d2 \times 03 \times 97 NW \times c1 \# (\xeav \times 0e\b \times e3 \times 8965 \times 026 d \times c5 \times 000 \times 000$

\u0689pW\x8f9\x8a\x02\x1e\x19\x99\xbb\xd5\u04be\x00\x00\u07d4\xee\xf1\xbb\xb1\xe5\xa8?\u0782H\xf8\x8e\xe3\x01\x8a\xfa-\x132\xeb\x89\n\u05ce\xbcZ\xc6\x00\x00\u07d4\xee\xfb\xa1-

 $\label{thm:class} $$ c\x0f\x1bo\xa3zNP\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xef\x1c\x04w\xf1\x18M`\xac\u02b3t\xd3t\Uz\n>\x10\xf3\x89\b=\x00\x00\u07d4\xef,4\xbbH}7b\xc3\u0327\x82\xcc\xddz\x8f\xbb\n\x99\x89\t\x62\x00\x00\u07d4\xef5\xf6\u0531\a^j\xa19\x15\x1c\x97K/FX\xf7\x058\x89<;\xc3?\x94\xe5\r\x80\x00\u07d4\xef9\u0291s\xdf\x15S\x1ds\xe6\xb7^hKQ\xba\x0f+\xb4\x89V\xa0\xb4\x00\x00\u07d4\xefF<&y\xfb'\x91d\xe2\f=&\x915\x87s\xa0\xad\x95\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xefG\xcf\a>6\xf2q\xd5\"\xd7\xfaNq$$

 $x94\x1a\xabl$\xb5\xf4\x92\x9a\x8a\x15-$

\x86\xac5\x10R`\x00\x00\u07d4\xef\xe0g]\xa9\x8a]\xdap\u0356\x19k\x87\xf4\xe7&\xb43H\x89?\x1 $9\xbe\xb8\xdd\x1a\xb0\x00\x00\u07d4\xef\xe8\xff\x87\xfc\&\x0e\agc\x8d\xd5\xd0/\xc4g.\x0e\xc0m\x$ 89lk\x93[\x8b\xbd@\x00\x00\u07d4\xef\xeb\x19\x97\xaa\xd2w\xcc3C\x0ea\x11\xed\tCY@H\xb8\x 89lk\x93[\x8b\xbd@\x00\x00\u07d4\xef\xee\xa0\x10uo\x81\xdaK\xa2[r\x17\x87\xf0X\x17\v\uff49\x0 $1\u009c\x9c\xf7p\xef\x00\x00\u07d4\xef\xf5\x1dr\xad\xfa\xe1C\xed\xf3\xa4+\x1a\xecU\xa2\xcc\xdd$ \v\x90\x89\x10CV\x1a\x88)0\x00\x00\u07d4\xef\xf8kQ#\xbc\xdc\x17\xedL\xe8\xe0[~\x12\xe5\x13\x 93\xa1\xf7\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xef\xfc\x15\u41f1\xbe\xda\n\x8d\x13%\xb d\xb4\x17\"@\xdcT\n\x89\x03\x8599\xee\xe1\xde\x00\x00\x94\xf0\x11\x95\xd6W\xef<\x94.l\xb 89I\xe5\xa2\v\\\xfa\x8b\x1e\x8a\x05ts\xd0]\xab\xae\x80\x00\x00\u07d4\xf0'\x96)Q\x01gB\x88\xc1\x $d94g\x05=\x04\"\x19\xb7\x94\x89(\x1d\x90\x1fO\xdd\x10\x00\x00\u07d4\xf09h=\{=\"[\xc7\xd8\u07e]\x07\xd8\x07e]$ d\xefc\x164A\xbeA\xe2\x89\x01\xdd\x1eK\xd8\xd1\xee\x00\x00\u07d4\xf0Jj7\x97\b\xb9B\x8dr*\xa 2\xb0kw\xe8\x895\u03c9\x89\x10CV\x1a\x88)0\x00\x00\u07d4\xf0M,\x91\xef\xb6\xe9\xc4 \xfb\xe7 KCL\x8c_+\x02\x8f\x1f\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xf0W\xaaf\xcav~\xde\x12J\x1c[\x9 c\xc5\xfc\x94\xef\v\x017\x89p\xa2K\u02b6\xf4]\x00\x00\u07d4\xf0[\xa8\u05f6\x859\xd930\v\xc9(\x 9c=\x94t\xd0A\x9e\x89\x06\xda'\x02M\xd9`\x00\x00\u07d4\xf0\\\xee\xabeA\x05dp\x99Qw<\x84E\x ad\x9fN\u01d7\x89\x10C\x16'\xa0\x93;\x00\x00\xe0\x94\xf0_\xcdL\rs\xaa\x16~US\xc8\xc0\xd6\xd4 \xf2\xfa\xa3\x97W\x8a\x02\xd6l1p\xb2\x98\x00\x00\u07d4\xf0g\xe1\xf1\u0583UjL\xc4\xfd\f\x03 \x13#\x9f2\xc4\xcf\u060965\u026d\xc5\u07a0\x00\x00\u07d4\xf0g\xfb\x10\u07f2\x93\u962b\xe5d\ xc0U\xe34\x8f\x9f\xbf\x1e\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xf0h\xdf\xe9]\x15\xcd:\u007f\x98\xf f\xa6\x88\xb44hB\xbe&\x90\x89D\n\xd8\x19\xe0\x97L\x00\x00\xe0\x94\xf0j\x85J<]\xc3m\x1cl\xf4\x c8}m\xb33\xb5~J\u074a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xf0y\xe1\xb1&_P\xe8\u022 9\x8e\xc0\u01c1^\xb3\xae\xac\x9e\xb4\x89\x01\x16\xdc:\x89\x94\xb3\x00\x00\xe0\x94\xf0{\xd0\xe 5\xc2\xcei\xc7\u0127\$\xbd&\xbb\xfa\x9d*\x17\xca\x03\x8a\x01@a\xb9\xd7z^\x98\x00\x00\xe0\x94 \xf0\x83*k\xb2U\x03\xee\xcaC[\xe3\x1b\v\xf9\x05\xca\x1f\xcfW\x8a\x01je\x02\xf1Z\x1eT\x00\x00\u 07d4\xf0\x9b>\x87\xf9\x13\xdd\xfd\W\xae\x80\\xc71\u06e9\xb66\xdf\u00c9

 $\x f5 x b1 uab4d x 80 x 00 x 00 u 07d4 x f0 x b14 v x 9900 v x f0 x d9 v x 1c x 84 x 9c x af u 007f D0 x be x fa x 89 x 05k x c7^-$

 $c\x10\x00\x00\u07d4\xf0\xb1\xf9\xe2x2\xc6\xdei\x14\xd7\n\xfc\#\x8ct\x99\x95\xac\xe4\x89lk\x93[\x8b\xbd@\x00\x00\xe0\x94\xf0\xb4i\xea\xe8\x9d@\f\xe7\xd5\xd6j\x96\x95\x03p6\xb8\x89\x03\x8a\xe04\<3\xc1\x93ud\x80\x00\x00\u07d4\xf0\xb9\u0583\u03a1+\xa6\x00\xba\xac\xe2\x19\xb0\xb3\xc9\x8c\x00\xe4\x89\x05k\xc7\-$

 $c\x10\x00\x00\u07d4\xf0\xbe\x0f\xafMy\#\xfcDF\''\u0458\f\xf2\u0650\xaa\xb3\a\x89lk\x93[\x8b\xbd\@\x00\x00\u07d4\xf0\xc0\x81\xdaR\xa9\xae6d*\xdf^\b$

 $\label{thm:linear} $$\x89\x1b\b\x93A\xe1O\xcc\x00\x00\u07d4\xf0\xd8X\x10^\x1bd\x81\x01\xac?\x85\xa0\xf8\"+\xf4\xf8\x1dj\x89\x86\xac5\x10R^\x00\x00\u07d4\xf0\xdcC\xf2\x05a\x91'P\{+\x1c\x1c\xfd\xf3-(1\t \x89\x10^\xb7\x9b\x94\x17\b\x80\x00\u07d4\xf0\xe1\u07e4^*\u07ac\x17\xf6\xfd\xf5\x84\xc9Hb\xfd\V3\x93\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xf0\xe2d\x9c\-j?,]\xfe3\xbb\xfb\xd9'\xca<5\n X\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xf0\xe7\xfb\x9eB\nS@\xd56\xf4\x04\b4O\xea\xef\xc0j\xef\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xf1\x04b\xe5\x8f\xcc\a\U000d5121\x87c\x94Q\x16\x85\x92\x01\x89\t4\xdd]3\xbc\x97\x00\x00\x00\xe0\x94\xf1\x06a\xff\x94\x14\x0f$

 $> zH%rCy8\xe9\xc3\xf7\x8a\x04<3\xc1\x93ud\x80\x00\x00\u0794\xf1\x14\xff\r\x0f$\xef\xf8\x96\xed\xdeTg\u07a4\x84\x82J\x99\xb3\x88\xbe -$

\x00\x00\u07d4\xf1Qx\xff\xc4:\xa8\a\x0e\xce2~\x93\x0f\x80\x9a\xb1\xa5O\x9d\x89\n\xb6@9\x12\x 010\x00\x00\u07d4\xf1V\xdc\v*\x98\x1e[U\xd3\xf2\xf0;\x814\xe31\u06ed\xb7\x89\x05k\xc7^-

 $c\x10\x00\x00\u07d4\xf1]\x9dZ!\xb1\x92\x9ey\x03q\xa1\u007f\x16\xd9_\fie\\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xf1^\x18,O\xbb\xady\xbd\x934\"B\xd4\xdc\xcf+\xe5\x89\%\x89i^\x89p\x81\xd0\x00\x00\u07d4\xf1bM\x98\ve3o\xea\u0166\xd5A\%\x00\\xf2\xaa\u02c9lk\x93[\x8b\xbd@\x00\x00\x00\u07d4\xf1g\xf5\x86\x8d\xcfB3\xa7\x83\x06\th,\xaf-$

\xb2\x03\x1f9\xc8%\x81\u0189\xbd\xbdz\x83\xbd/l\x00\x00\u07d4\xf1\xa1\xf3

@yd\xfd<\x8f.,\u0224X\r\xa9O\x01\xea\x89II!wU|D\x00\x00\u07d4\xf1\xb4\xec\xc65%\xf7C,=\x83O\xfe+\x97\x0f\xbe\xb8r\x12\x89\xa2\xa2@h\xfa\u0340\x00\x00\u07d4\U000753ef\xfa\x87\x94\xf5\n\xf8\xe8\x83\t\u01e6&TU\xd5\x1a\x8963\x03\"\xd5#\x8c\x00\x00\u07d4\xf1\xc8\u0129A\xb4b\x8c\r\10\xfd\xa5dR\u065c~\x1bd\x89N\x8c\xea\x1e\xdeu\x04\x00\x00\u07d4\xf1\xda@so\x99\xd5\xdf;\x06\x8a]t_\xaf\xc6F?\u0271\x89\x06\x96\xca#\x05\x8d\xa1\x00\x00\u07d4\xf1\u070a\xc8\x10B\xc6z\x9c<g\x92\xb20\xc4j\xc0\x16\xca\x10\x89\n\u05ce\xbcZ\xc6

 $\label{thm:condition} $$ \left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x_2}^2\left(\frac{x_1}{x_1}\right)_{x_1}^2\left(\frac{x_1}{x_1}\right)_{x$

\x00\x00\u07d4\xf2^Lp\xbcFV2\u021eV%\xa82\xa7r/k\xff\xab\x89\xf3K\x82\xfd\x8e\x91 \x00\x00\u07d4\xf2k\xce\xdc\xe3\xfe\xad\u03a3\xbc>\x96\xeb\x10@\xdf\xd8\xff\u1809*\x03I\x19\u07ff\xbc\x00\u07d4\xf2py%v\xf0]QD\x93\xff\xd1\xf5\xe8K\xecK-

\xf8\x10\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xf2s,\xf2\xc1;\x8b\xb8\xe7I*\x98\x8f_\x89\xe3\x82\s\xdd\u0209

\x14\x93\xc6_.\x89\xc5S%\xcat\x15\xe0\x00\x00\u07d4\xf2\xab\x11au\x02D\xd0\xec\xd0H\xee\r> Q\xab\xb1C\xa2\xfd\x89B\xfe+\x90ss\xbc\x00\x00\u07d4\xf2\xb4\xab,\x94'\xa9\x01^\xf6\xee\xff\xf5 \xed\xb6\x019\xb7\x19\u0449&\u06d9*;\x18\x00\x00\u07d4\xf2\xb4\xab,\x94'\xa9\x8c!d\x87`\xf1\xe5 \xae~\xa3\a}\x85\"\x89\x8f?q\x93\xab\a\x9c\x00\x00\u0794\xf2\u0090N\x9f\xa6d\xa1\x1e\xe2VV\x d8\xfd,\xc0\u0665\"\xa0\x88\xb9\x8b\xc8)\xa6\xf9\x00\x00\u07d4\xf2\xc3b\xb0\xef\x99\x1b\xc8\xb 3nf\xff\x\x93*\xe8\u0742%\x89\x04\x02\xf4\xcf\xeeb\xe8\x00\x00\u07d4\xf2\xd0\xe9\x86\xd8\x14\x ea\x13\xc8\xf4f\xa0S\x8cS\u0712&Q\xf0\x89J\xcfX\xe0rW\x10\x00\x00\x00\xe0\x94\xf2\u04775\w\$\xec L\x03\x18[\x87\x9bc\xf5~&X\x91S\x8a\x01EB\xba\x12\xa37\xc0\x00\x00\x00\xe0\x94\xf2\xd5v<\xe0s\x 12~,\xed\xdeo\xab\xa7\x86\xc7<\xa9AA\x8a\x01\xacB\x86\x10\x01\xab,\xf7\xc9\xf8~

 $9\xf1\xee\xe5{\xb9\u05c965\u026d\xc5\u07a0\x00\x00\u07d4\xf3\x16\xef\x1d\xf2\xffMl\x18\b\u06e} \\ 6c\uc013iyh\xe0\x89aFMl\u0700\xf0\x00\xe0\x94\xf3-$

 $\label{thm:complex} $$ \end{tabular} $$

 $\label{thm:linear} $$ \x86\xac5\x10R^\x00\x00\u07d4\xf4\x15W\xdf\u07f1\xa1\xbd\xce\xfe\xfe.\xba\x1e!\xfe\nJ\x99B\x89 if $$ \xcb=\xf2-\x1f\x88\x00\x00\u07d4\xf4\x17z\x85\u050b\x0e\&B\x11\xce^*\xa2\xef\xd3\xf1\xb4\u007f\x89\xc2\xcc\xca\&\xb7\xe8\x0e\x80\x00\u07d4\xf4\x90R1\xc7p\xf0\xa4\x06\xf2\xb7\x87\u007f\xb4\x9e\xee\x0f!\x89\n\xad\xec\x98?\xcf\xf4\x00\x00\u07d4\xf42\xb9\u06ef\x11\xbd\xbd\xb6\xb6\xpf$

\xc0\xa9\x04\x19\x87q\xaa\u0189\b=|z\xabc`\x00\x00\u07d4\xf4=\xa3\xa4\xe3\xf5\xfa\xb1\x04\u02 9b\xc1\xa0\xf7\xf3\xbbJV\xf3Q\x89|j\xccg\u05f1\xd4\x00\x00\xe0\x94\xf4G\x10\x8b\x98\xdfd\xb5~\ x87\x103\x88\\\x1a\xd7\x1d\xb1\xa3\xf9\x8a\x01v\xf4\x9e\xad4\x83P\x80\x00\u07d4\xf4O\x85Q\xa c\xe93r\a\x12\xc5\u0111\u0376\xf2\xf9Qs|\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u0794\xf4V\x05Z\x 11\xab\x91\xfff\x8e.\xc9\"\x96\x1f*#\xe3\xdb%\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xf4V\xa7[\ xb9\x96U\xa7A,\xe9}\xa0\x81\x81m\xfd\xb2\xb1\xf2\x89\n\u05ce\xbcZ\xc6

 $\label{thm:column} $$\x00\x00\u07d4\xf4[\x1d\xcb.A\xdc'\xff\xa0$\u06ad\xf6\x19\xc1\x11u\xc0\x87\x89\x01\x11du\x9f\xfb2\x00\x00\u07d4\xf4c\xa9\f\xb3\xf1>\x1f\x06CB66\xbe\xab\x84\xc1\#\xb0m\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xf4h\x90n~\xdffJ\xb0\u063e=\x83\xebz\xb3\xf7\xff\xdcx\x89\(=A\x03\x94\x10\x00\x00\u07d4\xf4i\x80\u3929\u049ajn\x90`E7\xa3\x11K\xcb(\x97\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xf4kk\x9c\x9c\x1d=\xfd\x8f\xfb\x11\xaa\xba\xe7\x82\xf6\x89\x01\#n\xfc\xbc\xbb4\x00\x00\u07d4\xf4kk\x9c\xe1\&\u007f\x86$|\xc9\b\x81o.z\xd58\x8c\x95-$

 $\xb0\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\u07d4\xf4v\xf2\xcbr\b\xa3.\x05\x1f\xd9N\xa8f)\x92c\x82\x87\xa2\x89\x05k\xc7^-$

\x00\x00\xe0\x94\xf4\xb4\x91\x00uwr\xf3<\x17{\x9av\xba\x95\"I\x8f=\u060a\x01k5-

 $\label{thm:p} $$ \x00\x00\u07d4\xf4\xd9vd\xccN\xec\x9e\xdb\xe7\xfa\t\xf4u\nf;P} y\x89\xd8\xd7\&\xb7\x17z\x80\x00\x00\x00\xe0\x94\xf4\xdc{\x87\x80\xbb\xb3\xf55\xc0\x95h\xaa\xa3\xafo7!\u018a\x01\x87\x1f\xb60~5\xe5\x00\x00\xe0\x94\xf4\xeb\xf5\v\xc7\xe5O\x82\u9e7d\xba\xef)C\x8e\%\x9c\xe6\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xf4\uc397\xa2\n\xa5\xf8\xdd\ oU$

~\x06\xb8\x13\xdf,\xc0\x89\n\u05ce\xbcZ\xc6

 $\label{thm:c2} $$\x9a2\x8f\x06\x8a\t`\xae\x12z\xf3/\xb2\x80\x00\u07d4\xf5P\x01x\u02d9\x8f\x12d\x17\x83\x1a \b\xc2\u05eb\xff\xf6\xab_\x89F\xf4\xf4\xa5\x87Z\x9f\x80\x00\u07d4\xf5SH\x15\xdcc^\xfa\\\xc8K^*\xc74r>!\xb2\x93r\x89U\xa6\xe7\x9c\xcd\x1d0\x00\x00\u07d4\xf5U\xa2\{\xb1\xe2\xfdN,\u01c4\xca\ue 493\x9f\xc0n\u0249lk\x93[\x8b\xbd@\x00\x00\u07d4\xf5X\xa2\xb2\xb2\xdd&\u0755\x93\xaa\xe0E1\xfd<<\u00c5Kg\x89\n\xbb\xcdN\xf3wX\x00\x00\u07d4\xf5`H\xdd!\x81\u0523od\xfc\xec\xc6!T\x81\xe 4*\xbc\x15\x89\n\u05ce\xbcZ\xc6$

 $\label{thm:convolu07d4} $$ \x00\x00\u07d4\xf5dB\xf6\x0e!i\x13\x95\u043f\xfa\xa9\x19M\xca\xff\x12\u2dc9\x0e\x189\x8ev\x01\x90\x00\u07d4\xf5\yqJE\xeb\x8fR\xc3\xd5{\xd5}\xd5\xc1[./x11\u07c9T\x91YV\xc4\t`\x00\x00\u07d4\xf5\x93\xc6R\x85\xeek\xbdf7\U000fe3c9\xad@\u0509\xf6U\x89\xa2\xa1]\tQ\x9b\xe0\x00\x00\u07d4\xf5\x98\xdb.\t\xa8\xa5\xee\rr+\C\xbb\x12m\x11\xec\u0089\n\u05ce\xbcZ\xc6$

 $\label{thm:continuous} $$ \frac{x}{x^2} x^2 \cdot x^2$

4\x10\x12\x8d\xbc\xeb\xe6\xd9\u0782C\x89P\xc5\xe7a\xa4D\b\x00\x00\u07d4\xf6E\xdd|\x89\x00\x93\xe8\xe4\u022a\x92\xa6\xbb55\"\xd3\u0718\x89\aC\x9f\xa2\t\x9eX\x00\x00\x00\xe0\x94\xf6H\xea\x89\xc2u%q\x01r\x94Ny\xed\xff\x84x\x03\xb7u\x8a\x15-

\x02\xc7\xe1J\xf6\x80\x00\x00\u07d4\xf6JJ\xc8\xd5@\xa9(\x9ch\xd9`\xd5\xfb|\xc4Zw\x83\x1c\x89| k\x93[\x8b\xbd@\x00\x00\u07d4\xf6N\xcf!\x17\x93\x1cmSZ1\x1eO\xfe\xae\xf9\u0514\x05\xb8\x89| x90\xf54`\x8ar\x88\x00\x00\u07d4\xf6N\xcf!\x17\x93\x1cmSZ1\x1eO\xfe\xae\xf9\u0514\x05\xb8\x89| x90\xf54`\x8ar\x88\x00\x00\u07d4\xf6O\xe0\x93\x9a\x8d\x1e\xea*\x0e\u035a\x970\xfdyX\xe31\t\x89\x01\x1d\xe1\xe6\xdbE\f\x00\x00\u07d4\xf6V\x16\xbe\x9c\x8by~t\x15\"|\x918\xfa\xa0\x89\x17B\ u05c9*\xd3s\xcef\x8e\x98\x00\x00\u07d4\xf6V\xf6V\xfc\xbeh.\xb4\xe8\xdb\x15.\u03c9\$\V\x00\vQ=\x15\ x89i*\xe8\x89p\x81\xd0\x00\x00\u07d4\xf6X\x19\xac1L\x13\u007f\x05\xddyw\xc7\xda\xe0\x8d\ x1aJ\xb5\x89\x05\x87\x88\u02d4\xb1\xd8\x00\x00\u07d4\xf6\xb8\xe2\x11\x8b\xbc\u0550'fn\xed\x f6\x94>\xc9\xf8\x80\xa5\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xf6\x86x[\x89r\va\x13\v\xe4\ xd3%\x0e\xfe\xfe\|P\xa5\xf6[\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xf6\x86x[\x89r\va\x13\x9d\ xf5\xb2\xe68\x89\x6\x6\x6\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xf6\x86x[\x89r\va\x13\x9d\ xf5\xb2\xe68\x86\xce4\xeb\xf3\u45dc\x89\xb3\xfa\xiaAi\xe2\xd8\xe0\x00\x00\u07d4\xf6\xb7\x82\xf4\xdc\ xd5\xc1\x02\x8e\x6\xc1\x02\x8e\xf7x\u03c6\txe4j\x89O\x1dw/xae\xc1|\x00\x00\u07d4\xf6\xb7\x82\xf4\xdc\ xd5\xb1\u04a3x\x8dX\x9bm\xe2\x12\xdc\x17\x13\xb2\xf6\u738a\x01\x0f\fxf0d\xddY

:\xe1S\x81\x11\xb1Q\xec\x82

 $c\x10\x00\x00\u07d4\xf7P\f\x16o\x8b\xea/\x824v\x06\xe5\x02K\xe9\xe4\xf4\u0399\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xf7W\xfc\x87$

 $\label{thm:colored} $$ \xd3\xc4\xfaRw\a^`\xbd\A\x1a\xeb\xd9w\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xf7[\xb3\x9cy\x97y\xeb\xc0J3m&\r\xa61F\xed\x98\u0409\x01Z\xf1\u05cbX\xc4\x00\x00\x00\x94\xf7h\xf3!\xfdd3\xd9k O5M<\xc1e,\x172\xf5\u007f\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\u07d4\xf7oi\xce\xe4\xfa\xa0\xa6;0\xae\x1ex\x81\xf4\xf7\x15ep\x10\x89\n\u05ce\xbcZ\xc6 $$$

\x00\x00\u07d4\xf7w6\x1a=\u062bb\xe5\xf1\xb9\xb0GV\x8c\xc0\xb5UpL\x8965\u026d\xc5\u07a0\

x00\x00\u07d4\xf7|{\x84QI\xef\xba\x19\xe2a\xbc|u\x15y\b\xaf\xa9\x90\x89Ik\x93[\x8b\xbd@\x00\x00\x00\u07d4\xf7\u007f\x95\x87\xffz-

 $r\x95\xf1\xf5q\u0206\xbd3\x92jR\x89lh\xcc\u041b\x02,\x00\x00\u07d4\xf7\x82X\xc1$\x81\xbc\xdd\u06f7*\x8c\xa0\xc0C\tra\xc6\u0149\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xf7\x98\xd1m\xa4\xe4\xd6\xc5\u07a0\x00\x00\u07d4\xf7\xa1\xad\xe2\xd0\xf5\x)\x12=\x10U\xf1\x9b\x17\x91\x9fV!Ng\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xf7\xac\xff\x9\x84\xda\ti\xdc7\xa8\xfc\xf6C\xb7\xd7\xfb\xedA\x89lj\xccg\u05f1\xd4\x00\x00\u07d4\xf7\xb1Q\xcc^W\x1c\x17\xc7e9\xdb\xe9\x96L\xbbo\xe5\xdey\x89tq\xfbh\x83\x10\x00\x00\u07d4\xf7\xb2\x9b\x82\x19\x88-$

 $\label{thm:colline} $$ \addivides (1) \addivides$

LV xf3 x1f xd9C x98 xe4 r xf1 x96K u063f x12 < x89 b! xd2! xb5) x1f x80 x00 u07d4 xf7 xdc% x11 x96 xfb u02f7 | x94 | x19F xb0 xffe x02 x1c xea x8965 u026d xc5 u07a0 x00 x00 xe0 x94 xf7 xe4Z x12 xaaq x1cp x9a xce xfe x95 xf3; xa-

 $\label{thm:color$

52m\x8965\u026d\xc5\u07a0\x00\x00\u07d4\xf8\x15\xc1\n\x03-

 $\x00\x00\u07d4\xf8H\xfc\xe9\xaba\x1c\x99$

 $n\#\xfa\u019a\u0508\xb9O\xe1\x89\x02\xa1\x12\x9d\t6r\x00\x00\u07d4\xf8O\t\n\xdf?\x8d\xb7\u153\\3P\xfb\xb7u\x00i\x9ff\xfd\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xf8Q\xb0\x10\xf63\xc4\n\xf1\xa8\xf0\y\xb9\xc2\xb5\x89\xc2\xb5\x89\xc2\xb5\x86D\xc0\x00\x00\x00\u07d4\xf8X\x17\x1a\x04\xd3W\xa1;IA\xc1n~U\xdd\u0514\x13)\x89\x02F\xa5!\x8f*\x00\x00\x00\u07d4\xf8[\xab\x1c\xb3q\x0f\xc0_\xa1\x9f\xfa\xc2.gR\x1a\v\xa2\x1d\x89|\x955\u007f\xa6\xb3|\x00\x00\u07d4\xf8j>\xa8\a\x1fp\x95\xc7\u06ca\x0$

 $5\xePz\x89)\u06f8v\x89\x126\xef\xcb\u02f3@\x00\x00\u07d4\xf8pL\x16\xd2\xfd[\xa3\xa2\xc0\x1d\x0e\xb2\x04\x84\xe6\xec\xfa1\t\x89\n\u05ce\xbcZ\xc6$

\xc7\xd4\u007f\x15`\x00\x00\u07d4\xf8\xa0e\xf2\x87\xd9\x1dw\xcdbj\xf3\x8f\xfa\"\r\x9bU*+\x89g\x8a\x93

 $\label{thm:convolution} $$ \x97;D\x13e\xcf\xfeYof\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xf8\xae\x85{g\xa4\xa2\x89:?\xbe\z\x89}\x89lk\x93[\x8b\x00\x00\x00\u07d4\xf8\xbf\x9c\x04\x87NZw\xf3\x8fL8R-\x80\xc6v\xf7\xb8\x87\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xf8\xc7\xf3J8\xb3\x18\x01\xda C\x064w\xb1+'\xd0\xf2\x03\xff\x89\x1a\u04ba\xbao\xefH\x00\x00\u07d4\xf8\xca3l\x8e\x91\xbd \xe3\x14\xc2\v-\xd4\x8b\x9c\x8b\x94Y\x89-$

^\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u07d4\xf9d

 $\label{thm:cond} $$ \x86\x01\xfb\xaea\xa6\x80M\xbe_\xb1^\xc2\u04b57\xf4\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xf9d\x88i\x85\x90\xdc;,UVB\xb8q4\x8d\xfa\x06z\u0549\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xf9d\u064d(\x170\xba5\xb2\xe3\xa3\x14\yn{B\xfe\xdfg\x89S\xb0\x87\x98\xd8\f\x00\x00\u07d4\xf9e\ri\x89\xf1\x99\xab\x1c\xc4\ycm\xed0\xf2A\x02\x1fe\x89.\x14\x1e\xa0\x81\xca\b\x00\x00\x00\xe0\x94\xf9h\x83X$Y\x90\x8c\x82v'\xe8o(\xe6F\xf9\xc7\xfcz\x8a\x01\u0127\x877\xcd\u03f8\x00\x00\u07d4\xf9kL\x00\voSsi\x85t\xf8\"\xe6GL/!\xda-$

\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xf9r\x9dH(,\x9e\x87\x16m^\xef-

\x00\x00\u07d4\xf9\x82Ps\fLa\xc5\u007f\x12\x985\xf2h\b\x94yEB\xf3\x89\xd8\xd7&\xb7\x17z\x80\\x00\x00\x00\x94\xf9\x894gr\x99^\xc1\x90o\xaf\xfe\xba*\u007f\xe7\u079ck\xab\x8a\x01je\x02\xf1Z\\x1eT\x00\x00\u07d4\xf9\x98\xca4\x11s\nl\xd1\x0etU\xb0A\x0f\xb0\xf6\xd3\xff\x80\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\xf9\x9a\xeeDKW\x83\xc0\x93\xcf\xff\xd1\xc4c,\xf9<o\x05\f\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xf9\x9e\xee\xce9\xfa~\xf5\am\x85Pa8@\ty,\xf2\xe0\x89\x1b\x1a\xe4\xd6\\xe2\xefP\x00\x00\u07d4\xf9\xa5\x9c<\xc5\xff\xac\xbc\xb6{\xe0\xfcrV\xf6L\x9b\x12|\xb4\x89\k\x93[\x8b\xbd@\x00\x00\u07d4\xf9\xa9K\xd5a\x98\xda\$^\xd0\x1d\x1ed0\xb2K'\b\xdc\xc0\x89(\xa7z\xfd\\xa8~\xe5\x00\x00\u07d4\xf9\xb3x\%\xf00s\xd3\x1e\$\x93x\xc3\fy\\3\xf8:\xf2\x89\n\u066a\xbf\x8c\x9\x90\x96\x89\x1b\x12\x89\x90\x96\x89\x90\x96\x88\x00\x00\x00\u07d4\xf9\xbf\xb5\x9dS\x8a\xfcHt\xd4\xf5\x94\x1b\b\xc9s\x0e8\xe2K\x89\x0\2+\x1c\x8c\x12'\xa0\x00\x00\u07d4\xf9\xdd#\x90\b\x18\xb5\x19\xfb0\xee\xdd

 $\x 93\x fe\x d1c\x 9b\x e8\x 89\x 1b\x 1a\x e4\x d6\x e2\x efP\x 00\x 00\u 07d4\x f9\u 07ba\x ec\x b5\x f39\x be\x eaH\x 94\x e5$

\x00\x00\xe0\x94\xfa\x10_\x1a\x11\xb6\xe4\xb1\xf5`\x12\xa2y\"\xe2\xac-

 $\label{thm:linear} $$ \x00\x00\u07d4\xfa\x19\xd6\xf7\xa5\x0fO\a\x98\x93\xd1g\xbf\x14\xe2\x1d\x00s\u0456\x89\x1c\xbb : ?\xf0\x8d\b\x00\x00\u07d4\xfa\x1f\x19q\xa7u\xc3PO\xefPy\xf6@\xc2\u013c\xe7\xac\x05\x89lk\x93\x90\xbd@\x00\x00\u07d4\xfa'\x9b\xfd\x87g\xf9V\xbf\u007f\xa0\xbdV`\x16\x8d\xa7V\x86\xbd\x89\x90\x54`\x8ar\x88\x00\x00\x00\x94\xfa'\xccl\xd0\vl\x98s6\xa8u\xae9\xdaX\xfb\x04\x1b.\x8a\x02\x1e\x19\xe0\u027a\xb2@\x00\x00\xe0\x94\xfa(2\x99\xe87X\xe8\u02b0\x82\x12],\x8f\DT)\x8a\x01\x2a\xcb\x1e\x05\x01\xae\x80\x00\u07d4\xfa+\xbc\xa1]?\u37ca2\x8e\x91\xf9\r\xa1Oz\xc6\%=\x89\x00\x00\x00\xe6\%=\x89\x00\x00\xe6\%$

b<\xd1\xc4\xe1\x89\x05k\xc7^-

 $c \x 10 \x 00 \$

 $B\%\x9cX\x\x8a\x01Z\xff\xb8B\fkd\x00\x00\xe0\x94\xfb\x12o\x0e\xc7i\xf4\x9d\xce\xfc\xa2\xf2\x00(d)\x90\x84\xb8\x8a\x01\x0f\xcb\xc25\x03\x96\xbf\x00\x00\xe0\x94\xfb\x13^\xb1Z\x8b\xacr\xb6\x99\x154^*\xbb\xc0k\-\a|\x8a\x04\-\3\xc1\x93\ud\x80\x00\x00\u07d4\xfb\"<\x1e\"\xea\xc1&\x9b2\xee\x15j S\x85\x92.\xd3o\xb8\x89|k\x93[\x8b\xbd@\x00\x00\x00\u07d4\xfb7\xcfkO\x81\xa9\xe2\"\xfb\xa2.\x9b\xd2KP\x98\xb73\u03c9\x02\x1auJm\xc5(\x00\x00\u07d4\xfb8`\xf4\x12\x1cC.\xbd\xc8\xecj\x031\xb1 \xb7\ty.\x90\x89$

\x8c9J\xf1\u0208\x00\x00\u07d4\xfb9\x18\x9a\xf8v\xe7b\xc7\x1dl>t\x18\x93\xdf\"I\xed\u0589\xd8\xd7\\x17z\x80\x00\x00\u07d4\xfb:\v\rkjq\x8fo\xc0)*\x82]\xc9\$z\x90\xa5\u0409\n\xd6\xdd\x19\x9e\x97[\x00\x00\x94\xfb?\xa1\xac\b\xab\xa9\xcc;\xf0\xfe\x9dH8

N\x80\xe0\x00\x00\u07d4\xfc7/\xf6\x92|\xb3\x96\xd9\xcf)\x805\x00\x11\r\xa62\xbcR\x89lk\x93[\x8b

e\xbcZ\xc6

\xbd@\x00\x00\u07d4\xfc9\xbeA\tK\x19\x97\xd2\x16\x9e\x82d\xc2\u00fa\xa6\u025b\u0109lk\x93[\ x8b\xbd@\x00\x00\u07d4\xfc=\"k\xb3jX\xf5&V\x88W\xb0\xbb\x12\xd1\t\xec\x93\x01\x89Ik\x93[\x8 b\xbd@\x00\x00\u07d4\xfcC\x82\x9a\u01c7\xff\x88\xaa\xf1\x83\xba5*\xad\xbfZ\x15\xb1\x93\x89\u 05ac\n+\x05R\xe0\x00\x00\u07d4\xfcl\xc1C\x9aA\u05b3\xcf&\xbbg\xe06R\$\xe5\xe3\x8f_\x8966\u 05ef^\u024e\x00\x00\u07d4\xfcU\x00\x82Q\x05\xcfq*1\x8a^\x9c;\xfci\u021d\f\x12\x89\xd8\xd7&\xb xb9%\xff\xd3 \x00\x00\xe0\x94\xfc~\"\xa5\x03\xecZ\xbe\x9b\b\xc5\v\xd1I\x99\xf5 \xfaH\x84\x8a\x01ZG}\xfb\xe1\xea\x14\x80\x00\u07d4\xfc\x82\x15\xa0\xa6\x99\x13\xf6*C\xbf\x1c\ x85\x90\xb9\xdd\xcd\r\x8d\u06c9lk\x93[\x8b\xbd@\x00\x00\u07d4\xfc\x98\x9c\xb4\x87\xbf\x1a}\x1 7\xe4\xc1\xb7\u0137\xaa\xfd\xdak\n\x8d\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\xe0\x94\xfc\x9b4td\x b2\xf9\x92\x9d\x80~\x03\x9d\xaeH\xd3\u064d\xe3y\x8a\x02\xf6\xf1\a\x80\xd2,\xc0\x00\x00\u07d4\ xfc\xa4;\xbc#\xa0\xd3!\xba\x9eF\xb9)s\\\xe7\xd8\xef\f\x18\x89\x01\x15\x8eF\t\x13\xd0\x00\x00\u0 7d4\xfc\xa7>\xff\x87q\xc0\x10;\xa3\xcc\x1a\x9c%\x94H\xc7*\xbf\v\x8965\u026d\xc5\u07a0\x00\x0 0\u07d4\xfc\xad\xa3\x00(?k\xcc\x13J\x91Eg`\xb0\xd7\\xe4\x10\xe0\x89lk\x93[\x8b\xbd@\x00\x00\ xe0\x94\xfc\xbc\\q\xac\xe7\x97AE\v\x01,\xf6\xb8\xd3\xf1}\xb6\x8ap\x8a\x02\x05\xb4\u07e1\xeetx\ x00\xe0\x94\xfc\xc9\u0524&.z\x02z\xb7Q\x91\x10\xd8\x02\u0115\xce\xea9\x8a\x01YQ\x82\"K&H\ 19\xe0\u027a\xb2@\x00\x00\xe0\x94\xfc\u0434\x82|\xd2\b\xff\xbf^u\x9d\xba\x8c<\xc6\x1d\x8c,<\x 8a\x01\xb1\xaeMn.\xf5\x00\x00\x00\u07d4\xfc\xe0\x89c\\\xe9z\xba\xc0kD\x81\x9b\xe5\xbb\n>.\v7\ x89\x05\x03\x92\nv0\xa7\x80\x00\u07d4\xfc\xf1\x99\xf8\xb8T\"/x18.N\x1d\t\x9dN2>*\xae\x01\x89 65\u026d\xc5\u07a0\x00\x00\u07d4\xfc\xfc:P\x04\xd6xa?\v6\xa6B&\x9a\u007f7\x1c?j\x8965\u026

 $d\xc5\u07a0\x00\u07d4\xfd\x19\x1a5\x15\x\x13s\xfbA\x1b\xf9\xf2R\x90\x04\|^\xef\x8965\u026\xc5\u07a0\x00\x00\u07d4\xfd\x1f\xaa4\x0f\u0300L-$

OOJ\xba%%\xbar\x8a\xfd\xf7\x87\x92\xcb\u07b75\xae\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xfd'W\xcc5Q\xa0\x95\x87\x8d\x97\x87\\x15\xfe\fj2\xaa\x8a\x89

 $m\xb1R\x99\xbe\xac\x00\x00\u07d4\xfd(r\u045eW\x85<\xfa\x16\xef\xfe\x93\u0431\xd4\{O\x93\xfb\x89\xd8\xd7\&\xb7\x17z\x80\x00\u07d4\xfd))'\x1e\x9d$

c\x10\x00\x00\u07d4\xfd`\u04b5\xaf=5\xf7\xaa\xf0\u00d3\x05.y\xc4\xd8#\u0645\x89\x03\x0e\xb5\r\.\x14\b\x00\x00\u07d4\xfdhm\xe5?\xa9\u007f\x99c\x9e%hT\x97 \xbcX\x8c\x9e\xfc\x89j\xc5\xc6-\x94\x86\a\x00\x00\u07d4\xfd~\u078fR@\xa0eA\xebi\x9dx,/x9a\xfb!p\xf6\x89Hz\x9a0E9D\x00\x00\u07d4\xfd\x81+\u019f\xb1p\xefW\xe22~\x80\xaf\xfd\x14\xf8\xe4\xb6\u0489lk\x93[\x8b\xbd@\x00\x00\u07d4\xfd\x88\xd1\x14\"\x0f\b\x1c\xb3\xd5\xe1[\xe8\x15*\xb0sfWj\x89\x10CV\x1a\x88)0\x00\x00\u07d4\xfd\x91\x856\xa8\xef\xa6\xf6\xce\xfe\x1f\xa1\x159\x95\xfe\xf5\xe3=;\x89\x1b\x1a\xe4\xd6\xe2\xefP\x00\x00\u07d4\xfd\x92\x0fr&\x82\xaf\xb5\xafE\x1b\x05D\xd4\xf4\x1b;\x9dWB\x89~R\x05\xb5\xafE\x10\x00\x00\u07d4\xfd\x95y\xf1\x19\xbb\xc8\x19\xa0+a\u3348\x03\xc9B\xf2M2\x89\x05\xb9~\x90\x81\xd9@\x00\x00\u07d4\xfd\xa0\xce\x153\a\xf1\v\xce2\x01\x17-

 $\label{thm:condition} $$ \x9d\x92/RY\xc5\x00\x00\u07d4\xfd\xbaSY\xf7\xec;\xc7p\xacl\x97]\x84N\xc9qbV\xf1\x8965\u026d\xc5\u07a0\x00\x00\x94\xfd\xc4\xd4vZ\x94/[\xf9i1\xa9\xe8\xccz\xb8\xb7W\xffL\x8a\x12lG\x8a\x0e>\xa8`\x00\x00\x00\x94\xfd\xcd]\x80\xb1\x05\x89zW\xab\xc4\xev\x8b)\x00RB\x95\x8a\x01Z\xf1\u05cbX\xc4\x00\x00\x00\u0794\xfd\xd1\x19_y\y05q\x15\xe6\xf9\x81\n\x9a?\xf5T\x88\xfc\x93c\x92\x80\x1c\x00\x00\u07d4\xfd\xd5\x02\xa7N\x81;\u03e3U\xce\xda<\x17oj\nq\xaf\u007f\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xfd\u357c\vm\\xbbL\x1d\x8f\xea>\vK\xffc^\x9d\xb7\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xfd\xea\xac*\xcf\x1d\x13\x8e\x19\xf2\xfc?\x9f\xb7E\x92\xe3\ud04a\x89\x89\x18\\x80\x00\x00\x00\u07d4\xfd\xec\xc8-$

xa5S\x98-

 $\label{thm:linear_continuous} $$ \x03\x92E\xbc\xf02\xdb\u0709\x15[\xd90\u007f\x9f\xe8\x00\x00\u07d4\xfe\x01n\xc1\xc5\xf1\x0e;\xb9\x8f\xf4\xa1\xed\xa0E\x15v\x82\xab\x89\x14_T\x02\xe7\xb2\xe6\x00\x00\u07d4\xfe\x0e0\xe2\x14)\rt=\xd3\x0e\xb0\x82\xf1\xf0\xa5\"Z\xdea\x89\n\u05ce\xbcZ\xc6$$

 $\label{thm:convolu07d4} $$ \onum{1} \converted by the converted by the c$

 $aS\x95\&\xbb\xe9y\xdd.\xa9\x89h\xa8u\a>)$\x00\x00\u07d4\xfeT\x9b\xbf\xe6G@\x18\x98\x92\x93\\ \%8\u06afF\u04b6\x1dO\x89\x02+\x1c\x8c\x12'\xa0\x00\x00\x00\x94\xfea]\x97\\b\x87\xe0\xc9\x11\\ >\xc7)\x84$

 $\label{thm:label} $$ \x 3\x 4\x 8b\x 96\x 8a\x 01\x 1\x aeMn.\x f5\x 00\x 00\x 00\u 07d4\x fee\x c4\x 18\x 8dy\''Wi\t dD\x fd\x c5\#\x 95\V\x 01e\x 89\x d8\x d7\x 17z\x 80\x 00\x 00\u 07d4\x fei\u 007f\x f2,\x a5G\x bf\x c9^3\x d9\x da\'\x gc\x f3[\x 89G\x d4\x 11\x 9f\x d9\x 00\x 00\u 07d4\x fej\x 89[y\\x b4\x bf\x 85\x 90=<\x e0\x 9c\x 2\x a49S\u 04ff\x 89\x b8Pz\x 82\a($

tE\xb1\x9e\xb5\xb0\x945j\xee\x89lk\x93[\x8b\xbd@\x00\x00\u07d4\xfe\x80\xe9#-

 $\x 9a\x c 7\x 15\x f 0\x 99L\u 00be\x 89\x 1b\x 1a\x e 4\x d 6\x e 2\x e f P\x 00\x 00\u 07d 4\x f e\x b 8\x b 8\x e 2\x a f qj\x e 4\x 1f\x c 7\x c 0K\x c f) T\x 0 1 V F\x 1 e\x 89TQt\x a 5(\x a 7z\x 0 0\x 0 0\u 0 7d 4\x f e\x b 9-$

\x00\x00\u07d4\xfe\xf3\xb3\u07ad\x1ai&\u051a\xa3+\x12\xc2*\xf5M\x9f\xf9\x85\x8965\u026d\xc5\\u07a0\x00\x00\u07d4\xff\v|\xb7\x1d\xa9\xd4\xc1\xean\xcc(\xeb\xdaPLc\xf8\u04498\x8a\x88]\xf2\xfc|\x00\x00\u07d4\xff\f\\x\98\xe8s=\xd2f\x81R\x89\x1b\xab\x80\xa8\xbe\x95\\\x89\x04YF\xb0\xf9\\xe9\xd6\x00\x00\u07d4\xff\f\xb0|B\xe3\u0609H\xe4[\u05f0\xd4\u246e\xfe\xeaQ\x89g\x8a\x93\b\xe4\x18\x00\x00\u07d4\xff\f\xc8\xda\xc8\$\xfa\$\xfa\$\xfc<\xaa!i\xe6\xe0W\xcfc\x8a\u0589\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xff\x12\x8fK5[\xe1\xdcJo\x94\xfaQ\r\u007f\x15\xd5<*\xff\x89\x93s\x954\u0486\x80\x00\x00\u07d4\xff\x12\u474e\x06\xaa

\xf8\x86)<\v\x98\xed~\xffx\x88\x05\x89\xd8\xd7&\xb7\x17z\x80\x00\x00\u07d4\xff

s\b\xce\xd28\xa6\xc0\x1a\xd0!<\xa9\xebDe\xd4%\x90\x89Ij\xccg\u05f1\xd4\x00\x00\u07d4\xff&\x1 3\x830'M\xf4\xe0\xa3\b\x1em\xf7\u0758>\xc6\u73c9Ik\x93[\x8b\xbd@\x00\x00\u07d4\xff'&)AH\xb8 Ix\xa97\$\x97\xe4Y\x89\x8e\xd3\xfe\xe3\x89j\xcb=\xf2~\x1f\x88\x00\x00\u07d4\xff=\xedz@\u04ef\xf 0\u05e8\xc4_\xa6\x13j\xa0C=\xb4W\x89Ih\xcc\u041b\x02,\x00\x00\u07d4\xff>\xeeW\xc3Mm\xae\x 97\r\x8b1\x11\x17\xc55\x86\xcd5\x02\x89\\(=A\x03\x94\x10\x00\x00\u07d4\xff>\xf6\xba\x15\x1c!\x b5\x99\x86\xaed\xf6\xe8\"\x8b\u0262\xc73\x89Ik\x93[\x8b\xbd@\x00\x00\u07d4\xffE\xcb4\xc9(6M\x9 c\xc9\u063b\x0074ta\x8f\x06\xf3\x89\x05k\xc7^-

cW\x89_h\xe8\x13\x1e\u03c0\x00\x00\x00\xe0\x94\xffxC\xc7\x01\n\xa7\xe6\x15\x19\xb7b\xdf\xe4\x91 \$\xa7k\x0eN\x8a\u0171y\$A+\x9b\xb0\x00\x00\xe0\x94\xffxT\x17V\xab+pn\rp\xb1\x8a\xdbp\x0f\xc4 \xf1d=\x8a\t(\x96R\x9b\xad\u0708\x00\x00\u07d4\xff\x83\x85PQ\xee\x8f\xfbp\xb4\x81}\xba2\x11\x ed#U\x86\x9d\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xff\x85\x0e;\xe1\xebjMrl\b\xfas\xaa\xd3 X\xf3\x97\x06\u0689i*\xe8\x89p\x81\xd0\x00\x00\u07d4\xff\x86\xe5\xe8\xe1[S\x90\x96\x00\xe4\x1 3\b\u06b7_\x0e\$\xe4k\x890\xebP\xd2\xe1@\x80\x00\x00\u07d4\xff\x88\xeb\xac\xc4\x1b6\x87\xf3\x9eKY\xe1YY\x9b\x80\u02e3?\x89\x15\xaf\x1dx\xb5\x8c@\x00\x00\u07d4\xff\x8a,\xa5\xa8\x133\x f1\x99\x98%_

 $x8d\xec`; @tc\xba\r1\u03c9j\xcb=\xf2\sim\x1f\x88\x00\x00\xe0\x94\xff\xad=\xd7N,\x1fyj\xc6@\xdeV\u0719\xb4\u01d2\xa4\x02\x8a\x01\x0f\f\xf0d\xddY$

 $\label{thm:convolu07d4} $$ \and $$ \$

 $\label{lem:classical} $c\x10\x00\x00\u07d4\xff\xe2\xe2\x8c?\xb7GI\xd7\xe7\x80\u070a]B\%8\xe6\xe4Q\x89\r\xbb\x81\xe0 [\xc1-$

 $\label{thm:condition} $$ \x80\x00\u07d4\xff\xea\xc0h\x1e^\x9d\xb7J\x0f\x93\xf8\xed\%\x89u\x19\x12\x0f\x89Q\xb1\u04$ $$ c3\x92a\xac\x00\x00\u07d4\xff\xea\xc00^\xde:\x91R\x95\xec\x8ea\xc7\xf8\x81\x00oDt\x89\x05\xf6$ $$ 6L\x1f\xe7\xfa\x00\x00\u07d4\xff\xec\tx13\xc65\xba\xca/^W\xa3z\xa9\xfb{I\x9bn}_{\x89+\xa3\x9e\x}$$ 82\xed]t\x00\x00\x00\x00\x94\xff\xf3:;\xd3j\xbd\xbdA'\a\xb8\xe3\x10\xd6\x01\x14T\xa7\xae\x8a\x01\xb1\xae\m.\xf5\x00\x00\x00\x00\u07d4\xff\xf4\xba\u0556c4y\xa2\xa2\x9f\x9a\x8b?x\xee\xfd\a\xe6\xee\x89\x05\xxee\xfd\a\xe6\xee\x89\x05\xxee\xfd\a\xe6\xee\x89\x05\xc7^-$$$

const testnetAllocData =

\x80\xc2!\x80\xc2\"\x80\xc2\\$\x80\xc

\x80\xc2.\x80\xc2/\x80\xc20\x80\xc21\x80\xc22\x80\xc23\x80\xc24\x80\xc25\x80\xc26\x80\xc27\x80\xc22\x80\xc22\x80\xc22\x80\xc25\x80\xc22\x8

x80\u00c1\x8c\x80\u00c1\x8d\x80\u00c1\x8e\x80\u00c1\x8f\x80\u00c1\x90\x80\u00c1\x91\x80\u00c1\x90\x80\u00c1\x90\x80\u00c1\x90\x80\u00c1\x90\x80\u00c1\x90\x80\u00c1\x90\x80\u00c1\x90\x80\u00c1\x80\ 0c1\x92\x80\u00c1\x93\x80\u00c1\x94\x80\u00c1\x95\x80\u00c1\x96\x80\u00c1\x97\x80\u00c1\x 98\x80\u00c1\x99\x80\u00c1\x9a\x80\u00c1\x9b\x80\u00c1\x9c\x80\u00c1\x9d\x80\u00c1\x9e\x8 0\u00c1\x9f\x80\u00c1\xa0\x80\u00c1\xa1\x80\u00c1\xa2\x80\u00c1\xa3\x80\u00c1\xa4\x80\u00c 1\xa5\x80\u00c1\xa6\x80\u00c1\xa7\x80\u00c1\xa8\x80\u00c1\xa9\x80\u00c1\xaa\x80\u00c1\xab\ x80\u00c1\xac\x80\u00c1\xad\x80\u00c1\xae\x80\u00c1\xaf\x80\u00c1\xb0\u00c1\xb0\x80\u00c1\xb0\u00c1\xb0\x80\u00c1\xb0\u00c 0c1\xb2\x80\u00c1\xb3\x80\u00c1\xb4\x80\u00c1\xb5\x80\u00c1\xb6\x80\u00c1\xb7\x80\u00c1\x b8\x80\u00c1\xb9\x80\u00c1\xba\x80\u00c1\xbb\x80\u00c1\xbc\x80\u00c1\xbd\x80\u00c1\xbe\x8 0\u00c1\xbf\x80\u00c1\xc0\x80\u00c1\xc1\x80\u00c1\u0080\u00c1\u00c0\u00c1\u00c 140\u00c1\u0180\u00c1\u01c0\u00c1\u0200\u00c1\u0240\u00c1\u0280\u00c1\u02c0\u00c1\u030 0\u00c1\u0340\u00c1\u0380\u00c1\u03c0\u00c1\u0440\u00c1\u0440\u00c1\u0480\u00c1\u04c0\ u00c1\u0500\u00c1\u0540\u00c1\u0580\u00c1\u05c0\u00c1\u0600\u00c1\u0640\u00c1\u0680\u0 0c1\u06c0\u00c1\u0700\u00c1\u0740\u00c1\u0780\u00c1\u07c0\u00c1\xe0\x80\u00c1\xe1xx80\u 00c1\xe2\x80\u00c1\xe3\x80\u00c1\xe4\x80\u00c1\xe5\x80\u00c1\xe5\x80\u00c1\xe7\x80\u00c1\ xe8\x80\u00c1\xe9\x80\u00c1\xea\x80\u00c1\xeb\x80\u00c1\xec\x80\u00c1\xed\x80\u00c1\xee\x8 0\u00c1\xef\x80\u00c1\xf0\x80\u00c1\xf1\x80\u00c1\xf2\x80\u00c1\xf3\x80\u00c1\xf4\x80\u00c1\x f5\x80\u00c1\xf6\x80\u00c1\xf7\x80\u00c1\xf8\x80\u00c1\xf9\x80\u00c1\xfa\x80\u00c1\xfb\x80\u0 0c1\xfc\x80\u00c1\xfd\x80\u00c1\xfe\x80\u00c1\xfe\x80\u00c1\xff\x80\u3507KT\xa8\xbd\x15)f\xd6?pk\xae\x1f\xfe \xb0A\x19!\xe5\x8d\f\x9f,\x9c\xd0Ft\xed\xea@\x00\x00\x00"

const rinkebyAllocData =

 $\x01\xc2!\x01\xc2'\$

\x01\xc2\x01\xc2\x01\xc20\x01\xc20\x01\xc22\x01\xc22\x01\xc23\x01\xc25\x01\xc26\x01\xc26\x01\xc27\x01\xc28\x01\xc22\x01\

x01\u00c1\xac\x01\u00c1\xad\x01\u00c1\xae\x01\u00c1\xaf\x01\u00c1\xb0\x01\u00c1\xb1\x01\u0 0c1\xb2\x01\u00c1\xb3\x01\u00c1\xb4\x01\u00c1\xb5\x01\u00c1\xb6\x01\u00c1\xb7\x01\u00c1\x b8\x01\u00c1\xb9\x01\u00c1\xba\x01\u00c1\xba\x01\u00c1\xbb\x01\u00c1\xbc\x01\u00c1\xbd\x01\u00c1\xbe\x0 1\u00c1\xbf\x01\u00c1\xc0\x01\u00c1\xc1\x01\u00c1\xc2\x01\u00c1\xc3\x01\u00c1\xc4\x01\u00c 1\xc5\x01\u00c1\xc6\x01\u00c1\xc7\x01\u00c1\xc8\x01\u00c1\xc9\x01\u00c1\xca\x01\u00c1\xcb\x c1\xd2\x01\u00c1\xd3\x01\u00c1\xd4\x01\u00c1\xd5\x01\u00c1\xd6\x01\u00c1\xd7\x01\u00c1\xd 8\x01\u00c1\xd9\x01\u00c1\xda\x01\u00c1\xda\x01\u00c1\xdd\x01\u00c1\xdd\x01\u00c1\xdd\x01\u00c1\xde\x01\ u00c1\xdf\x01\u00c1\xe0\x01\u00c1\xe1\x01\u00c1\xe2\x01\u00c1\xe3\x01\u00c1\xe4\x01\u00c1\ xe5\x01\u00c1\xe6\x01\u00c1\xe7\x01\u00c1\xe8\x01\u00c1\xe9\x01\u00c1\xea\x01\u00c1\xeb\x 01\u00c1\xec\x01\u00c1\xed\x01\u00c1\xed\x01\u00c1\xef\x01\u00c1\xf1\x01\u00c 1\xf2\x01\u00c1\xf3\x01\u00c1\xf4\x01\u00c1\xf5\x01\u00c1\xf6\x01\u00c1\xf7\x01\u00c1\xf8\x01\ u00c1\xf9\x01\u00c1\xfa\x01\u00c1\xfb\x01\u00c1\xfc\x01\u00c1\xfd\x01\u00c1\xfe\x01\u00c1\xff\ x01\xf6\x941\xb9\x8d\x14\x00{\xde\xe67)\x80\x86\x98\x8a\v\xbd1\x18E#\xa0\x02\x00\x00\x00\x00 \x00\x00\x00\x00"

const devAllocData =

"\xf9\x01\x94\xc2\x01\x01\xc2\x02\x01\xc2\x03\x01\xc2\x04\x01\xf0\x94\x1a&3\x8f\r\x90^) \u0337 4\xb9\xc0\x15\x91\x8b\u06ba\$\xb4\xff\x05z\x92\xa3\x87=n\xb2\x01\xbe\x9a\x01\x00\x00\x00\x00\x00\ xcd*=\x9f\x93\x8e\x13\u0354~\xc0Z\xbc\u007f\xe74\u07cd\xd8&\x9a\x01\x00\x00\x00\x00\x00\x00 b\xdb,\xbd#\xb7\x83t\x1e\x8d\u007f\xcfQ\xe4Y\xb4\x97\u499a\x01\x00\x00\x00\x00\x00\x00\x00\x00\x

81:F:\git\coin\ethereum\go-ethereum\core\genesis_test.go
// along with the go-ethereum library. If not, see http://www.gnu.org/licenses/>.

package core

import (
"math/big"
"reflect"

```
"testing"
"github.com/davecgh/go-spew/spew"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/consensus/ethash"
"github.com/ethereum/go-ethereum/core/vm"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
"github.com/ethereum/go-ethereum/params"
)
func TestDefaultGenesisBlock(t *testing.T) {
block, _ := DefaultGenesisBlock().ToBlock()
if block.Hash() != params.MainnetGenesisHash {
t.Errorf("wrong mainnet genesis hash, got %v, want %v", block.Hash(),
params.MainnetGenesisHash)
}
block, = DefaultTestnetGenesisBlock().ToBlock()
if block.Hash() != params.TestnetGenesisHash {
t.Errorf("wrong testnet genesis hash, got %v, want %v", block.Hash(),
params.TestnetGenesisHash)
}
}
func TestSetupGenesis(t *testing.T) {
var (
customghash =
common.HexToHash("0x89c99d90b79719238d2645c7642f2c9295246e80775b38cfd162b696817f
bd50")
          = Genesis{
customg
Config: &params.ChainConfig{HomesteadBlock: big.NewInt(3)},
Alloc: GenesisAlloc{
{1}: {Balance: big.NewInt(1), Storage: map[common.Hash]common.Hash{{1}: {1}}},
},
}
oldcustomg = customg
)
oldcustomg.Config = &params.ChainConfig{HomesteadBlock: big.NewInt(2)}
tests := []struct {
name
         string
       func(ethdb.Database) (*params.ChainConfig, common.Hash, error)
fn
wantConfig *params.ChainConfig
```

```
wantHash common.Hash
wantErr error
}{
name: "genesis without ChainConfig",
fn: func(db ethdb.Database) (*params.ChainConfig, common.Hash, error) {
return SetupGenesisBlock(db, new(Genesis))
},
wantErr: errGenesisNoConfig,
wantConfig: params.AllProtocolChanges,
},
{
name: "no block in DB, genesis == nil",
fn: func(db ethdb.Database) (*params.ChainConfig, common.Hash, error) {
return SetupGenesisBlock(db, nil)
},
wantHash: params.MainnetGenesisHash,
wantConfig: params.MainnetChainConfig,
},
{
name: "mainnet block in DB, genesis == nil",
fn: func(db ethdb.Database) (*params.ChainConfig, common.Hash, error) {
DefaultGenesisBlock().MustCommit(db)
return SetupGenesisBlock(db, nil)
},
wantHash: params.MainnetGenesisHash,
wantConfig: params.MainnetChainConfig,
},
name: "custom block in DB, genesis == nil",
fn: func(db ethdb.Database) (*params.ChainConfig, common.Hash, error) {
customg.MustCommit(db)
return SetupGenesisBlock(db, nil)
wantHash: customghash,
wantConfig: customg.Config,
},
{
name: "custom block in DB, genesis == testnet",
fn: func(db ethdb.Database) (*params.ChainConfig, common.Hash, error) {
customg.MustCommit(db)
return SetupGenesisBlock(db, DefaultTestnetGenesisBlock())
```

```
},
wantErr:
          &GenesisMismatchError{Stored: customghash, New: params.TestnetGenesisHash},
wantHash: params.TestnetGenesisHash,
wantConfig: params.TestnetChainConfig,
},
{
name: "compatible config in DB",
fn: func(db ethdb.Database) (*params.ChainConfig, common.Hash, error) {
oldcustomg.MustCommit(db)
return SetupGenesisBlock(db, &customg)
},
wantHash: customghash,
wantConfig: customg.Config,
},
{
name: "incompatible config in DB",
fn: func(db ethdb.Database) (*params.ChainConfig, common.Hash, error) {
// Commit the 'old' genesis block with Homestead transition at #2.
// Advance to block #4, past the homestead transition block of customg.
genesis := oldcustomg.MustCommit(db)
bc, _ := NewBlockChain(db, oldcustomg.Config, ethash.NewFullFaker(), new(event.TypeMux),
vm.Config{})
bc.SetValidator(bproc{})
bc.InsertChain(makeBlockChainWithDiff(genesis, []int{2, 3, 4, 5}, 0))
bc.CurrentBlock()
// This should return a compatibility error.
return SetupGenesisBlock(db, &customg)
},
wantHash: customghash,
wantConfig: customg.Config,
wantErr: &params.ConfigCompatError{
What:
           "Homestead fork block",
StoredConfig: big.NewInt(2),
NewConfig: big.NewInt(3),
RewindTo:
},
},
}
for _, test := range tests {
db, _ := ethdb.NewMemDatabase()
config, hash, err := test.fn(db)
```

```
// Check the return values.
if !reflect.DeepEqual(err, test.wantErr) {
spew := spew.ConfigState{DisablePointerAddresses: true, DisableCapacities: true}
t.Errorf("%s: returned error %#v, want %#v", test.name, spew.NewFormatter(err),
spew.NewFormatter(test.wantErr))
if !reflect.DeepEqual(config, test.wantConfig) {
t.Errorf("%s:\nreturned %v\nwant %v", test.name, config, test.wantConfig)
if hash != test.wantHash {
t.Errorf("%s: returned hash %s, want %s", test.name, hash.Hex(), test.wantHash.Hex())
} else if err == nil {
// Check database content.
stored := GetBlock(db, test.wantHash, 0)
if stored.Hash() != test.wantHash {
t.Errorf("%s: block in DB has hash %s, want %s", test.name, stored.Hash(), test.wantHash)
}
}
}
}
82:F:\git\coin\ethereum\go-ethereum\core\gen_genesis.go
func (g Genesis) MarshalJSON() ([]byte, error) {
type Genesis struct {
                                             `ison:"config"`
Confia
         *params.ChainConfig
         math.HexOrDecimal64
                                               `json:"nonce"`
Nonce
Timestamp math.HexOrDecimal64
                                                 `json:"timestamp"`
ParentHash common.Hash
                                              `ison:"parentHash"`
                                          `ison:"extraData"`
ExtraData hexutil.Bytes
GasLimit math.HexOrDecimal64
                                               `json:"gasLimit" gencodec:"required"`
Difficulty *math.HexOrDecimal256
                                               `json:"difficulty" gencodec:"required"`
Mixhash common.Hash
                                             `json:"mixHash"`
Coinbase common.Address
                                              `json:"coinbase"`
Alloc
        map[common.UnprefixedAddress]GenesisAccount `json:"alloc"
                                                                         gencodec: "required"`
}
var enc Genesis
enc.Config = g.Config
enc.Nonce = math.HexOrDecimal64(g.Nonce)
enc.Timestamp = math.HexOrDecimal64(g.Timestamp)
enc.ParentHash = g.ParentHash
enc.ExtraData = g.ExtraData
```

```
enc.GasLimit = math.HexOrDecimal64(g.GasLimit)
enc.Difficulty = (*math.HexOrDecimal256)(g.Difficulty)
enc.Mixhash = g.Mixhash
enc.Coinbase = g.Coinbase
if g.Alloc != nil {
enc.Alloc = make(map[common.UnprefixedAddress]GenesisAccount, len(g.Alloc))
for k, v := range g.Alloc {
enc.Alloc[common.UnprefixedAddress(k)] = v
}
}
return json.Marshal(&enc)
}
func (g *Genesis) UnmarshalJSON(input []byte) error {
type Genesis struct {
                                             `ison:"config"`
Config
         *params.ChainConfig
Nonce
         *math.HexOrDecimal64
                                               `json:"nonce"`
Timestamp *math.HexOrDecimal64
                                                 `ison:"timestamp"`
                                              `json:"parentHash"`
ParentHash *common.Hash
                                          `ison:"extraData"`
ExtraData hexutil.Bytes
GasLimit *math.HexOrDecimal64
                                                `json:"gasLimit" gencodec:"required"`
Difficulty *math.HexOrDecimal256
                                               `json:"difficulty" gencodec:"required"`
                                             `ison:"mixHash"`
Mixhash *common.Hash
Coinbase *common.Address
                                              `ison:"coinbase"`
        map[common.UnprefixedAddress]GenesisAccount `json:"alloc"
Alloc
                                                                         gencodec: "required"`
}
var dec Genesis
if err := json.Unmarshal(input, &dec); err != nil {
return err
if dec.Config != nil {
g.Config = dec.Config
}
if dec.Nonce != nil {
g.Nonce = uint64(*dec.Nonce)
}
if dec.Timestamp != nil {
g.Timestamp = uint64(*dec.Timestamp)
if dec.ParentHash != nil {
g.ParentHash = *dec.ParentHash
}
```

```
if dec.ExtraData != nil {
g.ExtraData = dec.ExtraData
if dec.GasLimit == nil {
return errors.New("missing required field 'gasLimit' for Genesis")
g.GasLimit = uint64(*dec.GasLimit)
if dec.Difficulty == nil {
return errors.New("missing required field 'difficulty' for Genesis")
}
g.Difficulty = (*big.Int)(dec.Difficulty)
if dec.Mixhash != nil {
g.Mixhash = *dec.Mixhash
if dec.Coinbase != nil {
g.Coinbase = *dec.Coinbase
}
if dec.Alloc == nil {
return errors.New("missing required field 'alloc' for Genesis")
}
g.Alloc = make(GenesisAlloc, len(dec.Alloc))
for k, v := range dec.Alloc {
g.Alloc[common.Address(k)] = v
return nil
83:F:\git\coin\ethereum\go-ethereum\core\gen_genesis_account.go
func (g GenesisAccount) MarshalJSON() ([]byte, error) {
type GenesisAccount struct {
                             `json:"code,omitempty"`
Code hexutil.Bytes
Storage map[common.Hash]common.Hash `json:"storage,omitempty"`
Balance *math.HexOrDecimal256
                                     `json:"balance" gencodec:"required"`
                                    `ison:"nonce,omitempty"`
Nonce math.HexOrDecimal64
var enc GenesisAccount
enc.Code = g.Code
enc.Storage = g.Storage
enc.Balance = (*math.HexOrDecimal256)(g.Balance)
enc.Nonce = math.HexOrDecimal64(g.Nonce)
return json.Marshal(&enc)
}
```

```
func (g *GenesisAccount) UnmarshalJSON(input []byte) error {
type GenesisAccount struct {
Code hexutil.Bytes
                               `ison:"code,omitempty"`
Storage map[common.Hash]common.Hash `json:"storage,omitempty"`
Balance *math.HexOrDecimal256
                                       'json:"balance" gencodec:"required"
Nonce *math.HexOrDecimal64
                                      `json:"nonce,omitempty"`
}
var dec GenesisAccount
if err := json.Unmarshal(input, &dec); err != nil {
return err
if dec.Code != nil {
g.Code = dec.Code
}
if dec.Storage != nil {
g.Storage = dec.Storage
}
if dec.Balance == nil {
return errors.New("missing required field 'balance' for GenesisAccount")
}
g.Balance = (*big.Int)(dec.Balance)
if dec.Nonce != nil {
g.Nonce = uint64(*dec.Nonce)
}
return nil
}
84:F:\git\coin\ethereum\go-ethereum\core\headerchain.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
crand "crypto/rand"
"errors"
"fmt"
"math"
"math/big"
mrand "math/rand"
"time"
```

```
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/consensus"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/params"
"github.com/hashicorp/golang-lru"
)
const (
headerCacheLimit = 512
tdCacheLimit = 1024
numberCacheLimit = 2048
// HeaderChain implements the basic block header chain logic that is shared by
// core.BlockChain and light.LightChain. It is not usable in itself, only as
// a part of either structure.
// It is not thread safe either, the encapsulating chain structures should do
// the necessary mutex locking/unlocking.
type HeaderChain struct {
config *params.ChainConfig
chainDb
            ethdb.Database
genesisHeader *types.Header
currentHeader
                 *types.Header // Current head of the header chain (may be above the block
chain!)
currentHeaderHash common.Hash // Hash of the current head of the header chain (prevent
recomputing all the time)
headerCache *Iru.Cache // Cache for the most recent block headers
tdCache
           *Iru.Cache // Cache for the most recent block total difficulties
numberCache *Iru.Cache // Cache for the most recent block numbers
procInterrupt func() bool
rand *mrand.Rand
engine consensus. Engine
}
// NewHeaderChain creates a new HeaderChain structure.
```

```
// getValidator should return the parent's validator
// procInterrupt points to the parent's interrupt semaphore
// wg points to the parent's shutdown wait group
func NewHeaderChain(chainDb ethdb.Database, config *params.ChainConfig, engine
consensus. Engine, procInterrupt func() bool) (*HeaderChain, error) {
headerCache, _ := Iru.New(headerCacheLimit)
tdCache, _ := Iru.New(tdCacheLimit)
numberCache, _ := Iru.New(numberCacheLimit)
// Seed a fast but crypto originating random generator
seed, err := crand.Int(crand.Reader, big.NewInt(math.MaxInt64))
if err != nil {
return nil, err
}
hc := &HeaderChain{
config:
           config,
chainDb:
            chainDb,
headerCache: headerCache,
tdCache:
           tdCache.
numberCache: numberCache,
procInterrupt: procInterrupt,
rand:
           mrand.New(mrand.NewSource(seed.Int64())),
engine:
           engine,
}
hc.genesisHeader = hc.GetHeaderByNumber(0)
if hc.genesisHeader == nil {
return nil, ErrNoGenesis
hc.currentHeader = hc.genesisHeader
if head := GetHeadBlockHash(chainDb); head != (common.Hash{}) {
if chead := hc.GetHeaderByHash(head); chead != nil {
hc.currentHeader = chead
}
}
hc.currentHeaderHash = hc.currentHeader.Hash()
return hc, nil
}
```

```
// GetBlockNumber retrieves the block number belonging to the given hash
// from the cache or database
func (hc *HeaderChain) GetBlockNumber(hash common.Hash) uint64 {
if cached, ok := hc.numberCache.Get(hash); ok {
return cached.(uint64)
number := GetBlockNumber(hc.chainDb, hash)
if number != missingNumber {
hc.numberCache.Add(hash, number)
}
return number
}
// WriteHeader writes a header into the local chain, given that its parent is
// already known. If the total difficulty of the newly inserted header becomes
// greater than the current known TD, the canonical chain is re-routed.
//
// Note: This method is not concurrent-safe with inserting blocks simultaneously
// into the chain, as side effects caused by reorganisations cannot be emulated
// without the real blocks. Hence, writing headers directly should only be done
// in two scenarios: pure-header mode of operation (light clients), or properly
// separated header/block phases (non-archive clients).
func (hc *HeaderChain) WriteHeader(header *types.Header) (status WriteStatus, err error) {
// Cache some values to prevent constant recalculation
var (
hash = header.Hash()
number = header.Number.Uint64()
)
// Calculate the total difficulty of the header
ptd := hc.GetTd(header.ParentHash, number-1)
if ptd == nil {
return NonStatTy, consensus.ErrUnknownAncestor
}
localTd := hc.GetTd(hc.currentHeaderHash, hc.currentHeader.Number.Uint64())
externTd := new(big.Int).Add(header.Difficulty, ptd)
// Irrelevant of the canonical status, write the td and header to the database
if err := hc.WriteTd(hash, number, externTd); err != nil {
log.Crit("Failed to write header total difficulty", "err", err)
if err := WriteHeader(hc.chainDb, header); err != nil {
log.Crit("Failed to write header content", "err", err)
```

```
}
// If the total difficulty is higher than our known, add it to the canonical chain
// Second clause in the if statement reduces the vulnerability to selfish mining.
// Please refer to http://www.cs.cornell.edu/~ie53/publications/btcProcFC.pdf
if externTd.Cmp(localTd) > 0 || (externTd.Cmp(localTd) == 0 && mrand.Float64() < 0.5) {
// Delete any canonical number assignments above the new head
for i := number + 1; ; i++ {
hash := GetCanonicalHash(hc.chainDb, i)
if hash == (common.Hash{}) {
break
DeleteCanonicalHash(hc.chainDb, i)
// Overwrite any stale canonical number assignments
var (
headHash = header.ParentHash
headNumber = header.Number.Uint64() - 1
headHeader = hc.GetHeader(headHash, headNumber)
for GetCanonicalHash(hc.chainDb, headNumber) != headHash {
WriteCanonicalHash(hc.chainDb, headHash, headNumber)
headHash = headHeader.ParentHash
headNumber = headHeader.Number.Uint64() - 1
headHeader = hc.GetHeader(headHash, headNumber)
// Extend the canonical chain with the new header
if err := WriteCanonicalHash(hc.chainDb, hash, number); err != nil {
log.Crit("Failed to insert header number", "err", err)
if err := WriteHeadHeaderHash(hc.chainDb, hash); err != nil {
log.Crit("Failed to insert head header hash", "err", err)
}
hc.currentHeaderHash, hc.currentHeader = hash, types.CopyHeader(header)
status = CanonStatTy
} else {
status = SideStatTy
hc.headerCache.Add(hash, header)
hc.numberCache.Add(hash, number)
```

```
return
}
// WhCallback is a callback function for inserting individual headers.
// A callback is used for two reasons: first, in a LightChain, status should be
// processed and light chain events sent, while in a BlockChain this is not
// necessary since chain events are sent after inserting blocks. Second, the
// header writes should be protected by the parent chain mutex individually.
type WhCallback func(*types.Header) error
func (hc *HeaderChain) ValidateHeaderChain(chain []*types.Header, checkFreq int) (int, error) {
// Do a sanity check that the provided chain is actually ordered and linked
for i := 1; i < len(chain); i++ {
if chain[i].Number.Uint64() != chain[i-1].Number.Uint64()+1 || chain[i].ParentHash != chain[i-
1].Hash() {
// Chain broke ancestry, log a messge (programming error) and skip insertion
log.Error("Non contiguous header insert", "number", chain[i].Number, "hash", chain[i].Hash(),
"parent", chain[i].ParentHash, "prevnumber", chain[i-1].Number, "prevhash", chain[i-1].Hash())
return 0, fmt.Errorf("non contiguous insert: item %d is #%d [%x...], item %d is #%d [%x...] (parent
[%x...])", i-1, chain[i-1].Number,
chain[i-1].Hash().Bytes()[:4], i, chain[i].Number, chain[i].Hash().Bytes()[:4], chain[i].ParentHash[:4])
}
// Generate the list of seal verification requests, and start the parallel verifier
seals := make([]bool, len(chain))
for i := 0; i < len(seals)/checkFreq; i++ {
index := i*checkFreq + hc.rand.Intn(checkFreq)
if index >= len(seals) {
index = len(seals) - 1
}
seals[index] = true
}
seals[len(seals)-1] = true // Last should always be verified to avoid junk
abort, results := hc.engine.VerifyHeaders(hc, chain, seals)
defer close(abort)
// Iterate over the headers and ensure they all check out
for i, header := range chain {
```

```
// If the chain is terminating, stop processing blocks
if hc.procInterrupt() {
log.Debug("Premature abort during headers verification")
return 0, errors.New("aborted")
}
// If the header is a banned one, straight out abort
if BadHashes[header.Hash()] {
return i, ErrBlacklistedHash
}
// Otherwise wait for headers checks and ensure they pass
if err := <-results; err != nil {
return i, err
}
}
return 0, nil
}
// InsertHeaderChain attempts to insert the given header chain in to the local
// chain, possibly creating a reorg. If an error is returned, it will return the
// index number of the failing header as well an error describing what went wrong.
//
// The verify parameter can be used to fine tune whether nonce verification
// should be done or not. The reason behind the optional check is because some
// of the header retrieval mechanisms already need to verfy nonces, as well as
// because nonces can be verified sparsely, not needing to check each.
func (hc *HeaderChain) InsertHeaderChain(chain []*types.Header, writeHeader WhCallback, start
time.Time) (int, error) {
// Collect some import statistics to report on
stats := struct{ processed, ignored int }{}
// All headers passed verification, import them into the database
for i, header := range chain {
// Short circuit insertion if shutting down
if hc.procInterrupt() {
log.Debug("Premature abort during headers import")
return i, errors.New("aborted")
}
// If the header's already known, skip it, otherwise store
if hc.GetHeader(header.Hash(), header.Number.Uint64()) != nil {
stats.ignored++
continue
}
```

```
if err := writeHeader(header); err != nil {
return i, err
}
stats.processed++
}
// Report some public statistics so the user has a clue what's going on
last := chain[len(chain)-1]
log.Info("Imported new block headers", "count", stats.processed, "elapsed",
common.PrettyDuration(time.Since(start)),
"number", last.Number, "hash", last.Hash(), "ignored", stats.ignored)
return 0, nil
}
// GetBlockHashesFromHash retrieves a number of block hashes starting at a given
// hash, fetching towards the genesis block.
func (hc *HeaderChain) GetBlockHashesFromHash(hash common.Hash, max uint64)
[]common.Hash {
// Get the origin header from which to fetch
header := hc.GetHeaderByHash(hash)
if header == nil {
return nil
}
// Iterate the headers until enough is collected or the genesis reached
chain := make([]common.Hash, 0, max)
for i := uint64(0); i < max; i++ {
next := header.ParentHash
if header = hc.GetHeader(next, header.Number.Uint64()-1); header == nil {
break
chain = append(chain, next)
if header.Number.Sign() == 0 {
break
}
return chain
}
// GetTd retrieves a block's total difficulty in the canonical chain from the
// database by hash and number, caching it if found.
func (hc *HeaderChain) GetTd(hash common.Hash, number uint64) *big.Int {
// Short circuit if the td's already in the cache, retrieve otherwise
```

```
if cached, ok := hc.tdCache.Get(hash); ok {
return cached.(*big.Int)
}
td := GetTd(hc.chainDb, hash, number)
if td == nil \{
return nil
// Cache the found body for next time and return
hc.tdCache.Add(hash, td)
return td
// GetTdByHash retrieves a block's total difficulty in the canonical chain from the
// database by hash, caching it if found.
func (hc *HeaderChain) GetTdByHash(hash common.Hash) *big.Int {
return hc.GetTd(hash, hc.GetBlockNumber(hash))
}
// WriteTd stores a block's total difficulty into the database, also caching it
// along the way.
func (hc *HeaderChain) WriteTd(hash common.Hash, number uint64, td *big.Int) error {
if err := WriteTd(hc.chainDb, hash, number, td); err != nil {
return err
hc.tdCache.Add(hash, new(big.Int).Set(td))
return nil
}
// GetHeader retrieves a block header from the database by hash and number,
// caching it if found.
func (hc *HeaderChain) GetHeader(hash common.Hash, number uint64) *types.Header {
// Short circuit if the header's already in the cache, retrieve otherwise
if header, ok := hc.headerCache.Get(hash); ok {
return header.(*types.Header)
}
header := GetHeader(hc.chainDb, hash, number)
if header == nil {
return nil
// Cache the found header for next time and return
hc.headerCache.Add(hash, header)
return header
```

```
}
// GetHeaderByHash retrieves a block header from the database by hash, caching it if
// found.
func (hc *HeaderChain) GetHeaderByHash(hash common.Hash) *types.Header {
return hc.GetHeader(hash, hc.GetBlockNumber(hash))
}
// HasHeader checks if a block header is present in the database or not, caching
// it if present.
func (hc *HeaderChain) HasHeader(hash common.Hash) bool {
return hc.GetHeaderByHash(hash) != nil
}
// GetHeaderByNumber retrieves a block header from the database by number,
// caching it (associated with its hash) if found.
func (hc *HeaderChain) GetHeaderByNumber(number uint64) *types.Header {
hash := GetCanonicalHash(hc.chainDb, number)
if hash == (common.Hash{}) {
return nil
return hc.GetHeader(hash, number)
}
// CurrentHeader retrieves the current head header of the canonical chain. The
// header is retrieved from the HeaderChain's internal cache.
func (hc *HeaderChain) CurrentHeader() *types.Header {
return hc.currentHeader
}
// SetCurrentHeader sets the current head header of the canonical chain.
func (hc *HeaderChain) SetCurrentHeader(head *types.Header) {
if err := WriteHeadHeaderHash(hc.chainDb, head.Hash()); err != nil {
log.Crit("Failed to insert head header hash", "err", err)
hc.currentHeader = head
hc.currentHeaderHash = head.Hash()
}
// DeleteCallback is a callback function that is called by SetHead before
// each header is deleted.
type DeleteCallback func(common.Hash, uint64)
```

```
// SetHead rewinds the local chain to a new head. Everything above the new head
// will be deleted and the new one set.
func (hc *HeaderChain) SetHead(head uint64, delFn DeleteCallback) {
height := uint64(0)
if hc.currentHeader != nil {
height = hc.currentHeader.Number.Uint64()
}
for hc.currentHeader != nil && hc.currentHeader.Number.Uint64() > head {
hash := hc.currentHeader.Hash()
num := hc.currentHeader.Number.Uint64()
if delFn != nil {
delFn(hash, num)
}
DeleteHeader(hc.chainDb, hash, num)
DeleteTd(hc.chainDb, hash, num)
hc.currentHeader = hc.GetHeader(hc.currentHeader.ParentHash,
hc.currentHeader.Number.Uint64()-1)
// Roll back the canonical chain numbering
for i := height; i > head; i-- {
DeleteCanonicalHash(hc.chainDb, i)
// Clear out any stale content from the caches
hc.headerCache.Purge()
hc.tdCache.Purge()
hc.numberCache.Purge()
if hc.currentHeader == nil {
hc.currentHeader = hc.genesisHeader
}
hc.currentHeaderHash = hc.currentHeader.Hash()
if err := WriteHeadHeaderHash(hc.chainDb, hc.currentHeaderHash); err != nil {
log.Crit("Failed to reset head header hash", "err", err)
}
}
// SetGenesis sets a new genesis block header for the chain
func (hc *HeaderChain) SetGenesis(head *types.Header) {
hc.genesisHeader = head
```

```
}
// Config retrieves the header chain's chain configuration.
func (hc *HeaderChain) Config() *params.ChainConfig { return hc.config }
// Engine retrieves the header chain's consensus engine.
func (hc *HeaderChain) Engine() consensus.Engine { return hc.engine }
// GetBlock implements consensus. ChainReader, and returns nil for every input as
// a header chain does not have blocks available for retrieval.
func (hc *HeaderChain) GetBlock(hash common.Hash, number uint64) *types.Block {
return nil
}
85:F:\git\coin\ethereum\go-ethereum\core\helper_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package core
import (
"container/list"
"fmt"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/event"
)
// Implement our EthTest Manager
type TestManager struct {
// stateManager *StateManager
eventMux *event.TypeMux
db
        ethdb.Database
txPool
        *TxPool
blockChain *BlockChain
Blocks
         []*types.Block
}
func (tm *TestManager) IsListening() bool {
return false
}
```

```
func (tm *TestManager) IsMining() bool {
return false
}
func (tm *TestManager) PeerCount() int {
return 0
}
func (tm *TestManager) Peers() *list.List {
return list.New()
}
func (tm *TestManager) BlockChain() *BlockChain {
return tm.blockChain
}
func (tm *TestManager) TxPool() *TxPool {
return tm.txPool
}
// func (tm *TestManager) StateManager() *StateManager {
// return tm.stateManager
// }
func (tm *TestManager) EventMux() *event.TypeMux {
return tm.eventMux
}
// func (tm *TestManager) KeyManager() *crypto.KeyManager {
// return nil
// }
func (tm *TestManager) Db() ethdb.Database {
return tm.db
}
func NewTestManager() *TestManager {
db, err := ethdb.NewMemDatabase()
if err != nil {
fmt.Println("Could not create mem-db, failing")
return nil
```

```
}
testManager := &TestManager{}
testManager.eventMux = new(event.TypeMux)
testManager.db = db
// testManager.txPool = NewTxPool(testManager)
// testManager.blockChain = NewBlockChain(testManager)
// testManager.stateManager = NewStateManager(testManager)
return testManager
}
86:F:\git\coin\ethereum\go-ethereum\core\mkalloc.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// +build none
  The mkalloc tool creates the genesis allocation constants in genesis_alloc.go
  It outputs a const declaration that contains an RLP-encoded list of (address, balance) tuples.
    go run mkalloc.go genesis.json
*/
package main
import (
"encoding/json"
"fmt"
"math/big"
"os"
"sort"
"strconv"
"github.com/ethereum/go-ethereum/core"
"github.com/ethereum/go-ethereum/rlp"
)
type allocItem struct{ Addr, Balance *big.Int }
type allocList []allocItem
```

```
func (a allocList) Len() int
                                 { return len(a) }
func (a allocList) Less(i, j int) bool { return a[i].Addr.Cmp(a[j].Addr) < 0 }
func (a allocList) Swap(i, j int) \{a[i], a[j] = a[j], a[i]\}
func makelist(g *core.Genesis) allocList {
a := make(allocList, 0, len(g.Alloc))
for addr, account := range g.Alloc {
if len(account.Storage) > 0 || len(account.Code) > 0 || account.Nonce != 0 {
panic(fmt.Sprintf("can't encode account %x", addr))
}
a = append(a, allocItem{addr.Big(), account.Balance})
}
sort.Sort(a)
return a
}
func makealloc(g *core.Genesis) string {
a := makelist(g)
data, err := rlp.EncodeToBytes(a)
if err != nil {
panic(err)
return strconv.QuoteToASCII(string(data))
}
func main() {
if len(os.Args) != 2 {
fmt.Fprintln(os.Stderr, "Usage: mkalloc genesis.json")
os.Exit(1)
}
g := new(core.Genesis)
file, err := os.Open(os.Args[1])
if err != nil {
panic(err)
}
if err := json.NewDecoder(file).Decode(g); err != nil {
panic(err)
fmt.Println("const allocData =", makealloc(g))
}
```

```
87:F:\git\coin\ethereum\go-ethereum\core\state\database.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"fmt"
"sync"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/trie"
Iru "github.com/hashicorp/golang-Iru"
)
// Trie cache generation limit after which to evic trie nodes from memory.
var MaxTrieCacheGen = uint16(120)
const (
// Number of past tries to keep. This value is chosen such that
// reasonable chain reorg depths will hit an existing trie.
maxPastTries = 12
// Number of codehash->size associations to keep.
codeSizeCacheSize = 100000
)
// Database wraps access to tries and contract code.
type Database interface {
// Accessing tries:
// OpenTrie opens the main account trie.
// OpenStorageTrie opens the storage trie of an account.
OpenTrie(root common.Hash) (Trie, error)
OpenStorageTrie(addrHash, root common.Hash) (Trie, error)
// Accessing contract code:
ContractCode(addrHash, codeHash common.Hash) ([]byte, error)
ContractCodeSize(addrHash, codeHash common.Hash) (int, error)
// CopyTrie returns an independent copy of the given trie.
CopyTrie(Trie) Trie
}
```

```
// Trie is a Ethereum Merkle Trie.
type Trie interface {
TryGet(key []byte) ([]byte, error)
TryUpdate(key, value []byte) error
TryDelete(key []byte) error
CommitTo(trie.DatabaseWriter) (common.Hash, error)
Hash() common. Hash
Nodelterator(startKey []byte) trie.Nodelterator
GetKey([]byte) []byte // TODO(fjl): remove this when SecureTrie is removed
}
// NewDatabase creates a backing store for state. The returned database is safe for
// concurrent use and retains cached trie nodes in memory.
func NewDatabase(db ethdb.Database) Database {
csc, _ := Iru.New(codeSizeCacheSize)
return &cachingDB{db: db, codeSizeCache: csc}
}
type cachingDB struct {
db
          ethdb.Database
mu
          sync.Mutex
            []*trie.SecureTrie
pastTries
codeSizeCache *Iru.Cache
}
func (db *cachingDB) OpenTrie(root common.Hash) (Trie, error) {
db.mu.Lock()
defer db.mu.Unlock()
for i := len(db.pastTries) - 1; i >= 0; i -- \{
if db.pastTries[i].Hash() == root {
return cachedTrie{db.pastTries[i].Copy(), db}, nil
}
tr, err := trie.NewSecure(root, db.db, MaxTrieCacheGen)
if err != nil {
return nil, err
}
return cachedTrie{tr, db}, nil
}
func (db *cachingDB) pushTrie(t *trie.SecureTrie) {
```

```
db.mu.Lock()
defer db.mu.Unlock()
if len(db.pastTries) >= maxPastTries {
copy(db.pastTries, db.pastTries[1:])
db.pastTries[len(db.pastTries)-1] = t
} else {
db.pastTries = append(db.pastTries, t)
}
func (db *cachingDB) OpenStorageTrie(addrHash, root common.Hash) (Trie, error) {
return trie.NewSecure(root, db.db, 0)
}
func (db *cachingDB) CopyTrie(t Trie) Trie {
switch t := t.(type) {
case cachedTrie:
return cachedTrie{t.SecureTrie.Copy(), db}
case *trie.SecureTrie:
return t.Copy()
default:
panic(fmt.Errorf("unknown trie type %T", t))
}
func (db *cachingDB) ContractCode(addrHash, codeHash common.Hash) ([]byte, error) {
code, err := db.db.Get(codeHash[:])
if err == nil {
db.codeSizeCache.Add(codeHash, len(code))
}
return code, err
}
func (db *cachingDB) ContractCodeSize(addrHash, codeHash common.Hash) (int, error) {
if cached, ok := db.codeSizeCache.Get(codeHash); ok {
return cached.(int), nil
}
code, err := db.ContractCode(addrHash, codeHash)
if err == nil {
db.codeSizeCache.Add(codeHash, len(code))
}
```

```
return len(code), err
}
// cachedTrie inserts its trie into a cachingDB on commit.
type cachedTrie struct {
*trie.SecureTrie
db *cachingDB
}
func (m cachedTrie) CommitTo(dbw trie.DatabaseWriter) (common.Hash, error) {
root, err := m.SecureTrie.CommitTo(dbw)
if err == nil {
m.db.pushTrie(m.SecureTrie)
return root, err
}
88:F:\git\coin\ethereum\go-ethereum\core\state\dump.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"encoding/json"
"fmt"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/rlp"
"github.com/ethereum/go-ethereum/trie"
)
type DumpAccount struct {
Balance string
                       `json:"balance"`
Nonce uint64
                       `ison:"nonce"`
                     `ison:"root"`
Root
       string
CodeHash string
                         `json:"codeHash"`
Code
        string
                      `ison:"code"`
Storage map[string]string `json:"storage"`
}
type Dump struct {
                         `ison:"root"`
Root
        string
```

```
Accounts map[string]DumpAccount `ison:"accounts"`
}
func (self *StateDB) RawDump() Dump {
dump := Dump{
        fmt.Sprintf("%x", self.trie.Hash()),
Root:
Accounts: make(map[string]DumpAccount),
}
it := trie.NewIterator(self.trie.NodeIterator(nil))
for it.Next() {
addr := self.trie.GetKey(it.Key)
var data Account
if err := rlp.DecodeBytes(it.Value, &data); err != nil {
panic(err)
}
obj := newObject(nil, common.BytesToAddress(addr), data, nil)
account := DumpAccount{
Balance: data.Balance.String(),
Nonce: data.Nonce,
Root: common.Bytes2Hex(data.Root[:]),
CodeHash: common.Bytes2Hex(data.CodeHash),
Code:
       common.Bytes2Hex(obj.Code(self.db)),
Storage: make(map[string]string),
}
storageIt := trie.NewIterator(obj.getTrie(self.db).NodeIterator(nil))
for storagelt.Next() {
account.Storage[common.Bytes2Hex(self.trie.GetKey(storagelt.Key))] =
common.Bytes2Hex(storageIt.Value)
}
dump.Accounts[common.Bytes2Hex(addr)] = account
}
return dump
}
func (self *StateDB) Dump() []byte {
json, err := json.MarshalIndent(self.RawDump(), "", " ")
if err != nil {
fmt.Println("dump err", err)
}
```

```
return json
}
89:F:\git\coin\ethereum\go-ethereum\core\state\iterator.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"bytes"
"fmt"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/rlp"
"github.com/ethereum/go-ethereum/trie"
)
// Nodelterator is an iterator to traverse the entire state trie post-order,
// including all of the contract code and contract state tries.
type Nodelterator struct {
state *StateDB // State being iterated
statelt trie. Nodelterator // Primary iterator for the global state trie
datalt trie. Nodelterator // Secondary iterator for the data trie of a contract
accountHash common.Hash // Hash of the node containing the account
codeHash
            common. Hash // Hash of the contract source code
                    // Source code associated with a contract
code
          []byte
Hash common. Hash // Hash of the current entry being iterated (nil if not standalone)
Parent common. Hash // Hash of the first full ancestor node (nil if current is the root)
Error error // Failure set in case of an internal error in the iterator
}
// NewNodeIterator creates an post-order state node iterator.
func NewNodelterator(state *StateDB) *Nodelterator {
return &Nodelterator{
state: state,
}
}
```

```
// Next moves the iterator to the next node, returning whether there are any
// further nodes. In case of an internal error this method returns false and
// sets the Error field to the encountered failure.
func (it *Nodelterator) Next() bool {
// If the iterator failed previously, don't do anything
if it.Error != nil {
return false
// Otherwise step forward with the iterator and report any errors
if err := it.step(); err != nil {
it.Error = err
return false
return it.retrieve()
// step moves the iterator to the next entry of the state trie.
func (it *Nodelterator) step() error {
// Abort if we reached the end of the iteration
if it.state == nil {
return nil
// Initialize the iterator if we've just started
if it.stateIt == nil {
it.stateIt = it.state.trie.NodeIterator(nil)
// If we had data nodes previously, we surely have at least state nodes
if it.datalt != nil {
if cont := it.datalt.Next(true); !cont {
if it.datalt.Error() != nil {
return it.datalt.Error()
}
it.datalt = nil
return nil
// If we had source code previously, discard that
if it.code != nil {
it.code = nil
return nil
}
// Step to the next state trie node, terminating if we're out of nodes
```

```
if cont := it.stateIt.Next(true); !cont {
if it.stateIt.Error() != nil {
return it.stateIt.Error()
it.state, it.stateIt = nil, nil
return nil
// If the state trie node is an internal entry, leave as is
if !it.stateIt.Leaf() {
return nil
// Otherwise we've reached an account node, initiate data iteration
var account Account
if err := rlp.Decode(bytes.NewReader(it.statelt.LeafBlob()), &account); err != nil {
return err
dataTrie, err := it.state.db.OpenStorageTrie(common.BytesToHash(it.stateIt.LeafKey()),
account.Root)
if err != nil {
return err
it.dataIt = dataTrie.NodeIterator(nil)
if !it.datalt.Next(true) {
it.datalt = nil
if !bytes.Equal(account.CodeHash, emptyCodeHash) {
it.codeHash = common.BytesToHash(account.CodeHash)
addrHash := common.BytesToHash(it.stateIt.LeafKey())
it.code, err = it.state.db.ContractCode(addrHash, common.BytesToHash(account.CodeHash))
if err != nil {
return fmt.Errorf("code %x: %v", account.CodeHash, err)
}
}
it.accountHash = it.stateIt.Parent()
return nil
}
// retrieve pulls and caches the current state entry the iterator is traversing.
// The method returns whether there are any more data left for inspection.
func (it *Nodelterator) retrieve() bool {
// Clear out any previously set values
it.Hash = common.Hash{}
```

```
// If the iteration's done, return no available data
if it.state == nil {
return false
// Otherwise retrieve the current entry
switch {
case it.datalt != nil:
it.Hash, it.Parent = it.datalt.Hash(), it.datalt.Parent()
if it.Parent == (common.Hash{}) {
it.Parent = it.accountHash
}
case it.code != nil:
it.Hash, it.Parent = it.codeHash, it.accountHash
case it.stateIt != nil:
it.Hash, it.Parent = it.stateIt.Hash(), it.stateIt.Parent()
}
return true
90:F:\git\coin\ethereum\go-ethereum\core\state\iterator_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"bytes"
"testing"
"github.com/ethereum/go-ethereum/common"
)
// Tests that the node iterator indeed walks over the entire database contents.
func TestNodelteratorCoverage(t *testing.T) {
// Create some arbitrary test state to iterate
db, mem, root, _ := makeTestState()
state, err := New(root, db)
if err != nil {
t.Fatalf("failed to create state trie at %x: %v", root, err)
}
// Gather all the node hashes found by the iterator
```

```
hashes := make(map[common.Hash]struct{})
for it := NewNodelterator(state); it.Next(); {
if it.Hash != (common.Hash{}) {
hashes[it.Hash] = struct{}{}
}
}
// Cross check the hashes and the database itself
for hash := range hashes {
if _, err := mem.Get(hash.Bytes()); err != nil {
t.Errorf("failed to retrieve reported node %x: %v", hash, err)
}
}
for _, key := range mem.Keys() {
if bytes.HasPrefix(key, []byte("secure-key-")) {
continue
}
if _, ok := hashes[common.BytesToHash(key)]; !ok {
t.Errorf("state entry not reported %x", key)
}
}
91:F:\git\coin\ethereum\go-ethereum\core\state\journal.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"math/big"
"github.com/ethereum/go-ethereum/common"
)
type journalEntry interface {
undo(*StateDB)
}
type journal []journalEntry
type (
// Changes to the account trie.
```

```
createObjectChange struct {
account *common.Address
resetObjectChange struct {
prev *stateObject
suicideChange struct {
account *common.Address
        bool // whether account had already suicided
prev
prevbalance *big.Int
// Changes to individual accounts.
balanceChange struct {
account *common.Address
prev *big.Int
}
nonceChange struct {
account *common.Address
prev uint64
storageChange struct {
           *common.Address
account
key, prevalue common. Hash
codeChange struct {
account
              *common.Address
prevcode, prevhash []byte
// Changes to other state values.
refundChange struct {
prev *big.Int
addLogChange struct {
txhash common. Hash
}
addPreimageChange struct {
hash common.Hash
touchChange struct {
account *common.Address
```

```
bool
prev
prevDirty bool
}
)
func (ch createObjectChange) undo(s *StateDB) {
delete(s.stateObjects, *ch.account)
delete(s.stateObjectsDirty, *ch.account)
}
func (ch resetObjectChange) undo(s *StateDB) {
s.setStateObject(ch.prev)
}
func (ch suicideChange) undo(s *StateDB) {
obj := s.getStateObject(*ch.account)
if obj != nil {
obj.suicided = ch.prev
obj.setBalance(ch.prevbalance)
// if the object wasn't suicided before, remove
// it from the list of destructed objects as well.
if !obj.suicided {
delete(s.stateObjectsDestructed, *ch.account)
}
}
}
func (ch touchChange) undo(s *StateDB) {
if !ch.prev && *ch.account != ripemd {
s.getStateObject(*ch.account).touched = ch.prev
if !ch.prevDirty {
delete(s.stateObjectsDirty, *ch.account)
}
}
}
func (ch balanceChange) undo(s *StateDB) {
s.getStateObject(*ch.account).setBalance(ch.prev)
}
```

```
func (ch nonceChange) undo(s *StateDB) {
s.getStateObject(*ch.account).setNonce(ch.prev)
}
func (ch codeChange) undo(s *StateDB) {
s.getStateObject(*ch.account).setCode(common.BytesToHash(ch.prevhash), ch.prevcode)
}
func (ch storageChange) undo(s *StateDB) {
s.getStateObject(*ch.account).setState(ch.key, ch.prevalue)
}
func (ch refundChange) undo(s *StateDB) {
s.refund = ch.prev
}
func (ch addLogChange) undo(s *StateDB) {
logs := s.logs[ch.txhash]
if len(logs) == 1 {
delete(s.logs, ch.txhash)
} else {
s.logs[ch.txhash] = logs[:len(logs)-1]
}
}
func (ch addPreimageChange) undo(s *StateDB) {
delete(s.preimages, ch.hash)
}
92:F:\git\coin\ethereum\go-ethereum\core\state\main_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"testing"
checker "gopkg.in/check.v1"
)
func Test(t *testing.T) { checker.TestingT(t) }
```

```
93:F:\git\coin\ethereum\go-ethereum\core\state\managed_state.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"sync"
"github.com/ethereum/go-ethereum/common"
)
type account struct {
stateObject *stateObject
nstart
         uint64
nonces
          []bool
}
type ManagedState struct {
*StateDB
mu sync.RWMutex
accounts map[common.Address]*account
}
// ManagedState returns a new managed state with the statedb as it's backing layer
func ManageState(statedb *StateDB) *ManagedState {
return &ManagedState{
StateDB: statedb.Copy(),
accounts: make(map[common.Address]*account),
}
}
// SetState sets the backing layer of the managed state
func (ms *ManagedState) SetState(statedb *StateDB) {
ms.mu.Lock()
defer ms.mu.Unlock()
ms.StateDB = statedb
// RemoveNonce removed the nonce from the managed state and all future pending nonces
func (ms *ManagedState) RemoveNonce(addr common.Address, n uint64) {
```

```
if ms.hasAccount(addr) {
ms.mu.Lock()
defer ms.mu.Unlock()
account := ms.getAccount(addr)
if n-account.nstart <= uint64(len(account.nonces)) {</pre>
reslice := make([]bool, n-account.nstart)
copy(reslice, account.nonces[:n-account.nstart])
account.nonces = reslice
}
}
// NewNonce returns the new canonical nonce for the managed account
func (ms *ManagedState) NewNonce(addr common.Address) uint64 {
ms.mu.Lock()
defer ms.mu.Unlock()
account := ms.getAccount(addr)
for i, nonce := range account.nonces {
if !nonce {
return account.nstart + uint64(i)
}
}
account.nonces = append(account.nonces, true)
return uint64(len(account.nonces)-1) + account.nstart
}
// GetNonce returns the canonical nonce for the managed or unmanaged account.
//
// Because GetNonce mutates the DB, we must take a write lock.
func (ms *ManagedState) GetNonce(addr common.Address) uint64 {
ms.mu.Lock()
defer ms.mu.Unlock()
if ms.hasAccount(addr) {
account := ms.getAccount(addr)
return uint64(len(account.nonces)) + account.nstart
} else {
return ms.StateDB.GetNonce(addr)
}
```

```
}
// SetNonce sets the new canonical nonce for the managed state
func (ms *ManagedState) SetNonce(addr common.Address, nonce uint64) {
ms.mu.Lock()
defer ms.mu.Unlock()
so := ms.GetOrNewStateObject(addr)
so.SetNonce(nonce)
ms.accounts[addr] = newAccount(so)
}
// HasAccount returns whether the given address is managed or not
func (ms *ManagedState) HasAccount(addr common.Address) bool {
ms.mu.RLock()
defer ms.mu.RUnlock()
return ms.hasAccount(addr)
}
func (ms *ManagedState) hasAccount(addr common.Address) bool {
_, ok := ms.accounts[addr]
return ok
}
// populate the managed state
func (ms *ManagedState) getAccount(addr common.Address) *account {
if account, ok := ms.accounts[addr]; !ok {
so := ms.GetOrNewStateObject(addr)
ms.accounts[addr] = newAccount(so)
} else {
// Always make sure the state account nonce isn't actually higher
// than the tracked one.
so := ms.StateDB.getStateObject(addr)
if so != nil && uint64(len(account.nonces))+account.nstart < so.Nonce() {
ms.accounts[addr] = newAccount(so)
}
}
return ms.accounts[addr]
}
```

```
func newAccount(so *stateObject) *account {
return &account(so, so.Nonce(), nil)
}
94:F:\git\coin\ethereum\go-ethereum\core\state\managed_state_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"testing"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/ethdb"
)
var addr = common.BytesToAddress([]byte("test"))
func create() (*ManagedState, *account) {
db, _ := ethdb.NewMemDatabase()
statedb, _ := New(common.Hash{}, NewDatabase(db))
ms := ManageState(statedb)
ms.StateDB.SetNonce(addr, 100)
ms.accounts[addr] = newAccount(ms.StateDB.getStateObject(addr))
return ms, ms.accounts[addr]
}
func TestNewNonce(t *testing.T) {
ms, _ := create()
nonce := ms.NewNonce(addr)
if nonce != 100 {
t.Error("expected nonce 100. got", nonce)
}
nonce = ms.NewNonce(addr)
if nonce != 101 {
t.Error("expected nonce 101. got", nonce)
}
}
```

```
func TestRemove(t *testing.T) {
ms, account := create()
nn := make([]bool, 10)
for i := range nn {
nn[i] = true
}
account.nonces = append(account.nonces, nn...)
i := uint64(5)
ms.RemoveNonce(addr, account.nstart+i)
if len(account.nonces) != 5 {
t.Error("expected", i, "'th index to be false")
}
func TestReuse(t *testing.T) {
ms, account := create()
nn := make([]bool, 10)
for i := range nn {
nn[i] = true
}
account.nonces = append(account.nonces, nn...)
i := uint64(5)
ms.RemoveNonce(addr, account.nstart+i)
nonce := ms.NewNonce(addr)
if nonce != 105 {
t.Error("expected nonce to be 105. got", nonce)
}
}
func TestRemoteNonceChange(t *testing.T) {
ms, account := create()
nn := make([]bool, 10)
for i := range nn {
nn[i] = true
account.nonces = append(account.nonces, nn...)
ms.NewNonce(addr)
```

```
ms.StateDB.stateObjects[addr].data.Nonce = 200
nonce := ms.NewNonce(addr)
if nonce != 200 {
t.Error("expected nonce after remote update to be", 200, "got", nonce)
}
ms.NewNonce(addr)
ms.NewNonce(addr)
ms.NewNonce(addr)
ms.StateDB.stateObjects[addr].data.Nonce = 200
nonce = ms.NewNonce(addr)
if nonce != 204 {
t.Error("expected nonce after remote update to be", 204, "got", nonce)
}
}
func TestSetNonce(t *testing.T) {
ms, _ := create()
var addr common.Address
ms.SetNonce(addr, 10)
if ms.GetNonce(addr) != 10 {
t.Error("Expected nonce of 10, got", ms.GetNonce(addr))
}
addr[0] = 1
ms.StateDB.SetNonce(addr, 1)
if ms.GetNonce(addr) != 1 {
t.Error("Expected nonce of 1, got", ms.GetNonce(addr))
}
}
95:F:\git\coin\ethereum\go-ethereum\core\state\statedb.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
// Package state provides a caching layer atop the Ethereum state trie.
package state
import (
"fmt"
"math/big"
```

```
"sort"
"sync"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/log"
"github.com/ethereum/go-ethereum/rlp"
"github.com/ethereum/go-ethereum/trie"
)
type revision struct {
id
        int
iournalIndex int
// StateDBs within the ethereum protocol are used to store anything
// within the merkle trie. StateDBs take care of caching and storing
// nested states. It's the general query interface to retrieve:
// * Contracts
// * Accounts
type StateDB struct {
db Database
trie Trie
// This map holds 'live' objects, which will get modified while processing a state transition.
stateObjects
                   map[common.Address]*stateObject
stateObjectsDirty
                     map[common.Address]struct{}
stateObjectsDestructed map[common.Address]struct{}
// DB error.
// State objects are used by the consensus core and VM which are
// unable to deal with database-level errors. Any error that occurs
// during a database read is memoized here and will eventually be returned
// by StateDB.Commit.
dbErr error
// The refund counter, also used by state transitioning.
refund *big.Int
thash, bhash common. Hash
txIndex
           int
```

```
map[common.Hash][]*types.Log
logs
logSize
           uint
preimages map[common.Hash][]byte
// Journal of state modifications. This is the backbone of
// Snapshot and RevertToSnapshot.
journal
           journal
validRevisions []revision
nextRevisionId int
lock sync.Mutex
}
// Create a new state from a given trie
func New(root common.Hash, db Database) (*StateDB, error) {
tr, err := db.OpenTrie(root)
if err != nil {
return nil, err
}
return &StateDB{
db:
                db,
trie:
                tr.
stateObjects:
                    make(map[common.Address]*stateObject),
stateObjectsDirty:
                      make(map[common.Address]struct{}),
stateObjectsDestructed: make(map[common.Address]struct{}),
refund:
                 new(big.Int),
                 make(map[common.Hash][]*types.Log),
logs:
                    make(map[common.Hash][]byte),
preimages:
}, nil
}
// setError remembers the first non-nil error it is called with.
func (self *StateDB) setError(err error) {
if self.dbErr == nil {
self.dbErr = err
}
}
func (self *StateDB) Error() error {
return self.dbErr
}
```

```
// Reset clears out all emphemeral state objects from the state db, but keeps
// the underlying state trie to avoid reloading data for the next operations.
func (self *StateDB) Reset(root common.Hash) error {
tr, err := self.db.OpenTrie(root)
if err != nil {
return err
}
self.trie = tr
self.stateObjects = make(map[common.Address]*stateObject)
self.stateObjectsDirty = make(map[common.Address]struct{})
self.stateObjectsDestructed = make(map[common.Address]struct{})
self.thash = common.Hash{}
self.bhash = common.Hash{}
self.txIndex = 0
self.logs = make(map[common.Hash][]*types.Log)
self.logSize = 0
self.preimages = make(map[common.Hash][]byte)
self.clearJournalAndRefund()
return nil
}
func (self *StateDB) AddLog(log *types.Log) {
self.journal = append(self.journal, addLogChange{txhash: self.thash})
log.TxHash = self.thash
log.BlockHash = self.bhash
log.TxIndex = uint(self.txIndex)
log.Index = self.logSize
self.logs[self.thash] = append(self.logs[self.thash], log)
self.logSize++
}
func (self *StateDB) GetLogs(hash common.Hash) []*types.Log {
return self.logs[hash]
}
func (self *StateDB) Logs() []*types.Log {
var logs []*types.Log
for _, lgs := range self.logs {
logs = append(logs, lgs...)
}
```

```
return logs
}
// AddPreimage records a SHA3 preimage seen by the VM.
func (self *StateDB) AddPreimage(hash common.Hash, preimage []byte) {
if _, ok := self.preimages[hash]; !ok {
self.journal = append(self.journal, addPreimageChange{hash: hash})
pi := make([]byte, len(preimage))
copy(pi, preimage)
self.preimages[hash] = pi
}
}
// Preimages returns a list of SHA3 preimages that have been submitted.
func (self *StateDB) Preimages() map[common.Hash][]byte {
return self.preimages
}
func (self *StateDB) AddRefund(gas *big.Int) {
self.journal = append(self.journal, refundChange{prev: new(big.Int).Set(self.refund)})
self.refund.Add(self.refund, gas)
}
// Exist reports whether the given account address exists in the state.
// Notably this also returns true for suicided accounts.
func (self *StateDB) Exist(addr common.Address) bool {
return self.getStateObject(addr) != nil
}
// Empty returns whether the state object is either non-existent
// or empty according to the EIP161 specification (balance = nonce = code = 0)
func (self *StateDB) Empty(addr common.Address) bool {
so := self.getStateObject(addr)
return so == nil || so.empty()
}
// Retrieve the balance from the given address or 0 if object not found
func (self *StateDB) GetBalance(addr common.Address) *big.Int {
stateObject := self.getStateObject(addr)
if stateObject != nil {
return stateObject.Balance()
}
```

```
return common.Big0
}
func (self *StateDB) GetNonce(addr common.Address) uint64 {
stateObject := self.getStateObject(addr)
if stateObject != nil {
return stateObject.Nonce()
}
return 0
}
func (self *StateDB) GetCode(addr common.Address) []byte {
stateObject := self.getStateObject(addr)
if stateObject != nil {
return stateObject.Code(self.db)
}
return nil
}
func (self *StateDB) GetCodeSize(addr common.Address) int {
stateObject := self.getStateObject(addr)
if stateObject == nil {
return 0
if stateObject.code != nil {
return len(stateObject.code)
}
size, err := self.db.ContractCodeSize(stateObject.addrHash,
common.BytesToHash(stateObject.CodeHash()))
if err != nil {
self.setError(err)
}
return size
}
func (self *StateDB) GetCodeHash(addr common.Address) common.Hash {
stateObject := self.getStateObject(addr)
if stateObject == nil {
return common.Hash{}
}
return common.BytesToHash(stateObject.CodeHash())
```

```
}
func (self *StateDB) GetState(a common.Address, b common.Hash) common.Hash {
stateObject := self.getStateObject(a)
if stateObject != nil {
return stateObject.GetState(self.db, b)
}
return common.Hash{}
}
// StorageTrie returns the storage trie of an account.
// The return value is a copy and is nil for non-existent accounts.
func (self *StateDB) StorageTrie(a common.Address) Trie {
stateObject := self.getStateObject(a)
if stateObject == nil {
return nil
}
cpy := stateObject.deepCopy(self, nil)
return cpy.updateTrie(self.db)
}
func (self *StateDB) HasSuicided(addr common.Address) bool {
stateObject := self.getStateObject(addr)
if stateObject != nil {
return stateObject.suicided
}
return false
}
* SETTERS
*/
// AddBalance adds amount to the account associated with addr
func (self *StateDB) AddBalance(addr common.Address, amount *big.Int) {
stateObject := self.GetOrNewStateObject(addr)
if stateObject != nil {
stateObject.AddBalance(amount)
}
}
```

// SubBalance subtracts amount from the account associated with addr

```
func (self *StateDB) SubBalance(addr common.Address, amount *big.Int) {
stateObject := self.GetOrNewStateObject(addr)
if stateObject != nil {
stateObject.SubBalance(amount)
}
}
func (self *StateDB) SetBalance(addr common.Address, amount *big.Int) {
stateObject := self.GetOrNewStateObject(addr)
if stateObject != nil {
stateObject.SetBalance(amount)
}
}
func (self *StateDB) SetNonce(addr common.Address, nonce uint64) {
stateObject := self.GetOrNewStateObject(addr)
if stateObject != nil {
stateObject.SetNonce(nonce)
}
func (self *StateDB) SetCode(addr common.Address, code []byte) {
stateObject := self.GetOrNewStateObject(addr)
if stateObject != nil {
stateObject.SetCode(crypto.Keccak256Hash(code), code)
}
}
func (self *StateDB) SetState(addr common.Address, key common.Hash, value common.Hash) {
stateObject := self.GetOrNewStateObject(addr)
if stateObject != nil {
stateObject.SetState(self.db, key, value)
}
}
// Suicide marks the given account as suicided.
// This clears the account balance.
//
// The account's state object is still available until the state is committed,
// getStateObject will return a non-nil account after Suicide.
func (self *StateDB) Suicide(addr common.Address) bool {
stateObject := self.getStateObject(addr)
```

```
if stateObject == nil {
return false
self.journal = append(self.journal, suicideChange{
account:
            &addr,
          stateObject.suicided,
prev:
prevbalance: new(big.Int).Set(stateObject.Balance()),
stateObject.markSuicided()
stateObject.data.Balance = new(big.Int)
self.stateObjectsDestructed[addr] = struct{}{}
return true
}
//
// Setting, updating & deleting state object methods
//
// updateStateObject writes the given object to the trie.
func (self *StateDB) updateStateObject(stateObject *stateObject) {
addr := stateObject.Address()
data, err := rlp.EncodeToBytes(stateObject)
if err != nil {
panic(fmt.Errorf("can't encode object at %x: %v", addr[:], err))
}
self.setError(self.trie.TryUpdate(addr[:], data))
}
// deleteStateObject removes the given object from the state trie.
func (self *StateDB) deleteStateObject(stateObject *stateObject) {
stateObject.deleted = true
addr := stateObject.Address()
self.setError(self.trie.TryDelete(addr[:]))
}
// Retrieve a state object given my the address. Returns nil if not found.
func (self *StateDB) getStateObject(addr common.Address) (stateObject *stateObject) {
// Prefer 'live' objects.
if obj := self.stateObjects[addr]; obj != nil {
if obj.deleted {
return nil
```

```
}
return obj
}
// Load the object from the database.
enc, err := self.trie.TryGet(addr[:])
if len(enc) == 0 {
self.setError(err)
return nil
}
var data Account
if err := rlp.DecodeBytes(enc, &data); err != nil {
log.Error("Failed to decode state object", "addr", addr, "err", err)
return nil
}
// Insert into the live set.
obj := newObject(self, addr, data, self.MarkStateObjectDirty)
self.setStateObject(obj)
return obj
}
func (self *StateDB) setStateObject(object *stateObject) {
self.stateObjects[object.Address()] = object
}
// Retrieve a state object or create a new state object if nil
func (self *StateDB) GetOrNewStateObject(addr common.Address) *stateObject {
stateObject := self.getStateObject(addr)
if stateObject == nil || stateObject.deleted {
stateObject, _ = self.createObject(addr)
}
return stateObject
}
// MarkStateObjectDirty adds the specified object to the dirty map to avoid costly
// state object cache iteration to find a handful of modified ones.
func (self *StateDB) MarkStateObjectDirty(addr common.Address) {
self.stateObjectsDirty[addr] = struct{}{}
}
// createObject creates a new state object. If there is an existing account with
// the given address, it is overwritten and returned as the second return value.
```

```
func (self *StateDB) createObject(addr common.Address) (newobj, prev *stateObject) {
prev = self.getStateObject(addr)
newobj = newObject(self, addr, Account{}, self.MarkStateObjectDirty)
newobj.setNonce(0) // sets the object to dirty
if prev == nil {
self.journal = append(self.journal, createObjectChange{account: &addr})
} else {
self.journal = append(self.journal, resetObjectChange{prev: prev})
self.setStateObject(newobj)
return newobj, prev
}
// CreateAccount explicitly creates a state object. If a state object with the address
// already exists the balance is carried over to the new account.
//
// CreateAccount is called during the EVM CREATE operation. The situation might arise that
// a contract does the following:
//
// 1. sends funds to sha(account ++ (nonce + 1))
// 2. tx_create(sha(account ++ nonce)) (note that this gets the address of 1)
//
// Carrying over the balance ensures that Ether doesn't disappear.
func (self *StateDB) CreateAccount(addr common.Address) {
new, prev := self.createObject(addr)
if prev != nil {
new.setBalance(prev.data.Balance)
}
}
func (db *StateDB) ForEachStorage(addr common.Address, cb func(key, value common.Hash)
bool) {
so := db.getStateObject(addr)
if so == nil {
return
}
// When iterating over the storage check the cache first
for h, value := range so.cachedStorage {
cb(h, value)
}
```

```
it := trie.NewIterator(so.getTrie(db.db).NodeIterator(nil))
for it.Next() {
// ignore cached values
key := common.BytesToHash(db.trie.GetKey(it.Key))
if _, ok := so.cachedStorage[key]; !ok {
cb(key, common.BytesToHash(it.Value))
}
}
}
// Copy creates a deep, independent copy of the state.
// Snapshots of the copied state cannot be applied to the copy.
func (self *StateDB) Copy() *StateDB {
self.lock.Lock()
defer self.lock.Unlock()
// Copy all the basic fields, initialize the memory ones
state := &StateDB{
db:
                self.db.
               self.trie.
trie:
stateObjects:
                    make(map[common.Address]*stateObject, len(self.stateObjectsDirty)),
stateObjectsDirty:
                     make(map[common.Address]struct{}, len(self.stateObjectsDirty)),
stateObjectsDestructed: make(map[common.Address]struct{}, len(self.stateObjectsDestructed)),
refund:
                  new(big.Int).Set(self.refund),
                make(map[common.Hash][]*types.Log, len(self.logs)),
logs:
logSize:
                  self.logSize,
                    make(map[common.Hash][]byte),
preimages:
}
// Copy the dirty states, logs, and preimages
for addr := range self.stateObjectsDirty {
state.stateObjects[addr] = self.stateObjects[addr].deepCopy(state, state.MarkStateObjectDirty)
state.stateObjectsDirty[addr] = struct{}{}
if self.stateObjects[addr].suicided {
state.stateObjectsDestructed[addr] = struct{}{}
}
}
for hash, logs := range self.logs {
state.logs[hash] = make([]*types.Log, len(logs))
copy(state.logs[hash], logs)
}
for hash, preimage := range self.preimages {
state.preimages[hash] = preimage
```

```
}
return state
}
// Snapshot returns an identifier for the current revision of the state.
func (self *StateDB) Snapshot() int {
id := self.nextRevisionId
self.nextRevisionId++
self.validRevisions = append(self.validRevisions, revision{id, len(self.journal)})
return id
// RevertToSnapshot reverts all state changes made since the given revision.
func (self *StateDB) RevertToSnapshot(revid int) {
// Find the snapshot in the stack of valid snapshots.
idx := sort.Search(len(self.validRevisions), func(i int) bool {
return self.validRevisions[i].id >= revid
})
if idx == len(self.validRevisions) || self.validRevisions[idx].id != revid {
panic(fmt.Errorf("revision id %v cannot be reverted", revid))
}
snapshot := self.validRevisions[idx].journalIndex
// Replay the journal to undo changes.
for i := len(self.journal) - 1; i >= snapshot; i-- {
self.journal[i].undo(self)
}
self.journal = self.journal[:snapshot]
// Remove invalidated snapshots from the stack.
self.validRevisions = self.validRevisions[:idx]
}
// GetRefund returns the current value of the refund counter.
// The return value must not be modified by the caller and will become
// invalid at the next call to AddRefund.
func (self *StateDB) GetRefund() *big.Int {
return self.refund
// IntermediateRoot computes the current root hash of the state trie.
// It is called in between transactions to get the root hash that
```

```
// goes into transaction receipts.
func (s *StateDB) IntermediateRoot(deleteEmptyObjects bool) common.Hash {
for addr := range s.stateObjectsDirty {
stateObject := s.stateObjects[addr]
if stateObject.suicided || (deleteEmptyObjects && stateObject.empty()) {
s.deleteStateObject(stateObject)
} else {
stateObject.updateRoot(s.db)
s.updateStateObject(stateObject)
}
// Invalidate journal because reverting across transactions is not allowed.
s.clearJournalAndRefund()
return s.trie.Hash()
}
// Prepare sets the current transaction hash and index and block hash which is
// used when the EVM emits new state logs.
func (self *StateDB) Prepare(thash, bhash common.Hash, ti int) {
self.thash = thash
self.bhash = bhash
self.txIndex = ti
}
// Finalise finalises the state by removing the self destructed objects
// in the current stateObjectsDestructed buffer and clears the journal
// as well as the refunds.
//
// Please note that Finalise is used by EIP#98 and is used instead of
// IntermediateRoot.
func (s *StateDB) Finalise() {
for addr := range s.stateObjectsDestructed {
s.deleteStateObject(s.stateObjects[addr])
s.clearJournalAndRefund()
}
// DeleteSuicides flags the suicided objects for deletion so that it
// won't be referenced again when called / queried up on.
//
// DeleteSuicides should not be used for consensus related updates
// under any circumstances.
```

```
func (s *StateDB) DeleteSuicides() {
// Reset refund so that any used-gas calculations can use this method.
s.clearJournalAndRefund()
for addr := range s.stateObjectsDirty {
stateObject := s.stateObjects[addr]
// If the object has been removed by a suicide
// flag the object as deleted.
if stateObject.suicided {
stateObject.deleted = true
}
delete(s.stateObjectsDirty, addr)
}
func (s *StateDB) clearJournalAndRefund() {
s.journal = nil
s.validRevisions = s.validRevisions[:0]
s.refund = new(big.Int)
}
// CommitTo writes the state to the given database.
func (s *StateDB) CommitTo(dbw trie.DatabaseWriter, deleteEmptyObjects bool) (root
common.Hash, err error) {
defer s.clearJournalAndRefund()
// Commit objects to the trie.
for addr, stateObject := range s.stateObjects {
_, isDirty := s.stateObjectsDirty[addr]
switch {
case stateObject.suicided || (isDirty && deleteEmptyObjects && stateObject.empty()):
// If the object has been removed, don't bother syncing it
// and just mark it for deletion in the trie.
s.deleteStateObject(stateObject)
case isDirty:
// Write any contract code associated with the state object
if stateObject.code != nil && stateObject.dirtyCode {
if err := dbw.Put(stateObject.CodeHash(), stateObject.code); err != nil {
return common.Hash{}, err
}
stateObject.dirtyCode = false
```

```
}
// Write any storage changes in the state object to its storage trie.
if err := stateObject.CommitTrie(s.db, dbw); err != nil {
return common.Hash{}, err
}
// Update the object in the main account trie.
s.updateStateObject(stateObject)
}
delete(s.stateObjectsDirty, addr)
}
// Write trie changes.
root, err = s.trie.CommitTo(dbw)
log.Debug("Trie cache stats after commit", "misses", trie.CacheMisses(), "unloads",
trie.CacheUnloads())
return root, err
}
96:F:\git\coin\ethereum\go-ethereum\core\state\statedb_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"bytes"
"encoding/binary"
"fmt"
"math"
"math/big"
"math/rand"
"reflect"
"strings"
"testing"
"testing/quick"
check "gopkg.in/check.v1"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/core/types"
"github.com/ethereum/go-ethereum/ethdb"
)
// Tests that updating a state trie does not leak any database writes prior to
```

```
// actually committing the state.
func TestUpdateLeaks(t *testing.T) {
// Create an empty state database
db, := ethdb.NewMemDatabase()
state, _ := New(common.Hash{}, NewDatabase(db))
// Update it with some accounts
for i := byte(0); i < 255; i++ \{
addr := common.BytesToAddress([]byte{i})
state.AddBalance(addr, big.NewInt(int64(11*i)))
state.SetNonce(addr, uint64(42*i))
if i\%2 == 0 {
state.SetState(addr, common.BytesToHash([]byte{i, i, i}), common.BytesToHash([]byte{i, i, i, i}))
if i\%3 == 0 {
state.SetCode(addr, []byte{i, i, i, i, i})
}
state.IntermediateRoot(false)
// Ensure that no data was leaked into the database
for _, key := range db.Keys() {
value, _ := db.Get(key)
t.Errorf("State leaked into database: %x -> %x", key, value)
}
}
// Tests that no intermediate state of an object is stored into the database,
// only the one right before the commit.
func TestIntermediateLeaks(t *testing.T) {
// Create two state databases, one transitioning to the final state, the other final from the beginning
transDb, _ := ethdb.NewMemDatabase()
finalDb, _ := ethdb.NewMemDatabase()
transState, _ := New(common.Hash{}, NewDatabase(transDb))
finalState, _ := New(common.Hash{}, NewDatabase(finalDb))
modify := func(state *StateDB, addr common.Address, i, tweak byte) {
state.SetBalance(addr, big.NewInt(int64(11*i)+int64(tweak)))
state.SetNonce(addr, uint64(42*i+tweak))
if i\%2 == 0 {
state.SetState(addr, common.Hash{i, i, i, 0}, common.Hash{})
state.SetState(addr, common.Hash{i, i, i, tweak}, common.Hash{i, i, i, i, tweak})
}
```

```
if i\%3 == 0 {
state.SetCode(addr, []byte{i, i, i, i, i, tweak})
}
}
// Modify the transient state.
for i := byte(0); i < 255; i++ \{
modify(transState, common.Address{byte(i)}, i, 0)
// Write modifications to trie.
transState.IntermediateRoot(false)
// Overwrite all the data with new values in the transient database.
for i := byte(0); i < 255; i++ {
modify(transState, common.Address{byte(i)}, i, 99)
modify(finalState, common.Address{byte(i)}, i, 99)
}
// Commit and cross check the databases.
if _, err := transState.CommitTo(transDb, false); err != nil {
t.Fatalf("failed to commit transition state: %v", err)
}
if _, err := finalState.CommitTo(finalDb, false); err != nil {
t.Fatalf("failed to commit final state: %v", err)
}
for _, key := range finalDb.Keys() {
if _, err := transDb.Get(key); err != nil {
val, _ := finalDb.Get(key)
t.Errorf("entry missing from the transition database: %x -> %x", key, val)
}
}
for _, key := range transDb.Keys() {
if _, err := finalDb.Get(key); err != nil {
val, _ := transDb.Get(key)
t.Errorf("extra entry in the transition database: %x -> %x", key, val)
}
}
}
func TestSnapshotRandom(t *testing.T) {
config := &quick.Config{MaxCount: 1000}
err := quick.Check((*snapshotTest).run, config)
```

```
if cerr, ok := err.(*quick.CheckError); ok {
test := cerr.ln[0].(*snapshotTest)
t.Errorf("%v:\n%s", test.err, test)
} else if err != nil {
t.Error(err)
}
// A snapshotTest checks that reverting StateDB snapshots properly undoes all changes
// captured by the snapshot. Instances of this test with pseudorandom content are created
// by Generate.
//
// The test works as follows:
// A new state is created and all actions are applied to it. Several snapshots are taken
// in between actions. The test then reverts each snapshot. For each snapshot the actions
// leading up to it are replayed on a fresh, empty state. The behaviour of all public
// accessor methods on the reverted state must match the return value of the equivalent
// methods on the replayed state.
type snapshotTest struct {
        []common.Address // all account addresses
addrs
actions []testAction // modifications to the state
snapshots []int
                      // actions indexes at which snapshot is taken
err
       error
                   // failure details are reported through this field
}
type testAction struct {
name string
fn func(testAction, *StateDB)
args []int64
noAddr bool
}
// newTestAction creates a random action that changes state.
func newTestAction(addr common.Address, r *rand.Rand) testAction {
actions := []testAction{
{
name: "SetBalance",
fn: func(a testAction, s *StateDB) {
s.SetBalance(addr, big.NewInt(a.args[0]))
},
args: make([]int64, 1),
```

```
},
{
name: "AddBalance",
fn: func(a testAction, s *StateDB) {
s.AddBalance(addr, big.NewInt(a.args[0]))
},
args: make([]int64, 1),
},
{
name: "SetNonce",
fn: func(a testAction, s *StateDB) {
s.SetNonce(addr, uint64(a.args[0]))
},
args: make([]int64, 1),
},
{
name: "SetState",
fn: func(a testAction, s *StateDB) {
var key, val common. Hash
binary.BigEndian.PutUint16(key[:], uint16(a.args[0]))
binary.BigEndian.PutUint16(val[:], uint16(a.args[1]))
s.SetState(addr, key, val)
},
args: make([]int64, 2),
},
{
name: "SetCode",
fn: func(a testAction, s *StateDB) {
code := make([]byte, 16)
binary.BigEndian.PutUint64(code, uint64(a.args[0]))
binary.BigEndian.PutUint64(code[8:], uint64(a.args[1]))
s.SetCode(addr, code)
},
args: make([]int64, 2),
},
{
name: "CreateAccount",
fn: func(a testAction, s *StateDB) {
s.CreateAccount(addr)
},
},
{
```

```
name: "Suicide",
fn: func(a testAction, s *StateDB) {
s.Suicide(addr)
},
},
name: "AddRefund",
fn: func(a testAction, s *StateDB) {
s.AddRefund(big.NewInt(a.args[0]))
},
args: make([]int64, 1),
noAddr: true,
},
{
name: "AddLog",
fn: func(a testAction, s *StateDB) {
data := make([]byte, 2)
binary.BigEndian.PutUint16(data, uint16(a.args[0]))
s.AddLog(&types.Log{Address: addr, Data: data})
},
args: make([]int64, 1),
},
}
action := actions[r.Intn(len(actions))]
var nameargs []string
if !action.noAddr {
nameargs = append(nameargs, addr.Hex())
}
for _, i := range action.args {
action.args[i] = rand.Int63n(100)
nameargs = append(nameargs, fmt.Sprint(action.args[i]))
}
action.name += strings.Join(nameargs, ", ")
return action
}
// Generate returns a new snapshot test of the given size. All randomness is
// derived from r.
func (*snapshotTest) Generate(r *rand.Rand, size int) reflect.Value {
// Generate random actions.
addrs := make([]common.Address, 50)
for i := range addrs {
```

```
addrs[i][0] = byte(i)
}
actions := make([]testAction, size)
for i := range actions {
addr := addrs[r.Intn(len(addrs))]
actions[i] = newTestAction(addr, r)
}
// Generate snapshot indexes.
nsnapshots := int(math.Sqrt(float64(size)))
if size > 0 && nsnapshots == 0 {
nsnapshots = 1
}
snapshots := make([]int, nsnapshots)
snaplen := len(actions) / nsnapshots
for i := range snapshots {
// Try to place the snapshots some number of actions apart from each other.
snapshots[i] = (i * snaplen) + r.Intn(snaplen)
}
return reflect. Value Of (&snapshot Test {addrs, actions, snapshots, nil})
}
func (test *snapshotTest) String() string {
out := new(bytes.Buffer)
sindex := 0
for i, action := range test.actions {
if len(test.snapshots) > sindex && i == test.snapshots[sindex] {
fmt.Fprintf(out, "---- snapshot %d ----\n", sindex)
sindex++
fmt.Fprintf(out, "%4d: %s\n", i, action.name)
}
return out.String()
}
func (test *snapshotTest) run() bool {
// Run all actions and create snapshots.
var (
db, _
          = ethdb.NewMemDatabase()
         = New(common.Hash{}, NewDatabase(db))
snapshotRevs = make([]int, len(test.snapshots))
sindex
           = 0
)
```

```
for i, action := range test.actions {
if len(test.snapshots) > sindex && i == test.snapshots[sindex] {
snapshotRevs[sindex] = state.Snapshot()
sindex++
}
action.fn(action, state)
}
// Revert all snapshots in reverse order. Each revert must yield a state
// that is equivalent to fresh state with all actions up the snapshot applied.
for sindex--; sindex >= 0; sindex-- {
checkstate, _ := New(common.Hash{}, NewDatabase(db))
for _, action := range test.actions[:test.snapshots[sindex]] {
action.fn(action, checkstate)
}
state.RevertToSnapshot(snapshotRevs[sindex])
if err := test.checkEqual(state, checkstate); err != nil {
test.err = fmt.Errorf("state mismatch after revert to snapshot %d\n%v", sindex, err)
return false
}
return true
}
// checkEqual checks that methods of state and checkstate return the same values.
func (test *snapshotTest) checkEqual(state, checkstate *StateDB) error {
for _, addr := range test.addrs {
var err error
checkeq := func(op string, a, b interface{}) bool {
if err == nil && !reflect.DeepEqual(a, b) {
err = fmt.Errorf("got %s(%s) == %v, want %v", op, addr.Hex(), a, b)
return false
}
return true
// Check basic accessor methods.
checkeq("Exist", state.Exist(addr), checkstate.Exist(addr))
checkeg("HasSuicided", state.HasSuicided(addr), checkstate.HasSuicided(addr))
checkeq("GetBalance", state.GetBalance(addr), checkstate.GetBalance(addr))
checkeg("GetNonce", state.GetNonce(addr), checkstate.GetNonce(addr))
checkeq("GetCode", state.GetCode(addr), checkstate.GetCode(addr))
checkeg("GetCodeHash", state.GetCodeHash(addr), checkstate.GetCodeHash(addr))
```

```
checkeq("GetCodeSize", state.GetCodeSize(addr), checkstate.GetCodeSize(addr))
// Check storage.
if obj := state.getStateObject(addr); obj != nil {
state.ForEachStorage(addr, func(key, val common.Hash) bool {
return checkeq("GetState("+key.Hex()+")", val, checkstate.GetState(addr, key))
})
checkstate.ForEachStorage(addr, func(key, checkval common.Hash) bool {
return checkeq("GetState("+key.Hex()+")", state.GetState(addr, key), checkval)
})
}
if err != nil {
return err
}
}
if state.GetRefund().Cmp(checkstate.GetRefund()) != 0 {
return fmt.Errorf("got GetRefund() == %d, want GetRefund() == %d",
state.GetRefund(), checkstate.GetRefund())
if !reflect.DeepEqual(state.GetLogs(common.Hash{})), checkstate.GetLogs(common.Hash{})) {
return fmt.Errorf("got GetLogs(common.Hash{}) == %v, want GetLogs(common.Hash{}) == %v",
state.GetLogs(common.Hash{}), checkstate.GetLogs(common.Hash{}))
}
return nil
}
func (s *StateSuite) TestTouchDelete(c *check.C) {
s.state.GetOrNewStateObject(common.Address{})
root, := s.state.CommitTo(s.db, false)
s.state.Reset(root)
snapshot := s.state.Snapshot()
s.state.AddBalance(common.Address{}, new(big.Int))
if len(s.state.stateObjectsDirty) != 1 {
c.Fatal("expected one dirty state object")
}
s.state.RevertToSnapshot(snapshot)
if len(s.state.stateObjectsDirty) != 0 {
c.Fatal("expected no dirty state object")
}
}
```

```
97:F:\git\coin\ethereum\go-ethereum\core\state\state_object.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"bytes"
"fmt"
"io"
"math/big"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/rlp"
"github.com/ethereum/go-ethereum/trie"
)
var emptyCodeHash = crypto.Keccak256(nil)
type Code []byte
func (self Code) String() string {
return string(self) //strings.Join(Disassemble(self), " ")
}
type Storage map[common.Hash]common.Hash
func (self Storage) String() (str string) {
for key, value := range self {
str += fmt.Sprintf("%X : %X\n", key, value)
}
return
}
func (self Storage) Copy() Storage {
cpy := make(Storage)
for key, value := range self {
```

cpy[key] = value

}

```
return cpy
}
// stateObject represents an Ethereum account which is being modified.
//
// The usage pattern is as follows:
// First you need to obtain a state object.
// Account values can be accessed and modified through the object.
// Finally, call CommitTrie to write the modified storage trie into a database.
type stateObject struct {
address common.Address
addrHash common. Hash // hash of ethereum address of the account
data
       Account
      *StateDB
db
// DB error.
// State objects are used by the consensus core and VM which are
// unable to deal with database-level errors. Any error that occurs
// during a database read is memoized here and will eventually be returned
// by StateDB.Commit.
dbErr error
// Write caches.
trie Trie // storage trie, which becomes non-nil on first access
code Code // contract bytecode, which gets set when code is loaded
cachedStorage Storage // Storage entry cache to avoid duplicate reads
dirtyStorage Storage // Storage entries that need to be flushed to disk
// Cache flags.
// When an object is marked suicided it will be delete from the trie
// during the "update" phase of the state transition.
dirtyCode bool // true if the code was updated
suicided bool
touched bool
deleted bool
onDirty func(addr common.Address) // Callback method to mark a state object newly dirty
}
// empty returns whether the account is considered empty.
func (s *stateObject) empty() bool {
return s.data.Nonce == 0 && s.data.Balance.Sign() == 0 && bytes.Equal(s.data.CodeHash,
```

```
emptyCodeHash)
}
// Account is the Ethereum consensus representation of accounts.
// These objects are stored in the main account trie.
type Account struct {
Nonce uint64
Balance *big.Int
       common. Hash // merkle root of the storage trie
CodeHash []byte
}
// newObject creates a state object.
func newObject(db *StateDB, address common.Address, data Account, onDirty func(addr
common.Address)) *stateObject {
if data.Balance == nil {
data.Balance = new(big.Int)
}
if data.CodeHash == nil {
data.CodeHash = emptyCodeHash
}
return &stateObject{
db:
          db.
address:
             address,
addrHash:
              crypto.Keccak256Hash(address[:]),
data:
           data.
cachedStorage: make(Storage),
dirtyStorage: make(Storage),
onDirty:
         onDirty,
}
}
// EncodeRLP implements rlp.Encoder.
func (c *stateObject) EncodeRLP(w io.Writer) error {
return rlp.Encode(w, c.data)
}
// setError remembers the first non-nil error it is called with.
func (self *stateObject) setError(err error) {
if self.dbErr == nil {
self.dbErr = err
}
```

```
}
func (self *stateObject) markSuicided() {
self.suicided = true
if self.onDirty != nil {
self.onDirty(self.Address())
self.onDirty = nil
}
}
func (c *stateObject) touch() {
c.db.journal = append(c.db.journal, touchChange{
account: &c.address,
        c.touched,
prev:
prevDirty: c.onDirty == nil,
})
if c.onDirty != nil {
c.onDirty(c.Address())
c.onDirty = nil
}
c.touched = true
}
func (c *stateObject) getTrie(db Database) Trie {
if c.trie == nil {
var err error
c.trie, err = db.OpenStorageTrie(c.addrHash, c.data.Root)
if err != nil {
c.trie, _ = db.OpenStorageTrie(c.addrHash, common.Hash{})
c.setError(fmt.Errorf("can't create storage trie: %v", err))
}
}
return c.trie
}
// GetState returns a value in account storage.
func (self *stateObject) GetState(db Database, key common.Hash) common.Hash {
value, exists := self.cachedStorage[key]
if exists {
return value
}
// Load from DB in case it is missing.
```

```
enc, err := self.getTrie(db).TryGet(key[:])
if err != nil {
self.setError(err)
return common.Hash{}
}
if len(enc) > 0 {
_, content, _, err := rlp.Split(enc)
if err != nil {
self.setError(err)
}
value.SetBytes(content)
}
if (value != common.Hash{}) {
self.cachedStorage[key] = value
}
return value
}
// SetState updates a value in account storage.
func (self *stateObject) SetState(db Database, key, value common.Hash) {
self.db.journal = append(self.db.journal, storageChange{
account: &self.address,
key:
        key,
prevalue: self.GetState(db, key),
self.setState(key, value)
}
func (self *stateObject) setState(key, value common.Hash) {
self.cachedStorage[key] = value
self.dirtyStorage[key] = value
if self.onDirty != nil {
self.onDirty(self.Address())
self.onDirty = nil
}
}
// updateTrie writes cached storage modifications into the object's storage trie.
func (self *stateObject) updateTrie(db Database) Trie {
tr := self.getTrie(db)
for key, value := range self.dirtyStorage {
```

```
delete(self.dirtyStorage, key)
if (value == common.Hash{}) {
self.setError(tr.TryDelete(key[:]))
continue
}
// Encoding []byte cannot fail, ok to ignore the error.
v, _ := rlp.EncodeToBytes(bytes.TrimLeft(value[:], "\x00"))
self.setError(tr.TryUpdate(key[:], v))
return tr
}
// UpdateRoot sets the trie root to the current root hash of
func (self *stateObject) updateRoot(db Database) {
self.updateTrie(db)
self.data.Root = self.trie.Hash()
}
// CommitTrie the storage trie of the object to dwb.
// This updates the trie root.
func (self *stateObject) CommitTrie(db Database, dbw trie.DatabaseWriter) error {
self.updateTrie(db)
if self.dbErr != nil {
return self.dbErr
root, err := self.trie.CommitTo(dbw)
if err == nil {
self.data.Root = root
return err
}
// AddBalance removes amount from c's balance.
// It is used to add funds to the destination account of a transfer.
func (c *stateObject) AddBalance(amount *big.Int) {
// EIP158: We must check emptiness for the objects such that the account
// clearing (0,0,0 objects) can take effect.
if amount.Sign() == 0 {
if c.empty() {
c.touch()
}
```

```
return
}
c.SetBalance(new(big.Int).Add(c.Balance(), amount))
}
// SubBalance removes amount from c's balance.
// It is used to remove funds from the origin account of a transfer.
func (c *stateObject) SubBalance(amount *big.Int) {
if amount.Sign() == 0 {
return
c.SetBalance(new(big.Int).Sub(c.Balance(), amount))
}
func (self *stateObject) SetBalance(amount *big.Int) {
self.db.journal = append(self.db.journal, balanceChange{
account: &self.address,
prev: new(big.Int).Set(self.data.Balance),
})
self.setBalance(amount)
}
func (self *stateObject) setBalance(amount *big.Int) {
self.data.Balance = amount
if self.onDirty != nil {
self.onDirty(self.Address())
self.onDirty = nil
}
}
// Return the gas back to the origin. Used by the Virtual machine or Closures
func (c *stateObject) ReturnGas(gas *big.Int) {}
func (self *stateObject) deepCopy(db *StateDB, onDirty func(addr common.Address)) *stateObject
{
stateObject := newObject(db, self.address, self.data, onDirty)
if self.trie != nil {
stateObject.trie = db.db.CopyTrie(self.trie)
stateObject.code = self.code
stateObject.dirtyStorage = self.dirtyStorage.Copy()
stateObject.cachedStorage = self.dirtyStorage.Copy()
```

```
stateObject.suicided = self.suicided
stateObject.dirtyCode = self.dirtyCode
stateObject.deleted = self.deleted
return stateObject
}
//
// Attribute accessors
// Returns the address of the contract/account
func (c *stateObject) Address() common.Address {
return c.address
}
// Code returns the contract code associated with this object, if any.
func (self *stateObject) Code(db Database) []byte {
if self.code != nil {
return self.code
if bytes.Equal(self.CodeHash(), emptyCodeHash) {
return nil
}
code, err := db.ContractCode(self.addrHash, common.BytesToHash(self.CodeHash()))
if err != nil {
self.setError(fmt.Errorf("can't load code hash %x: %v", self.CodeHash(), err))
}
self.code = code
return code
func (self *stateObject) SetCode(codeHash common.Hash, code []byte) {
prevcode := self.Code(self.db.db)
self.db.journal = append(self.db.journal, codeChange{
account: &self.address,
prevhash: self.CodeHash(),
prevcode: prevcode,
})
self.setCode(codeHash, code)
}
func (self *stateObject) setCode(codeHash common.Hash, code []byte) {
```

```
self.code = code
self.data.CodeHash = codeHash[:]
self.dirtyCode = true
if self.onDirty != nil {
self.onDirty(self.Address())
self.onDirty = nil
}
}
func (self *stateObject) SetNonce(nonce uint64) {
self.db.journal = append(self.db.journal, nonceChange{
account: &self.address,
prev: self.data.Nonce,
})
self.setNonce(nonce)
}
func (self *stateObject) setNonce(nonce uint64) {
self.data.Nonce = nonce
if self.onDirty != nil {
self.onDirty(self.Address())
self.onDirty = nil
}
}
func (self *stateObject) CodeHash() []byte {
return self.data.CodeHash
}
func (self *stateObject) Balance() *big.Int {
return self.data.Balance
}
func (self *stateObject) Nonce() uint64 {
return self.data.Nonce
}
// Never called, but must be present to allow stateObject to be used
// as a vm.Account interface that also satisfies the vm.ContractRef
// interface. Interfaces are awesome.
func (self *stateObject) Value() *big.Int {
panic("Value on stateObject should never be called")
```

```
}
98:F:\git\coin\ethereum\go-ethereum\core\state\state_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"bytes"
"math/big"
"testing"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/ethdb"
checker "gopkg.in/check.v1"
)
type StateSuite struct {
db *ethdb.MemDatabase
state *StateDB
}
var _ = checker.Suite(&StateSuite{})
var toAddr = common.BytesToAddress
func (s *StateSuite) TestDump(c *checker.C) {
// generate a few entries
obj1 := s.state.GetOrNewStateObject(toAddr([]byte{0x01}))
obj1.AddBalance(big.NewInt(22))
obj2 := s.state.GetOrNewStateObject(toAddr([]byte{0x01, 0x02}))
obj2.SetCode(crypto.Keccak256Hash([]byte{3, 3, 3, 3, 3, 3, 3}), []byte{3, 3, 3, 3, 3, 3})
obj3 := s.state.GetOrNewStateObject(toAddr([]byte{0x02}))
obj3.SetBalance(big.NewInt(44))
// write some of them to the trie
s.state.updateStateObject(obj1)
s.state.updateStateObject(obj2)
s.state.CommitTo(s.db, false)
// check that dump contains the state objects that are in trie
```

```
got := string(s.state.Dump())
want := `{
  "root": "71edff0130dd2385947095001c73d9e28d862fc286fca2b922ca6f6f3cddfdd2",
  "accounts": {
    "balance": "22",
      "nonce": 0,
      "root": "56e81f171bcc55a6ff8345e692c0f86e5b48e01b996cadc001622fb5e363b421",
      "codeHash":
"c5d2460186f7233c927e7db2dcc703c0e500b653ca82273b7bfad8045d85a470",
      "code": "",
      "storage": {}
    "balance": "44".
      "nonce": 0,
      "root": "56e81f171bcc55a6ff8345e692c0f86e5b48e01b996cadc001622fb5e363b421",
      "codeHash":
"c5d2460186f7233c927e7db2dcc703c0e500b653ca82273b7bfad8045d85a470",
      "code": "".
      "storage": {}
    },
    "balance": "0",
      "nonce": 0,
      "root": "56e81f171bcc55a6ff8345e692c0f86e5b48e01b996cadc001622fb5e363b421".
      "codeHash":
"87874902497a5bb968da31a2998d8f22e949d1ef6214bcdedd8bae24cca4b9e3",
      "code": "03030303030303",
      "storage": {}
}`
if got != want {
c.Errorf("dump mismatch:\ngot: %s\nwant: %s\n", got, want)
}
}
func (s *StateSuite) SetUpTest(c *checker.C) {
s.db, _ = ethdb.NewMemDatabase()
s.state, _ = New(common.Hash{}, NewDatabase(s.db))
}
```

```
func (s *StateSuite) TestNull(c *checker.C) {
address := common.HexToAddress("0x823140710bf13990e4500136726d8b55")
s.state.CreateAccount(address)
//value := common.FromHex("0x823140710bf13990e4500136726d8b55")
var value common. Hash
s.state.SetState(address, common.Hash{}, value)
s.state.CommitTo(s.db, false)
value = s.state.GetState(address, common.Hash{})
if !common.EmptyHash(value) {
c.Errorf("expected empty hash. got %x", value)
}
}
func (s *StateSuite) TestSnapshot(c *checker.C) {
stateobjaddr := toAddr([]byte("aa"))
var storageaddr common. Hash
data1 := common.BytesToHash([]byte{42})
data2 := common.BytesToHash([]byte{43})
// set initial state object value
s.state.SetState(stateobjaddr, storageaddr, data1)
// get snapshot of current state
snapshot := s.state.Snapshot()
// set new state object value
s.state.SetState(stateobjaddr, storageaddr, data2)
// restore snapshot
s.state.RevertToSnapshot(snapshot)
// get state storage value
res := s.state.GetState(stateobjaddr, storageaddr)
c.Assert(data1, checker.DeepEquals, res)
}
func (s *StateSuite) TestSnapshotEmpty(c *checker.C) {
s.state.RevertToSnapshot(s.state.Snapshot())
}
// use testing instead of checker because checker does not support
// printing/logging in tests (-check.vv does not work)
```

```
func TestSnapshot2(t *testing.T) {
db, _ := ethdb.NewMemDatabase()
state, _ := New(common.Hash{}, NewDatabase(db))
stateobjaddr0 := toAddr([]byte("so0"))
stateobjaddr1 := toAddr([]byte("so1"))
var storageaddr common. Hash
data0 := common.BytesToHash([]byte{17})
data1 := common.BytesToHash([]byte{18})
state.SetState(stateobjaddr0, storageaddr, data0)
state.SetState(stateobjaddr1, storageaddr, data1)
// db, trie are already non-empty values
so0 := state.getStateObject(stateobjaddr0)
so0.SetBalance(big.NewInt(42))
so0.SetNonce(43)
so0.SetCode(crypto.Keccak256Hash([]byte{'c', 'a', 'f', 'e'}), []byte{'c', 'a', 'f', 'e'})
so0.suicided = false
so0.deleted = false
state.setStateObject(so0)
root, _ := state.CommitTo(db, false)
state.Reset(root)
// and one with deleted == true
so1 := state.getStateObject(stateobjaddr1)
so1.SetBalance(big.NewInt(52))
so1.SetNonce(53)
so1.SetCode(crypto.Keccak256Hash([]byte{'c', 'a', 'f', 'e', '2'}), []byte{'c', 'a', 'f', 'e', '2'})
so1.suicided = true
so1.deleted = true
state.setStateObject(so1)
so1 = state.getStateObject(stateobjaddr1)
if so1 != nil {
t.Fatalf("deleted object not nil when getting")
}
snapshot := state.Snapshot()
state.RevertToSnapshot(snapshot)
```

```
so0Restored := state.getStateObject(stateobjaddr0)
// Update lazily-loaded values before comparing.
so0Restored.GetState(state.db, storageaddr)
so0Restored.Code(state.db)
// non-deleted is equal (restored)
compareStateObjects(so0Restored, so0, t)
// deleted should be nil, both before and after restore of state copy
so1Restored := state.getStateObject(stateobjaddr1)
if so1Restored != nil {
t.Fatalf("deleted object not nil after restoring snapshot: %+v", so1Restored)
}
}
func compareStateObjects(so0, so1 *stateObject, t *testing.T) {
if so0.Address() != so1.Address() {
t.Fatalf("Address mismatch: have %v, want %v", so0.address, so1.address)
if so0.Balance().Cmp(so1.Balance()) != 0 {
t.Fatalf("Balance mismatch: have %v, want %v", so0.Balance(), so1.Balance())
}
if so0.Nonce() != so1.Nonce() {
t.Fatalf("Nonce mismatch: have %v, want %v", so0.Nonce(), so1.Nonce())
}
if so0.data.Root != so1.data.Root {
t.Errorf("Root mismatch: have %x, want %x", so0.data.Root[:], so1.data.Root[:])
}
if !bytes.Equal(so0.CodeHash(), so1.CodeHash()) {
t.Fatalf("CodeHash mismatch: have %v, want %v", so0.CodeHash(), so1.CodeHash())
}
if !bytes.Equal(so0.code, so1.code) {
t.Fatalf("Code mismatch: have %v, want %v", so0.code, so1.code)
}
if len(so1.cachedStorage) != len(so0.cachedStorage) {
t.Errorf("Storage size mismatch: have %d, want %d", len(so1.cachedStorage),
len(so0.cachedStorage))
for k, v := range so1.cachedStorage {
if so0.cachedStorage[k] != v {
t.Errorf("Storage key %x mismatch: have %v, want %v", k, so0.cachedStorage[k], v)
```

```
}
}
for k, v := range so0.cachedStorage {
if so1.cachedStorage[k] != v {
t.Errorf("Storage key %x mismatch: have %v, want none.", k, v)
}
if so0.suicided != so1.suicided {
t.Fatalf("suicided mismatch: have %v, want %v", so0.suicided, so1.suicided)
if so0.deleted != so1.deleted {
t.Fatalf("Deleted mismatch: have %v, want %v", so0.deleted, so1.deleted)
}
99:F:\git\coin\ethereum\go-ethereum\core\state\sync.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
package state
import (
"bytes"
"math/big"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/rlp"
"github.com/ethereum/go-ethereum/trie"
)
// StateSync is the main state synchronisation scheduler, which provides yet the
// unknown state hashes to retrieve, accepts node data associated with said hashes
// and reconstructs the state database step by step until all is done.
type StateSync trie.TrieSync
// NewStateSync create a new state trie download scheduler.
func NewStateSync(root common.Hash, database trie.DatabaseReader) *StateSync {
var syncer *trie.TrieSync
callback := func(leaf []byte, parent common.Hash) error {
var obj struct {
Nonce
        uint64
```

```
Balance *big.Int
Root
        common.Hash
CodeHash []byte
if err := rlp.Decode(bytes.NewReader(leaf), &obj); err != nil {
return err
}
syncer.AddSubTrie(obj.Root, 64, parent, nil)
syncer.AddRawEntry(common.BytesToHash(obj.CodeHash), 64, parent)
return nil
}
syncer = trie.NewTrieSync(root, database, callback)
return (*StateSync)(syncer)
}
// Missing retrieves the known missing nodes from the state trie for retrieval.
func (s *StateSync) Missing(max int) []common.Hash {
return (*trie.TrieSync)(s).Missing(max)
}
// Process injects a batch of retrieved trie nodes data, returning if something
// was committed to the memcache and also the index of an entry if processing of
// it failed.
func (s *StateSync) Process(list []trie.SyncResult) (bool, int, error) {
return (*trie.TrieSync)(s).Process(list)
}
// Commit flushes the data stored in the internal memcache out to persistent
// storage, returning the number of items written and any occurred error.
func (s *StateSync) Commit(dbw trie.DatabaseWriter) (int, error) {
return (*trie.TrieSync)(s).Commit(dbw)
}
// Pending returns the number of state entries currently pending for download.
func (s *StateSync) Pending() int {
return (*trie.TrieSync)(s).Pending()
}
100:F:\git\coin\ethereum\go-ethereum\core\state\sync_test.go
// along with the go-ethereum library. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/</a>.
```

```
package state
import (
"bytes"
"math/big"
"testing"
"github.com/ethereum/go-ethereum/common"
"github.com/ethereum/go-ethereum/crypto"
"github.com/ethereum/go-ethereum/ethdb"
"github.com/ethereum/go-ethereum/trie"
)
// testAccount is the data associated with an account used by the state tests.
type testAccount struct {
address common.Address
balance *big.Int
nonce uint64
code []byte
}
// makeTestState create a sample test state to test node-wise reconstruction.
func makeTestState() (Database, *ethdb.MemDatabase, common.Hash, []*testAccount) {
// Create an empty state
mem, _ := ethdb.NewMemDatabase()
db := NewDatabase(mem)
state, _ := New(common.Hash{}, db)
// Fill it with some arbitrary data
accounts := []*testAccount{}
for i := byte(0); i < 96; i++ {
obj := state.GetOrNewStateObject(common.BytesToAddress([]byte{i}))
acc := &testAccount{address: common.BytesToAddress([]byte{i}))}
obj.AddBalance(big.NewInt(int64(11 * i)))
acc.balance = big.NewInt(int64(11 * i))
obj.SetNonce(uint64(42 * i))
acc.nonce = uint64(42 * i)
if i\%3 == 0 {
obj.SetCode(crypto.Keccak256Hash([]byte{i, i, i, i, i}), []byte{i, i, i, i, i})
```

```
acc.code = []byte{i, i, i, i, i}
}
state.updateStateObject(obj)
accounts = append(accounts, acc)
}
root, _ := state.CommitTo(mem, false)
// Return the generated state
return db, mem, root, accounts
}
// checkStateAccounts cross references a reconstructed state with an expected
// account array.
func checkStateAccounts(t *testing.T, db ethdb.Database, root common.Hash, accounts
[]*testAccount) {
// Check root availability and state contents
state, err := New(root, NewDatabase(db))
if err != nil {
t.Fatalf("failed to create state trie at %x: %v", root, err)
}
if err := checkStateConsistency(db, root); err != nil {
t.Fatalf("inconsistent state trie at %x: %v", root, err)
}
for i, acc := range accounts {
if balance := state.GetBalance(acc.address); balance.Cmp(acc.balance) != 0 {
t.Errorf("account %d: balance mismatch: have %v, want %v", i, balance, acc.balance)
}
if nonce := state.GetNonce(acc.address); nonce != acc.nonce {
t.Errorf("account %d: nonce mismatch: have %v, want %v", i, nonce, acc.nonce)
if code := state.GetCode(acc.address); !bytes.Equal(code, acc.code) {
t.Errorf("account %d: code mismatch: have %x, want %x", i, code, acc.code)
}
}
}
// checkTrieConsistency checks that all nodes in a (sub-)trie are indeed present.
func checkTrieConsistency(db ethdb.Database, root common.Hash) error {
if v, _ := db.Get(root[:]); v == nil {
return nil // Consider a non existent state consistent.
}
trie, err := trie.New(root, db)
```

```
if err != nil {
return err
it := trie.NodeIterator(nil)
for it.Next(true) {
return it.Error()
}
// checkStateConsistency checks that all data of a state root is present.
func checkStateConsistency(db ethdb.Database, root common.Hash) error {
// Create and iterate a state trie rooted in a sub-node
if _, err := db.Get(root.Bytes()); err != nil {
return nil // Consider a non existent state consistent.
}
state, err := New(root, NewDatabase(db))
if err != nil {
return err
it := NewNodeIterator(state)
for it.Next() {
return it.Error
// Tests that an empty state is not scheduled for syncing.
func TestEmptyStateSync(t *testing.T) {
empty :=
common.HexToHash("56e81f171bcc55a6ff8345e692c0f86e5b48e01b996cadc001622fb5e363b42
1")
db, _ := ethdb.NewMemDatabase()
if reg := NewStateSync(empty, db).Missing(1); len(reg) != 0 {
t.Errorf("content requested for empty state: %v", req)
}
// Tests that given a root hash, a state can sync iteratively on a single thread,
// requesting retrieval tasks and returning all of them in one go.
func TestIterativeStateSyncIndividual(t *testing.T) { testIterativeStateSync(t, 1) }
func TestIterativeStateSyncBatched(t *testing.T) { testIterativeStateSync(t, 100) }
func testIterativeStateSync(t *testing.T, batch int) {
```

```
// Create a random state to copy
_, srcMem, srcRoot, srcAccounts := makeTestState()
// Create a destination state and sync with the scheduler
dstDb, _ := ethdb.NewMemDatabase()
sched := NewStateSync(srcRoot, dstDb)
queue := append([]common.Hash{}, sched.Missing(batch)...)
for len(queue) > 0 {
results := make([]trie.SyncResult, len(queue))
for i, hash := range queue {
data, err := srcMem.Get(hash.Bytes())
if err != nil {
t.Fatalf("failed to retrieve node data for %x: %v", hash, err)
}
results[i] = trie.SyncResult{Hash: hash, Data: data}
}
if _, index, err := sched.Process(results); err != nil {
t.Fatalf("failed to process result #%d: %v", index, err)
}
if index, err := sched.Commit(dstDb); err != nil {
t.Fatalf("failed to commit data #%d: %v", index, err)
}
queue = append(queue[:0], sched.Missing(batch)...)
// Cross check that the two states are in sync
checkStateAccounts(t, dstDb, srcRoot, srcAccounts)
}
// Tests that the trie scheduler can correctly reconstruct the state even if only
// partial results are returned, and the others sent only later.
func TestIterativeDelayedStateSync(t *testing.T) {
// Create a random state to copy
_, srcMem, srcRoot, srcAccounts := makeTestState()
// Create a destination state and sync with the scheduler
dstDb, _ := ethdb.NewMemDatabase()
sched := NewStateSync(srcRoot, dstDb)
queue := append([]common.Hash{}, sched.Missing(0)...)
for len(queue) > 0 {
// Sync only half of the scheduled nodes
```

```
results := make([]trie.SyncResult, len(queue)/2+1)
for i, hash := range queue[:len(results)] {
data, err := srcMem.Get(hash.Bytes())
if err != nil {
t.Fatalf("failed to retrieve node data for %x: %v", hash, err)
results[i] = trie.SyncResult{Hash: hash, Data: data}
}
if _, index, err := sched.Process(results); err != nil {
t.Fatalf("failed to process result #%d: %v", index, err)
if index, err := sched.Commit(dstDb); err != nil {
t.Fatalf("failed to commit data #%d: %v", index, err)
queue = append(queue[len(results):], sched.Missing(0)...)
// Cross check that the two states are in sync
checkStateAccounts(t, dstDb, srcRoot, srcAccounts)
}
// Tests that given a root hash, a trie can sync iteratively on a single thread,
// requesting retrieval tasks and returning all of them in one go, however in a
// random order.
func TestIterativeRandomStateSyncIndividual(t *testing.T) { testIterativeRandomStateSync(t, 1) }
func TestIterativeRandomStateSyncBatched(t *testing.T) { testIterativeRandomStateSync(t, 100)
}
func testIterativeRandomStateSync(t *testing.T, batch int) {
// Create a random state to copy
_, srcMem, srcRoot, srcAccounts := makeTestState()
// Create a destination state and sync with the scheduler
dstDb, _ := ethdb.NewMemDatabase()
sched := NewStateSync(srcRoot, dstDb)
queue := make(map[common.Hash]struct{})
for _, hash := range sched.Missing(batch) {
queue[hash] = struct{}{}
for len(queue) > 0 {
// Fetch all the queued nodes in a random order
results := make([]trie.SyncResult, 0, len(queue))
```

```
for hash := range queue {
data, err := srcMem.Get(hash.Bytes())
if err != nil {
t.Fatalf("failed to retrieve node data for %x: %v", hash, err)
}
results = append(results, trie.SyncResult{Hash: hash, Data: data})
}
// Feed the retrieved results back and queue new tasks
if _, index, err := sched.Process(results); err != nil {
t.Fatalf("failed to process result #%d: %v", index, err)
if index, err := sched.Commit(dstDb); err != nil {
t.Fatalf("failed to commit data #%d: %v", index, err)
queue = make(map[common.Hash]struct{})
for _, hash := range sched.Missing(batch) {
queue[hash] = struct{}{}
}
// Cross check that the two states are in sync
checkStateAccounts(t, dstDb, srcRoot, srcAccounts)
}
// Tests that the trie scheduler can correctly reconstruct the state even if only
// partial results are returned (Even those randomly), others sent only later.
func TestIterativeRandomDelayedStateSync(t *testing.T) {
// Create a random state to copy
_, srcMem, srcRoot, srcAccounts := makeTestState()
// Create a destination state and sync with the scheduler
dstDb, _ := ethdb.NewMemDatabase()
sched := NewStateSync(srcRoot, dstDb)
queue := make(map[common.Hash]struct{})
for _, hash := range sched.Missing(0) {
queue[hash] = struct{}{}
}
for len(queue) > 0 {
// Sync only half of the scheduled nodes, even those in random order
results := make([]trie.SyncResult, 0, len(queue)/2+1)
for hash := range queue {
delete(queue, hash)
```

```
data, err := srcMem.Get(hash.Bytes())
if err != nil {
t.Fatalf("failed to retrieve node data for %x: %v", hash, err)
}
results = append(results, trie.SyncResult{Hash: hash, Data: data})
if len(results) >= cap(results) {
break
}
// Feed the retrieved results back and queue new tasks
if _, index, err := sched.Process(results); err != nil {
t.Fatalf("failed to process result #%d: %v", index, err)
}
if index, err := sched.Commit(dstDb); err != nil {
t.Fatalf("failed to commit data #%d: %v", index, err)
}
for _, hash := range sched.Missing(0) {
queue[hash] = struct{}{}
}
// Cross check that the two states are in sync
checkStateAccounts(t, dstDb, srcRoot, srcAccounts)
}
// Tests that at any point in time during a sync, only complete sub-tries are in
// the database.
func TestIncompleteStateSync(t *testing.T) {
// Create a random state to copy
_, srcMem, srcRoot, srcAccounts := makeTestState()
checkTrieConsistency(srcMem, srcRoot)
// Create a destination state and sync with the scheduler
dstDb, _ := ethdb.NewMemDatabase()
sched := NewStateSync(srcRoot, dstDb)
added := []common.Hash{}
queue := append([]common.Hash{}, sched.Missing(1)...)
for len(queue) > 0 {
// Fetch a batch of state nodes
```

```
results := make([]trie.SyncResult, len(queue))
for i, hash := range queue {
data, err := srcMem.Get(hash.Bytes())
if err != nil {
t.Fatalf("failed to retrieve node data for %x: %v", hash, err)
results[i] = trie.SyncResult{Hash: hash, Data: data}
// Process each of the state nodes
if _, index, err := sched.Process(results); err != nil {
t.Fatalf("failed to process result #%d: %v", index, err)
}
if index, err := sched.Commit(dstDb); err != nil {
t.Fatalf("failed to commit data #%d: %v", index, err)
}
for _, result := range results {
added = append(added, result.Hash)
}
// Check that all known sub-tries added so far are complete or missing entirely.
checkSubtries:
for _, hash := range added {
for _, acc := range srcAccounts {
if hash == crypto.Keccak256Hash(acc.code) {
continue checkSubtries // skip trie check of code nodes.
}
// Can't use checkStateConsistency here because subtrie keys may have odd
// length and crash in LeafKey.
if err := checkTrieConsistency(dstDb, hash); err != nil {
t.Fatalf("state inconsistent: %v", err)
}
// Fetch the next batch to retrieve
queue = append(queue[:0], sched.Missing(1)...)
}
// Sanity check that removing any node from the database is detected
for _, node := range added[1:] {
key := node.Bytes()
value, _ := dstDb.Get(key)
dstDb.Delete(key)
if err := checkStateConsistency(dstDb, added[0]); err == nil {
```

```
t.Fatalf("trie inconsistency not caught, missing: %x", key)
}
dstDb.Put(key, value)
}
```