Jancy

LLVM-based scripting language for IO and UI programming

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http://tibbo.com/jancy

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List of programming languages

From Wikipedia, the free encyclopedia

The aim of this **list of programming languages** is to include all notable programming languages in existence, both those in current use and historical ones, in alphabetical order, except for dialects of BASIC and esoteric programming languages.

***Note**: Dialects of BASIC have been moved to the separate List of BASIC dialects.*

***Note**: This page does not list esoteric programming languages.*

Programming language lists

- **Alphabetical**
- Categorical
- Chronological
- Generational

V·T·E

A · B · C · D · E · F · G · H · I · J · K · L · M · N · O · P · Q · R · S · T · U · V · W · X · Y · Z

Contents : See also

A [edit]

- A# .NET
- A# (Axiom)
- A-0 System
- A+
- A++
- ABAP
- ABC
- Ada
- Adenine
- Agda
- Agilent VEE
- Agora
- AIMMS
- Alef
- Apex (Salesforce.com)
- API
- ARexx

~700 already!!

Wanted! (for IO Ninja)

- IO
  - Safe pointer arithmetic
  - High level of source compatibility with C
  - Built-in incremental lexer generator

Wanted! (for IO Ninja)

- IO
  - Safe pointer arithmetic
  - High level of source compatibility with C
  - Built-in incremental lexer generator
- UI
  - Properties
  - Events
  - Excel-like “reactive“ evaluation

Jancy Design Goals

- Embedded scripting language
- Statically typed
- C-family language syntax
- ABI-compatible with C
- Garbage collected (accurate GC)
- LLVM as back-end

Other interesting features

- Const-correctness
- Multiple inheritance
- Partial application
- Schedulers
- Exception-style syntax over error code checks
- Dual type modifiers
- Bigendian integers
- Bitflag enums
- Break-n/Continue-n
- Hex literals

Handling binary data (wrong)

```
public class IPv4Packet {
    private static final int IP_TOS_POS = 1;  // type of service
    private static final int IP_LEN_POS = 2;  // total packet length
    private static final int IP_ID_POS = 4;   // the packet id
    private static final int IP_FRAG_POS = 6; // the frag flags and offset
    // ...
    public int getTypeOfService() {
        if (_isReadTOS == false) {
            myTOS = myPacket[myIPHdrOffset + IP_TOS_POS] & 0x0f;
            _isReadTOS = true;
        }
        return myTOS;
    }
    public int getFragmentFlags() {
        if (_isReadFragFlags == false) {
            _isReadFragFlags = true;
            myFragmentFlags = ByteUtils.getByteNetOrderTo_uint16(
                myPacket, myIPHdrOffset + IP_FRAG_POS) >> 13;
        }
        return myFragmentFlags;
    }
    // ...
}
```

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        }
        return myFragmentFlags;
    }
    // ...
}
```

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            _isReadTOS = true;
        }
        return myTOS;
    }
    public int getFragmentFlags() {
        if (_isReadFragFlags == false) {
            _isReadFragFlags = true;
            myFragmentFlags = ByteUtils.getByteNetOrderTo_uint16(
                myPacket, myIPHdrOffset + IP_FRAG_POS) >> 13;
        }
        return myFragmentFlags;
    }
    // ...
}
```

Handling binary data (right)

Step #1 – Define data layout

```
struct IpHdr
{
    uint8_t m_headerLength : 4;
    uint8_t m_version      : 4;
    uint8_t m_typeOfService;
    // ...
}

struct IcmpHdr
{
    uint8_t m_type;
    uint8_t m_code;
    bigendian uint16_t m_checksum;
    // ...
}
```

Handling binary data (right)

Step #2 – Access buffer

```
printIpHdr (void const* buffer)
{
    IpHdr const* ipHdr = (IpHdr const*) buffer;

    print ($"IP version = $(ipHdr.m_version)\n");
    // ...

    if (ipHdr.m_protocol == IPPROTO_ICMP)
    {
        buffer += ipHdr.m_headerLength * 4;
        IcmpHdr const* icmpHdr = (IcmpHdr const*) buffer;

        print ($"ICMP type = $(icmpHdr.m_type)\n");
        // ...
    }
}
```

Handling binary data (right)

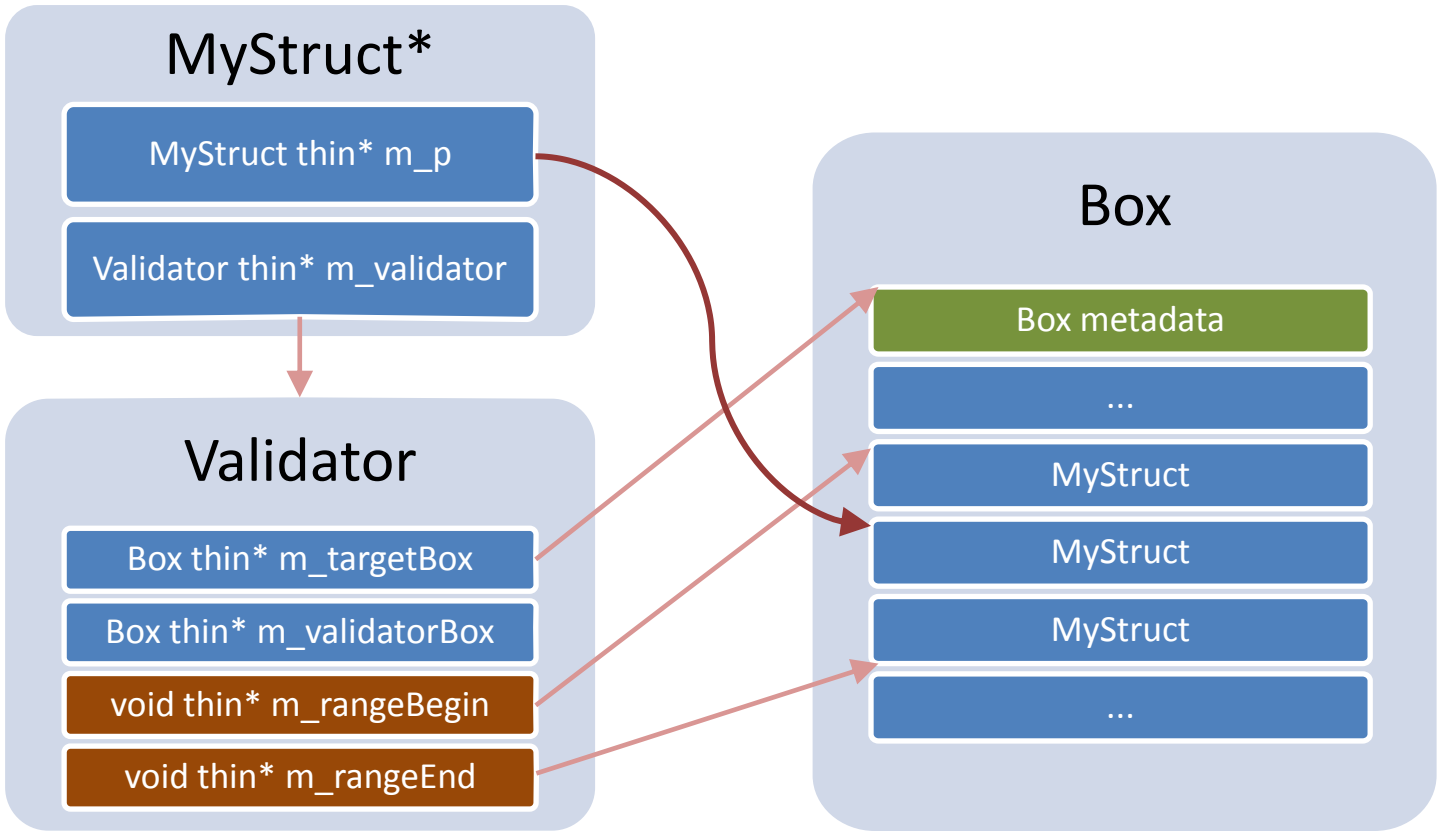
Step #2 – Access buffer

```
printIpHdr (void const* buffer)
{
    IpHdr const* ipHdr = (IpHdr const*) buffer;

    print ($"IP version = $(ipHdr.m_version)\n");
    // ...

    if (ipHdr.m_protocol == IPPROTO_ICMP)
    {
        buffer += ipHdr.m_headerLength * 4;
        IcmpHdr const* icmpHdr = (IcmpHdr const*) buffer;

        print ($"ICMP type = $(icmpHdr.m_type)\n");
        // ...
    }
}
```

How is pointer arithmetic safe?

Fat pointers, obviously

```
MyStruct* p;
```



Loads/stores are bounds checked

Pointer dereference

```
foo (char* p, size_t i)
{
    p += i;
    *p = 10; // <-- range is checked
}
```

Array indexing

```
bar (size_t i)
{
    static int a [] = { 10, 20, 30 };
    int x = a [i]; // <-- range is checked
}
```

Dynamic sizeof/countof

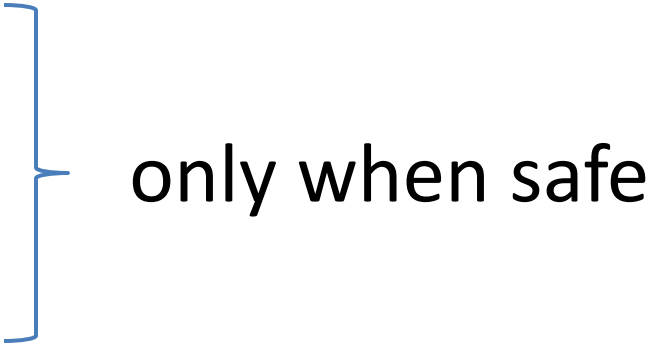
```
foo (int* a)
{
    size_t count = dynamic countof (a);
    for (size_t i = 0; i < count; i++)
    {
        // do something with a [i]
    }
}
```

Are bounds checks enough?

- Dangling pointers?
- Unions?
- Reinterpret casts?
- Pointer-to-fields increments?
- Downcasts?

Are bounds checks enough?

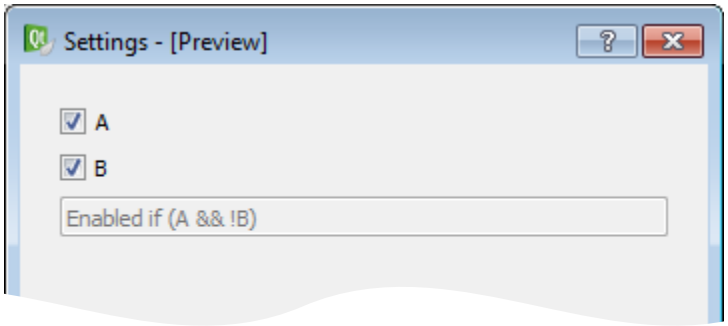
- Dangling pointers – impossible
- Unions
- Reinterpret casts
- Pointer-to-fields increments
- Downcasts – dynamic casts




```
foo (Parent* a)
{
    Child* c = dynamic (Child*) a;
    // ...
}
```

Reactive Programming for UI

- Automatic propagation of changes
- Observable pattern
- Our goal: Excel-like re-evaluation for UI
- Our workhorses:
  - Multicasts & events
  - Properties




```
m_editBox.m_isEnabled =
    m_checkBoxA.m_isChecked &&
    !m_checkBoxB.m_isChecked;
```

Reactive Programming for UI

- Automatic propagation of changes
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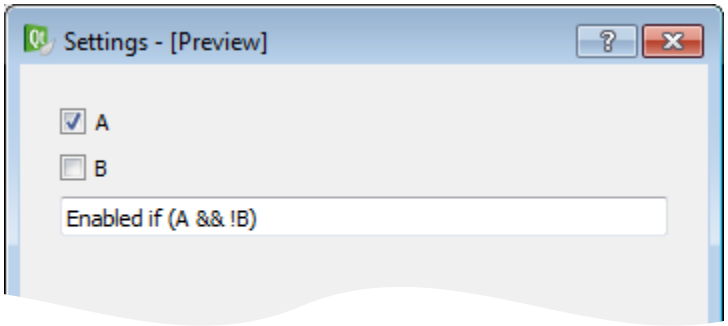



```
m_editBox.m_isEnabled =
    m_checkBoxA.m_isChecked &&
    !m_checkBoxB.m_isChecked;
```

Multicasts & events

```
class C1
{
    event m_onComplete ();

    work ()
    {
        // ...
        m_onComplete (); // OK, 'call' is accessible from C1
    }
}

foo (C1* c)
{
    multicast m (int);
    m += bar;
    m += baz;
    m (100);  // <-- foo (100); bar (100);

    c.m_onComplete (); // <-- error, 'call' is inaccessible
}
```

Bindable properties

```
int bindable property g_bindableProp;
```

```
g_bindableProp.set (int x)
{
    if (x == m_value)
        return;

    m_value = x;
    m_onChanged (); // compiler-generated event is 'm_onChanged'
}
```

```
onPropChanged ()
{
    // ...
}

foo ()
{
    bindingof (g_bindableProp) += onPropChanged;
    g_bindableProp = 100; // onPropChanged will be called
}
```

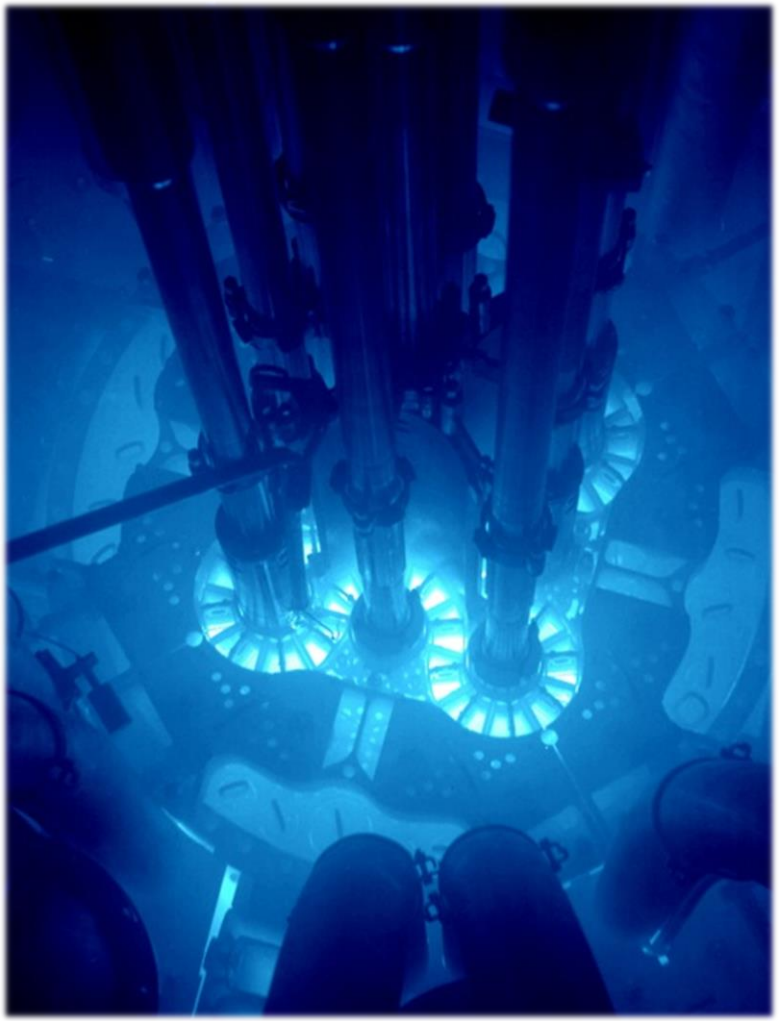
Dilemma

- We want Excel-like re-evaluation

Dilemma

- We want Excel-like re-evaluation
- Implicit subscriptions are hard to control

Solution – reactors!



Solution – reactors!

```
reactor TcpConnectionSession.m_uiReactor ()
{
    m_title = $"TCP $(m_addressCombo.m_editText)";
    m_isTransmitEnabled = m_state == State.Connected;
    m_actionTable [ActionId.Disconnect].m_isEnabled = m_state != State.Closed;
    m_adapterProp.m_isEnabled = m_useLocalAddressProp.m_value;
    m_localPortProp.m_isEnabled = m_useLocalAddressProp.m_value;
}
```

Solution – reactors!

```
reactor TcpConnectionSession.m_uiReactor ()
{
    m_title = $"TCP $(m_addressCombo.m_editText)";
    m_isTransmitEnabled = m_state == State.Connected;
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    m_adapterProp.m_isEnabled = m_useLocalAddressProp.m_value;
    m_localPortProp.m_isEnabled = m_useLocalAddressProp.m_value;
}
```

Automated, but controlled

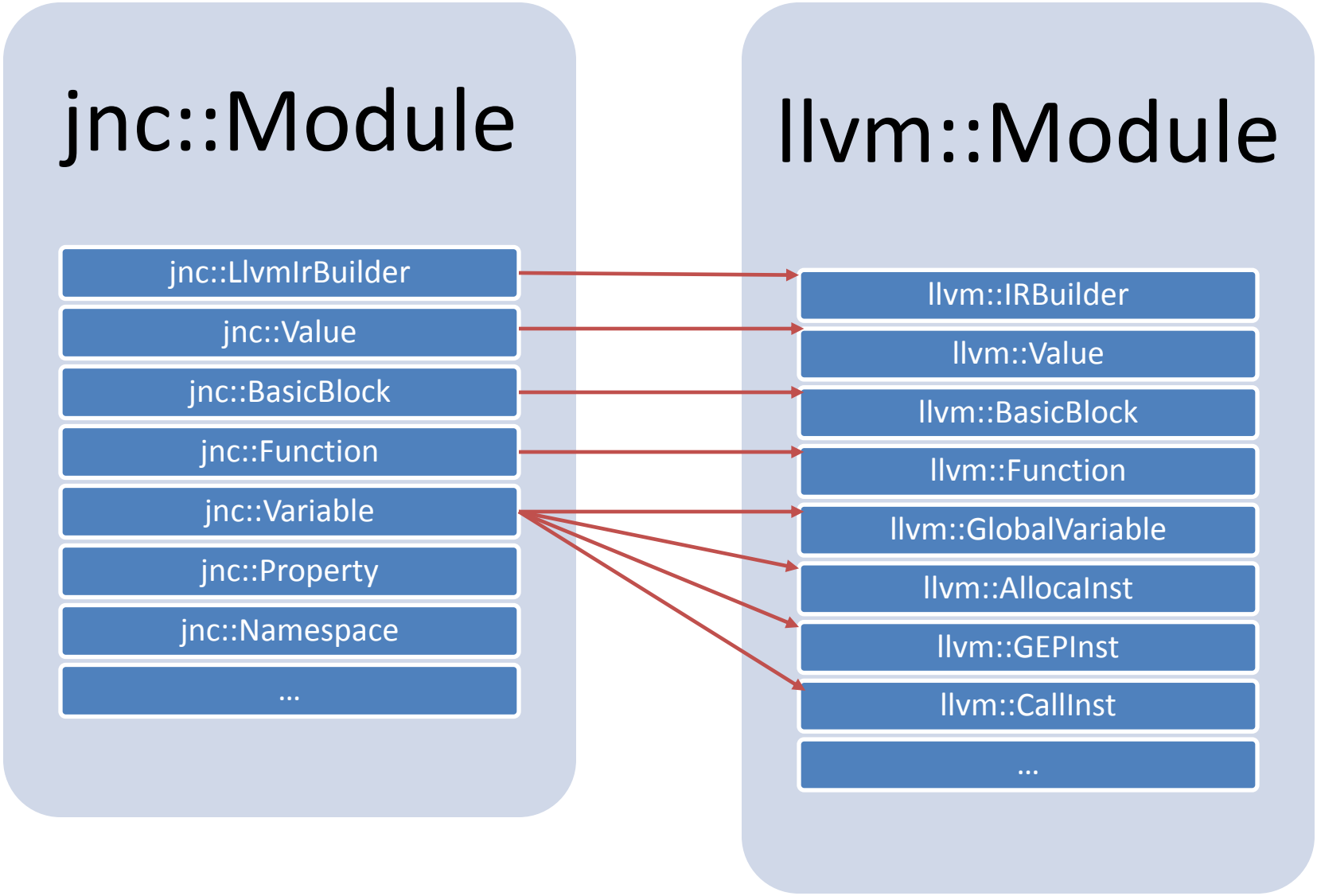
```
reactor m_uiReactor ()
{
    m_title = $"TCP $(m_addressCombo.m_editText)";
    m_isTransmitEnabled = m_state == State.Connected;
    // ...

    onevent m_transmitButton.m_onClicked ()
    {
        // handle start button click...
    }

    onevent (m_userEdit.m_onChanged, m_passwordEdit.m_onChanged) ()
    {
        // handle login change...
    }
}
```

```
m_uiReactor.start ();
// ...
m_uiReactor.stop ();
```

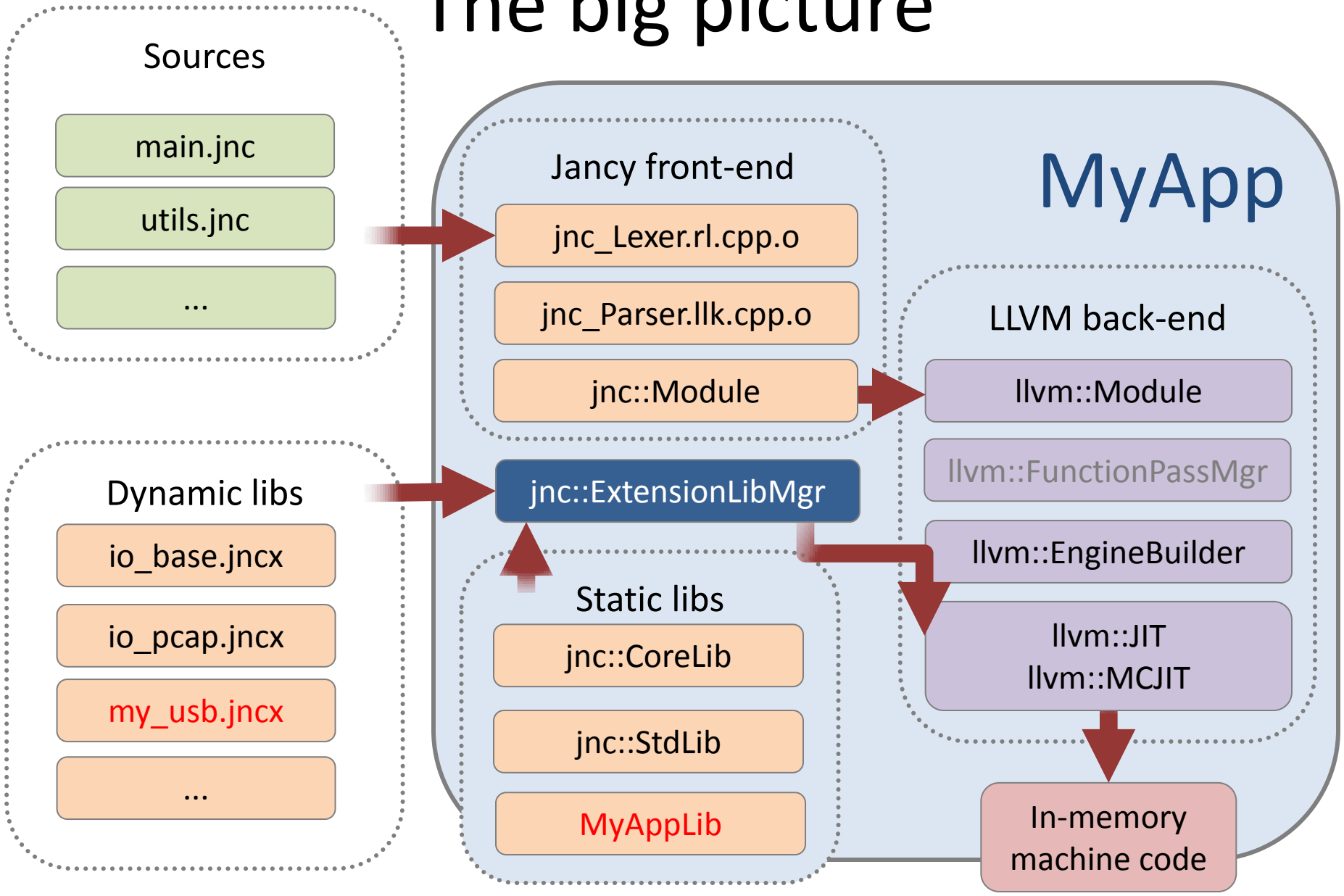
Implementation

- Main goal: embedded scripting
- Ragel-generated lexer as a front-end
- Table-driven generated top-down parser
- LLVM API to generate in-memory IR
- LLVM MCJIT to machine code
- Plugins for NetBeans IDE

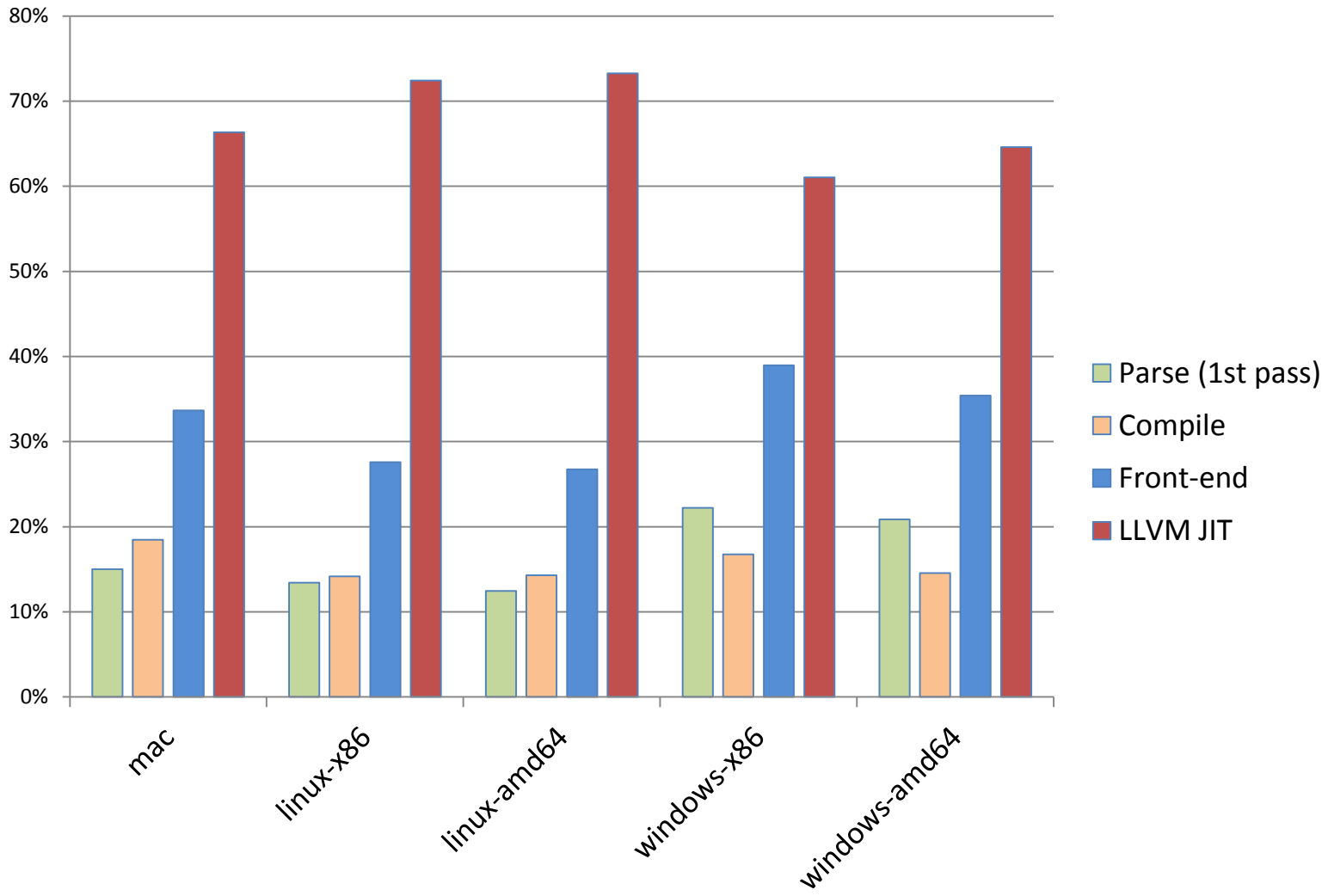
jnc::Module vs llvm::Module



The big picture



Where is time spent?



Summary

- Open source LLVM-based scripting language
- Offers unique features
- Used in a real-life product IO Ninja
- Comes with NetBeans-based IDE
- Live demo on the website
- Play, contribute, use in your projects

http://tibbo.com/jancy

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Overview

- Why?
- 2 main Jancy features
- Compiler design and how we use LLVM
- Questions

Why not recursive descent?

- Easy to experiment with syntax
- EBNF grammar as a permanently relevant syntax reference
- Natural constraints to not let you get too crazy with the syntax

Partial application

```
class C1
{
    foo (int x, int y, int z);

    // ...
}

bar ()
{
    C1 c;

    function* f (int, int) = c.foo ~(,, 300);
    f (100, 200); // => c.foo (100, 200, 300);
}
```

Autoget properties

```
int autoget property g_simpleProp;
```

```
g_simpleProp.set (int x)
{
    m_value = x; // the name of a compiler-generated field is 'm_value'
}
```

Indexed properties

```
int indexed property g_simpleProp (size_t i);
```

```
property g_prop
{
    int get (size_t i, size_t j);

    set (size_t i, size_t j, int x);
    set (size_t i, size_t j, double x);
}
```

```
foo ()
{
    int x = g_simpleProp [10];
    g_prop [x] [20] = 100;
}
```

Handling binary data (right)

Step #1 – Define structures

```
class IpHdr (BigEndianStructure):
    _fields_ = [
        ("version",         c_ubyte, 4),
        ("headerLength",    c_ubyte, 4),
        ("typeOfService",   c_ubyte),
        # ...
    ]

class IcmpHdr (BigEndianStructure):
    _fields_ = [
        ("type",            c_ubyte),
        ("code",            c_ubyte),
        ("headerChecksum", c_ushort),
        # ...
    ]
```

Handling binary data (right)

Step #2 – Access buffer

```
def packStruct (dst, src):
    size = min (len (src), sizeof (dst))
    memmove (addressof (dst), src, size)

def printIp (buffer):
    ipHdr = IpHdr ()
    packStruct (ipHdr, buffer)

    print "IP version = ", ipHdr.version
    # ...

    if ipHdr.protocol == 1:
        icmpHdr = IcmpHdr ()
        packStruct (icmpHdr, buffer [ipHdr.headerLength * 4:])

        print "ICMP type     = ", icmpHdr.type
        #...
```

Handling binary data (right)

Step #2 – Access buffer

```
def packStruct (dst, src):
    size = min (len (src), sizeof (dst))
    memmove (addressof (dst), src, size)

def printIp (buffer):
    ipHdr = IpHdr ()
    packStruct (ipHdr, buffer)

    print "IP version = ", ipHdr.version
    # ...

    if ipHdr.protocol == 1:
        icmpHdr = IcmpHdr ()
        packStruct (icmpHdr, buffer [ipHdr.headerLength * 4:])

        print "ICMP type     = ", icmpHdr.type
        #...
```

Schedulers

```
class Scheduler
{
    abstract schedule (function* f ());
}
```

```
class WorkerThread: jnc.Scheduler
{
    override schedule (function* f ())
    {
        // enqueue f and signal worker thread event
    }

    workerThread ()
    {
        for (;;)
        {
            // wait for worker thread event
            function* f () = getNextRequest ();
            f ();
        }
    }
}
```

Using schedulers

```
startSomeAsyncStuff (function* onComplete (int));

foo (int result);

bar ()
{
    WorkerThread workerThread;
    workerThread.start ();

    // create a scheduled pointer and pass it as completion routine
    doSomeAsyncStuff  (foo @ workerThread);

    (foo @ workerThread) (-1); // ...or schedule immediatly
}
```

Real-life example from IO Ninja

```
TcpListenerSession.construct (doc.PluginHost* pluginHost)
{
    // ...

    m_listenerSocket = new io.Socket ();
    m_listenerSocket.m_onSocketEvent +=
        onListenerSocketEvent @ pluginHost.m_mainThreadScheduler;

    // ...
}

TcpListenerSession.onListenerSocketEvent (
    io.SocketEventParams const* params)
{
    // ...
}
```

POD vs non-POD

- POD: no meta-data
  - Primitive types
  - Aggregates of PODs
  - Can be arbitrary modified byte-by-byte
- Non-POD: have meta-data
  - Classes
  - Pointers
  - Aggregates of non-PODs
  - Cannot be arbitrary modified byte-by-byte

Only cast when it’s safe

Sample types:

```
struct PodParent
{
    int m_a;
}

struct NonPodChild: PodParent
{
    char const* m_s;
}
```

Only cast when it's safe

Upcasts:

```
foo (NonPodChild* b)
{
    PodParent* a = b;
}
```

Reinterpret casts:

- POD-to-POD
- non-POD-to-const-POD

```
foo (PodParent* a, NonPodChild* b)
{
    char* p = (char*) a;
    char* p2 = (char*) b; // <-- error
    char const* p3 = (char const*) b; // <-- OK
}
```

Const-correctness is forced

```
foo (int const* src)
{
    int a = *src;

    *src = 0; // <-- error

    int* p = (int*) src; // <-- error
    *p = 0;
}
```

Otherwise, dynamic cast

```
foo (PodParent* a)
{
    NonPodChild* c = (NonPodChild*) a; // <-- error
    NonPodChild const* c = (NonPodChild const*) a; // <-- error

    NonPodChild* c = dynamic (NonPodChild*) a; // OK
}
```

Is it enough to be safe?

Method #1 – Reinterpret casts

```
foo (char* a)
{
    intptr* p = (intptr*) &a; // get a pointer to our pointer
    p [1] = 0x1234; // replace validator with garbage
    *a = 0; // <-- bang?
}

bar ()
{
    intptr a [] = { 0x1234, 0x5678 }; // fat pointer buffer
    char* p = *(char**) a; // construct a bogus fat pointer
    *p = 0; // <-- bang?
}
```

Is it enough to be safe?

Method #2 – Downcasts

```
struct Parent
{
    // ...
}

struct Child: Parent
{
    char const* m_p;
}

foo (Parent* a)
{
    Child* c = (Child*) a; // assume a is Child
    char c = c.m_p [0]; // <-- bang?
}
```

Is it enough to be safe?

Method #2 – Field member pointers

```
struct MyStruct
{
    intptr m_i;
    char const* m_p;
}

foo (MyStruct* a)
{
    intptr* p = &a.m_i; // get a pointer to a field
    p [2] = 0x1234; // replace validator of m_p with garbage
    *a.m_p = 0; // <-- bang?
}
```

Properties

- Two forms of declarations
  - Simple
  - Full
- Read-only properties
- Indexed properties
- Autoget properties
- Bindable properties
- Property pointers!

Multicasts

```
multicast m (int);
```

```
void clear ();
intptr setup (function* (int)); // returns cookie
intptr add (function* (int)); // returns cookie
function* remove (intptr cookie) (int);
function* getSnapshot () (int);
void call (int);
```

```
m = foo;      // same as m.setup (foo);
m += bar;     // same as m.add (bar);
m -= cookie; // same as m.remove (cookie);
m = null;     // same as m.clear ();
m (10);       // same as m.call (10);
```

Simple property declaration

```
int property g_simpleProp;

int const property g_simpleConstProp;
```

```
int property g_simpleProp;

int g_simpleProp.get ()
{
    // ...
}

g_simpleProp.set (int x)
{
    // ...
}
```

Why you should NOT write a new programming language?

- Time- and effort-consuming
- New syntax and concepts for others to learn
- Immature and buggy toolset
- Lack of a good standard library
- Lack of community and 3rd party libraries
- Lack of good documentation
- …

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- Lack of a good standard library
- Lack of community and 3rd party libraries
- Lack of good documentation
- …
- Chances are you will be the only user

Why you should STILL write a new programming language?

Selfish

- It’s really fun!
- Learn a lot
- Apply creativity
- We have LLVM now!
- Challenging task
  - Ego boost
  - Looks good in resume

Why you should STILL write a new programming language?

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Not as selfish

- Fill a gap
- Combine features
- Change annoying things
- Field-test new concepts
- Be a part of The Progress

Lexer generator

```
jnc.AutomatonResult automaton scanRx (jnc.Recognizer* recognizer)
{
    %% "get"
        createToken (Token.Get);

    %% "set"
        createToken (Token.Set);

    %% "quit"
        createToken (Token.Quit);

    %% [_\w][_\w\d]*
        createToken (Token.Identifier, recognizer.m_lexeme);

    // ...
}
```

Running automatons

```
jnc.Recognizer recognizer;
recognizer.m_automatonFunc = scanRx;
```

```
bool result = try recognizer.recognize ("getOption myOption");
if (!result)
{
    // handle recognition error
}
```

```
try
{
    recognizer.write ("ge");
    recognizer.write ("tOp");
    recognizer.write ("tion");
    recognizer.eof (); // notify recognizer about eof
                       // this can trigger actions or errors
catch:
    // handle recognition error
}
```

Switching languages

```
jnc.AutomatonResult automaton scanGlobal (jnc.Recognizer* recognizer)
{
    %% '#'
        recognizer.m_automatonFunc = scanPreprocessor; // switch to pp

    // ...
}
```

```
jnc.AutomatonResult automaton scanPreprocessor (jnc.Recognizer* recognizer)
{
    %% "if"
        createToken (Token.If);

    %% "ifdef"
        createToken (Token.Ifdef);

    // ...

    %% '\n'
        recognizer.m_automatonFunc = scanGlobal; // switch back
}
```

Properties

```
property g_prop
{
    int m_x = 5; // member field with in-place initializer

    int get ()
    {
        return m_x;
    }

    set (int x)
    {
        m_x = x;
        update ();
    }

    set (double x); // overloaded setter
    update ();      // helper method
}
```

Binding to bindable properties

```
int bindable property g_bindableProp;
```

```
onPropChanged ()
{
    // ...
}

foo ()
{
    bindingof (g_bindableProp) += onPropChanged;
    g_bindableProp = 100; // onPropChanged will be called
}
```

Under the hood

class ReactorClass

methods:

- start (...)
- stop ()

fields:

- int m_state
- ReactorBindSite m_bindSite [0]
- ReactorBindSite m_bindSite [1]
- ReactorBindSite m_bindSite [2]
- ...
- int m_reactionState [0]
- int m_reactionState [1]
- int m_reactionState [2]
- ...

```
reactor m_uiReactor ()
{
    m_title = $"Title: $(m_name.m_editText)";
    m_a.m_isEnabled = m_state != 0;
    m_b.m_isEnabled = m_useB.m_isChecked;
    m_c.m_isEnabled = m_useC.m_isChecked;
    // ...
    onevent m_button.m_onClicked ()
    {
        // ...
    }
}
```

struct ReactorBindSite

- event* m_event
- intptr m_cookie

Under the hood

class ReactorClass

methods:

- start (…)
- stop ()

fields:

- int m_state
- ReactorBindSite m_bindSite [0]
- ReactorBindSite m_bindSite [1]
- ReactorBindSite m_bindSite [2]
- …
- int m_reactionState [0]
- int m_reactionState [1]
- int m_reactionState [2]
- …

```
reactor m_uiReactor ()
{
 #1 m_title = $"Title: $(m_name.m_editText)";
 #2 m_a.m_isEnabled = m_state != 0;
 #3 m_b.m_isEnabled = m_useB.m_isChecked;
 #4 m_c.m_isEnabled = m_useC.m_isChecked;
    // ...
 #5 onevent m_button.m_onClicked ()
    {
        // ...
    }
}
```

struct ReactorBindSite

- event* m_event
- intptr m_cookie

reactions >= # bind sites

OK to return addresses of locals

```
int* foo ()
{
    int a = 10;

    // ...

    return &a; // no problem
}
```

Multicasts

```
foo (int x);
bar (int x);

baz ()
{
    multicast m (int);

    m += foo;
    m += bar;
    m (100);  // <-- foo (100); bar (100);
}
```

Properties

```
int property g_simpleProp;
```

```
int g_simpleProp.get ()
{
    // ...
}

g_simpleProp.set (int x)
{
    // ...
}
```

```
foo ()
{
    g_simpleProp = 10;     // g_simpleProp.set is called
    int x = g_simpleProp; // g_simpleProp.get is called
}
```