Cornell University
Computer Systems Laboratory

CHP Compiler

Ned Bingham & Nicholas Kramer

Problem Statement

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Asynchronous is awesome

Tool infrastructure lacking

CHP great at describing behavior

PRs great at representing circuitry

Bridge that gap?

How Would You Use This?

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Synthesize new elements from CHP...

...Using syntax we are all familiar with...

...that can be integrated into any toolchain requiring PRs

How might we do this?

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Syntax Directed Translation (Tangram)

Pre-Charge Half Buffer Design (ARCWelder)

Martin Synthesis (Us!)

Problems: CHP to HSE

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Expand expressions

Expand process/operator instantiations

Expand multi bit variables/records/channels

Optimizations

Problems: HSE to State Space

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Information loss in guards

Information loss in parallel branches

Loop invariant

Impossible branches

Conflicting states

Problems: State Space to PRs

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Minterms

Logic Minimization

Optimizations (symmetrization, factoring...)

Supported Syntax: CHP

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Assignment

```
q, r, t := x^y | z^w, a+b, a*b;
```

Conditional

```
[ a | b -> c+ [] ~a & ~b -> c- ]
```

Loop

```
*[ a -> x := x + 1; a := 0
 [] ~a -> x := x*x; a := 1
 ]
```

sequential composition

```
x := x^y; y := x^y; x := x^y
```

assignment

parallel composition

```
q := x^y || r := y^z || s := z^x
```

assignment

Supported Syntax: Instantiation

```
int<32> var;
int var;
mux0b2 MyMux(a, b, c, d);
chan4p1b MyChan;
```

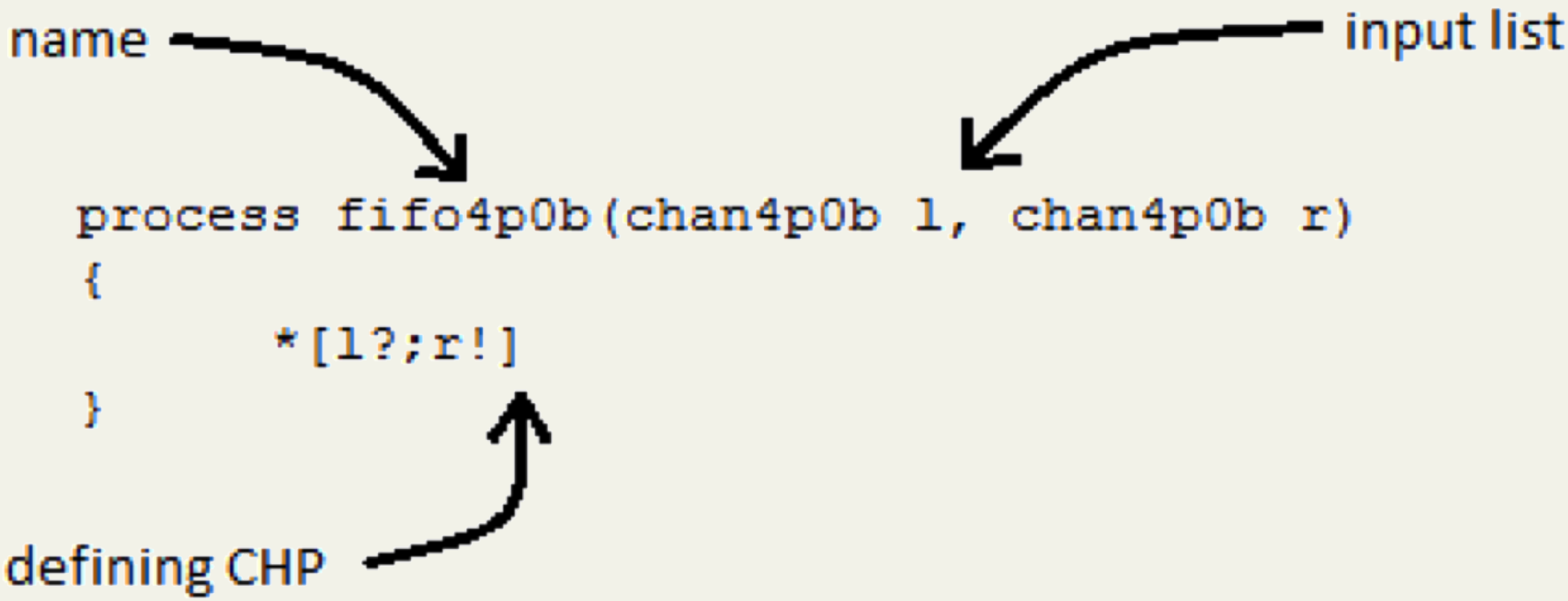
Supported Syntax: Records

```
record dualrail
{
        int<1> t;
        int<1> f;
}
```

name

variable list

Supported Syntax: Processes



Supported Syntax: Operators

name

input list

```
operator&(int<1> s, int<1> a, int<1> b)
{
        [    a &  b -> s+
        [] ~a | ~b -> s-
        ];
}
```

defining CHP

Supported Syntax: Channels

```
channel chan4p0b
{
        int<1> r;
        int<1> a;

        operator!()
        {
                r+; [a]; r-; [~a];
        }

        operator?()
        {
                [r]; a+; [~r]; a-;
        }

        operator@()
        {
                r
        }
}
```

name

variable list

send operator

receive operator

probe operator

Implementation: Preprocessing

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#include means libraries!

//comments are useful

/*So are block comments
that span multiple lines!*/

nee d to remove unne
eded whit e spa
ce t o make pa rsi ng eas ier

Implementation: Shortcuts/Parsing

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Easier to parse if syntax 1to1 with meaning

So, make 'shortcut' syntax fully explicit!

e.g. a.r+ means a.r:=1 , [a.a] means [a.a->skip], *[S] means *[1->S]

Recursively break CHP into lists of blocks/instructions

Implementation: Instantiation

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Record Instantiation

Process Instantiation

Copy code + search and replace

Expression Instantiation

Parse Expression + Process Instantiation

Implementation: Guard/Assign Merging

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[G1][G2] turns into [G1&G2]

[G1->[Ga->Sa[]Gb->Sb]]
turns into
[G1&Ga->Sa[]G1&Gb->Sb]

x+; y-; z:=x; turns into x,y:=1,0; z:=x;

Implementation: State Space Generation

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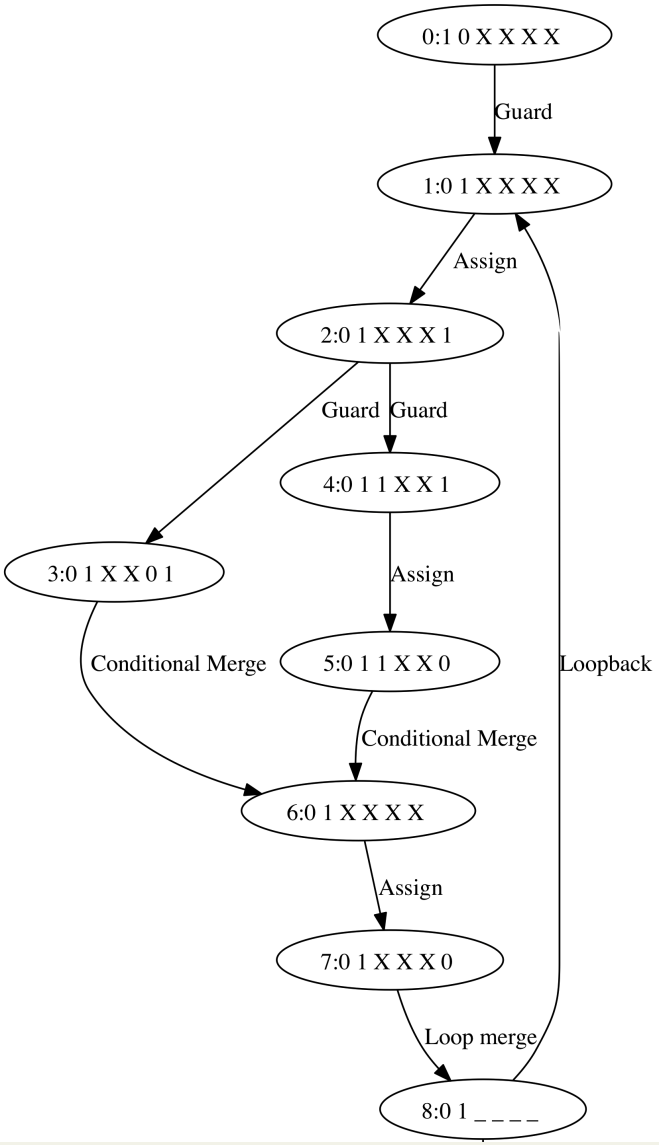
What gains state information?

- Assignments
- Guards
- Mutual Exclusion (future)

What loses information?

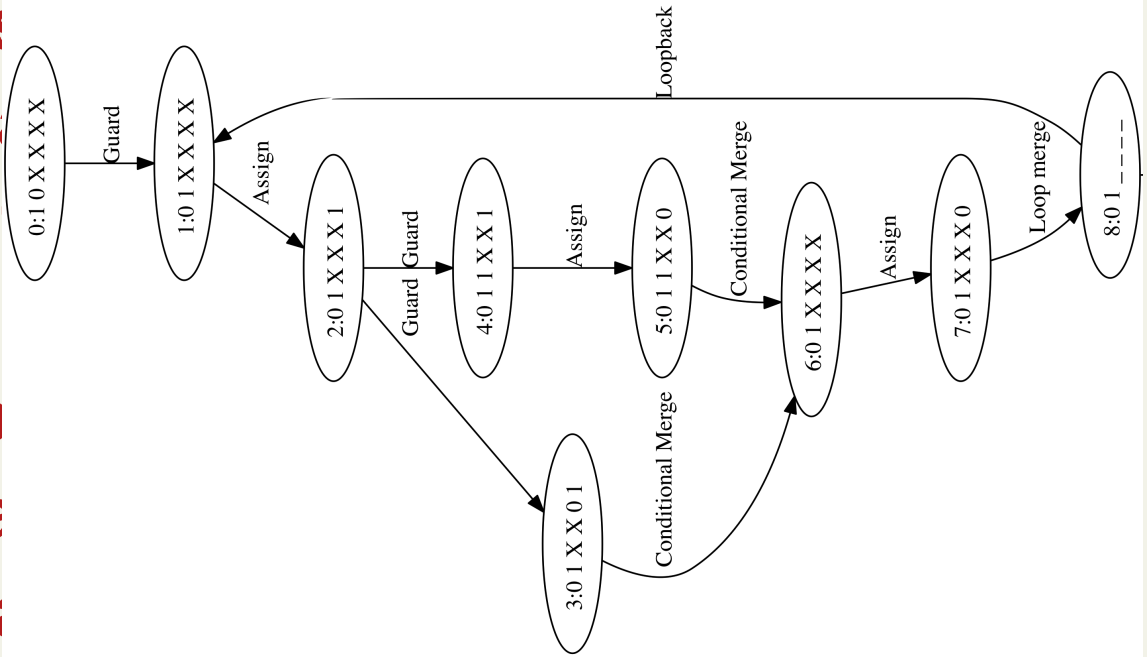
- Branch Merges
- Channel Assigns
- Across Parallel Branches



Implementation: Trace Space Generation

What gains state information?

- Ass
- Gu
- Mu



What lo

- Bra
- Cha
- Across Parallel Branches

Implementation: Scribe Variables

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Find guard with OR

Create variable whose name is the guard

Add it to the state space

Implementation: State Variable Insertion

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Maximize the number of conflicts removed

Brute Force

Implementation: PR Generation

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For each variable/direction pair:

Find all implicant states that cause change

Build weakest 'sufficient' PR guard

Implementation: Logic Minimization

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Quine McCluskey reduction:

- Reduce to prime implicants (think prime factors)
- Find 'essential' implicants

Factor implicants:

- Too long to implement?
- Lots of common terms?

Future Directions:

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Handshake Reshuffling

Process Decomposition/Projection

Impossible Branch Removal

Isochronic Fork Detection

Future Directions:

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Power Analysis

Timing Analysis

Design Space Exploration

CHP to CHP Optimizations

Verification

Toolchain Integration

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Full integration into ACT

CHP Block

Interchangeable ACT and CHP libraries

Requests/Suggestions/Questions??

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With all the time we have already and plan to spend on this project, let's try to make it as useful as possible!

Tech demo until Out of time!!