Reducing Architecture Complexity with AADL

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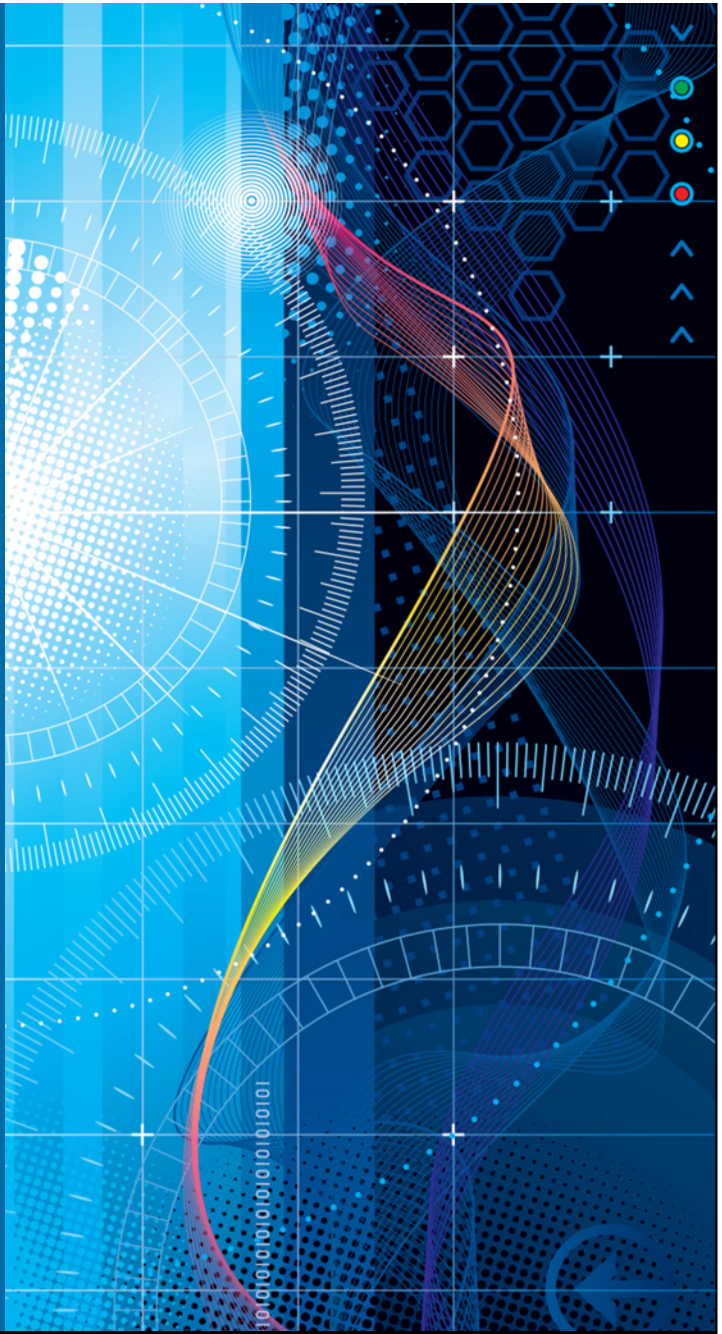

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Objectives

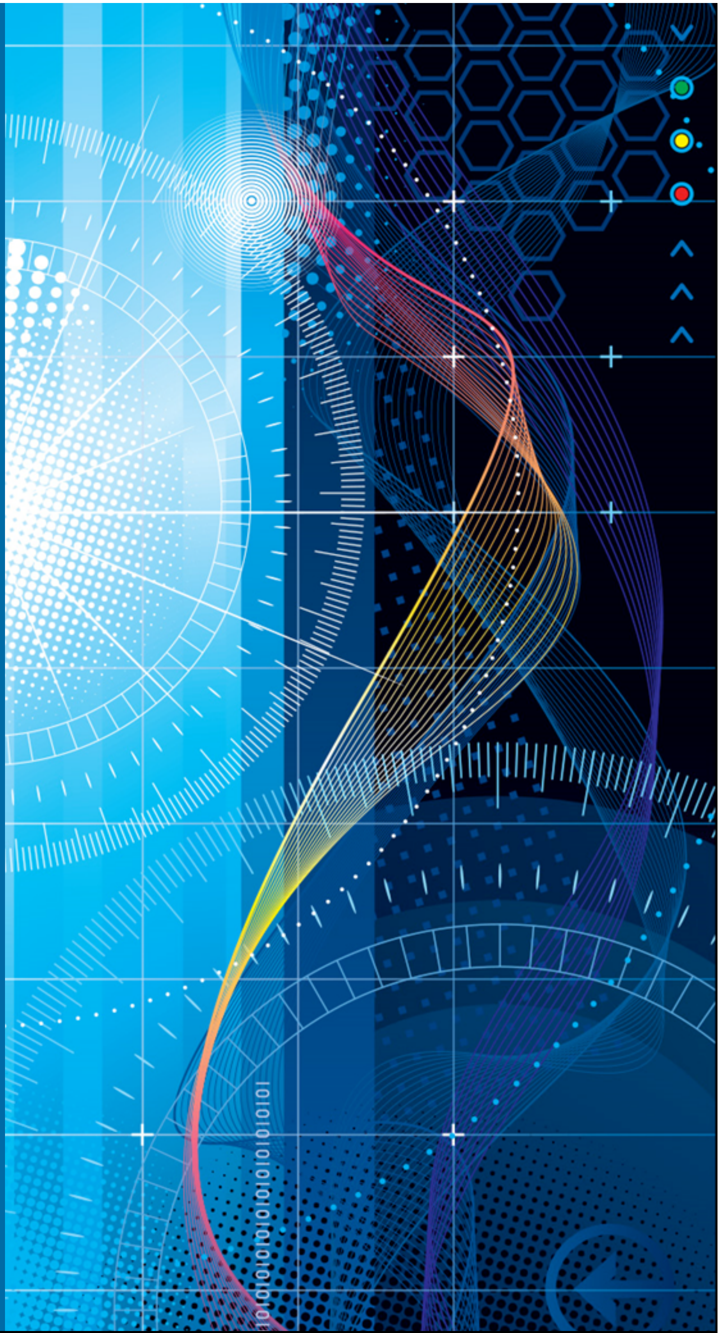
Explain Complexity in models

Detect Complexity in Models

Mitigate Complexity

Cost of Complexity

Complexity in Architecture Models



What is complexity?

Software hard to read & understand

Several factors

- Components coupling (fan-in/fan-out)
- Number of entities (components, connectors)
- Nesting levels

Supporting Metrics

- **McCabe**: connections between component
- **Halstead**: # operands and # operators
- **Zage**: fan-in/fan-out

Why complexity matters?

Increase development costs

Testing: increase # tests and ultimately, development costs

Maintenance: more time to update/upgrade

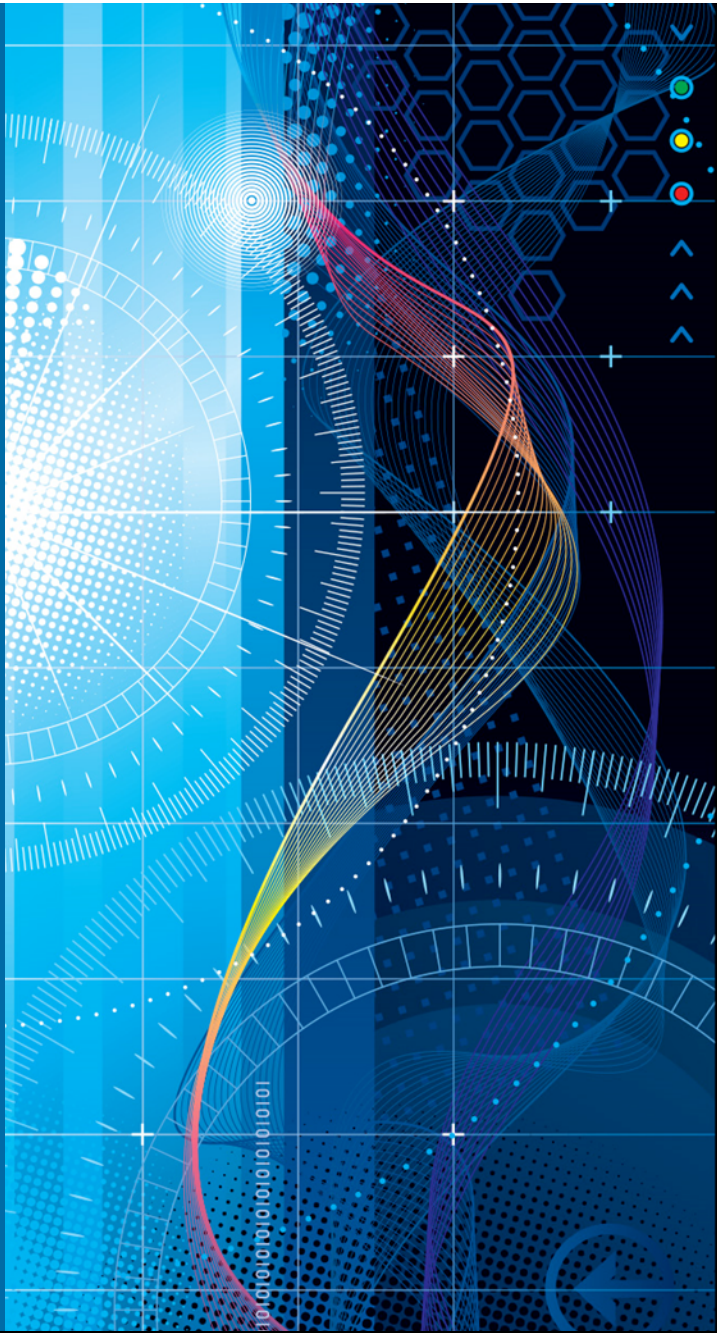
Reduce component reuse

Interfaces design issues

Software is getting a major costs for safety-critical

Reducing complexity = reduce costs, deliver quicker

Identifying and Mitigating Complexity



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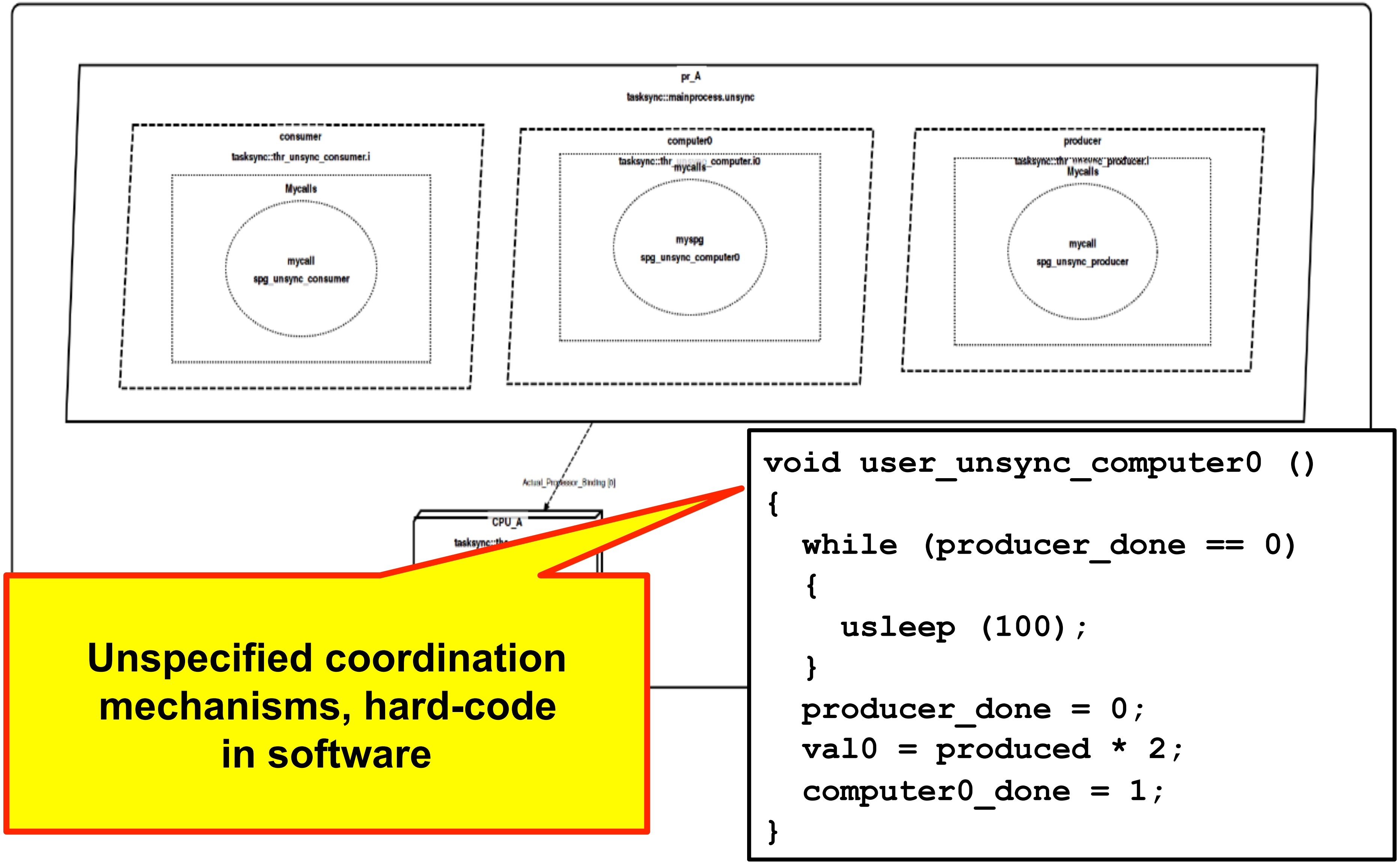
Synchronization methods – usual design issue


pr_A
tasksync::mainprocess.unsync
consumer
tasksync::thr_unsync_consumer.i
Mycalls
mycall
spg_unsync_consumer
computer0
tasksync::thr_unsync_computer.i0
mycalls
myspg
spg_unsync_computer0
producer
tasksync::thr_unsync_producer.i
Mycalls
mycall
spg_unsync_producer
Actual_Processor_Binding [b]
CPU_A
tasksync::th

```
void user_unsync_computer0 ()
{
  while (producer_done == 0)
  {
    usleep (100);
  }
  producer_done = 0;
  val0 = produced * 2;
  computer0_done = 1;
}
```

Unspecified coordination mechanisms, hard-code in software

Synchronization methods - impacts

Architecture decision embedded in the code

- Bad separation of concerns
- Architecture decision tightly coupled with code

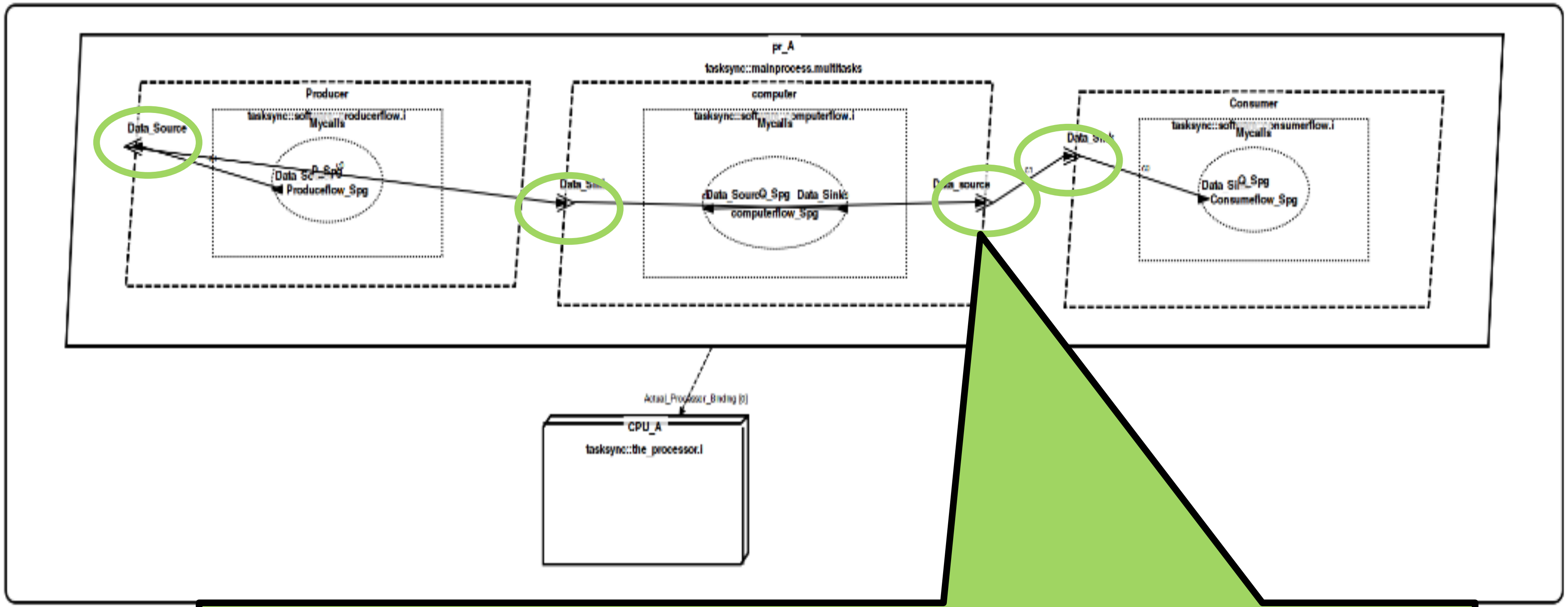
Potential for Analysis

- Scheduling Analysis
- Data flow (latency) analysis

Performance issues

- Performance issues (*busy wait*)

Synchronization methods



Synchronization through event data port, show the synchronization method at the architecture level.

Synchronization methods - benefits

Highlight architecture decisions in models

- Disconnect the non-functional and functional aspects
- Improve code and components reusability

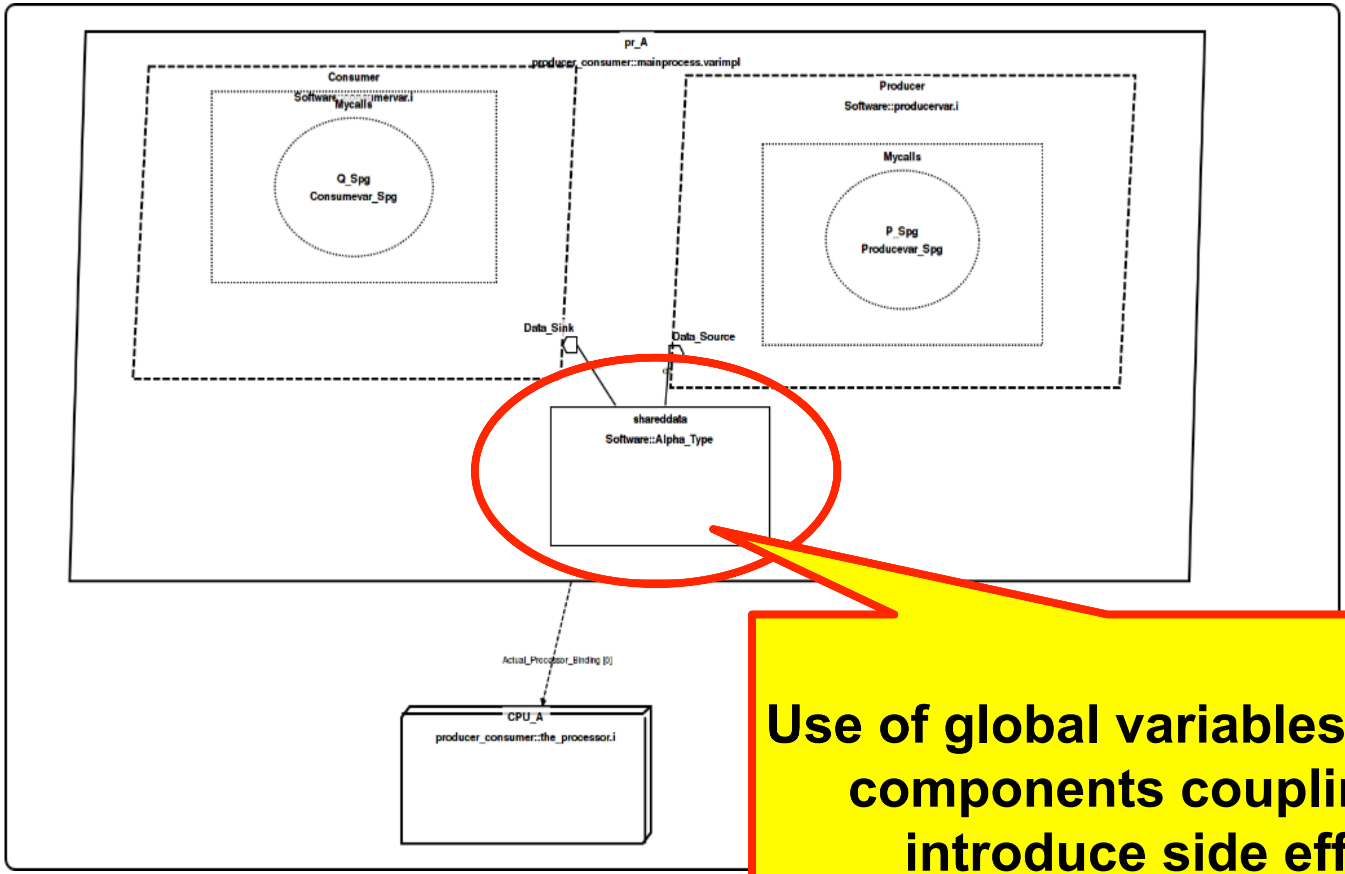
Enable Architecture Analysis

- Scheduling Analysis (tasks scheduling)
- Data flow (latency) analysis

Performance issues

- Avoid inappropriate implementation decisions
- Rely on code generator and potential optimizations

Data Sharing – usual design issues



Use of global variables, increase components coupling and introduce side effects

Data Sharing - impacts

Loss of data flow analysis

- Hard to keep track of who is reading/writing

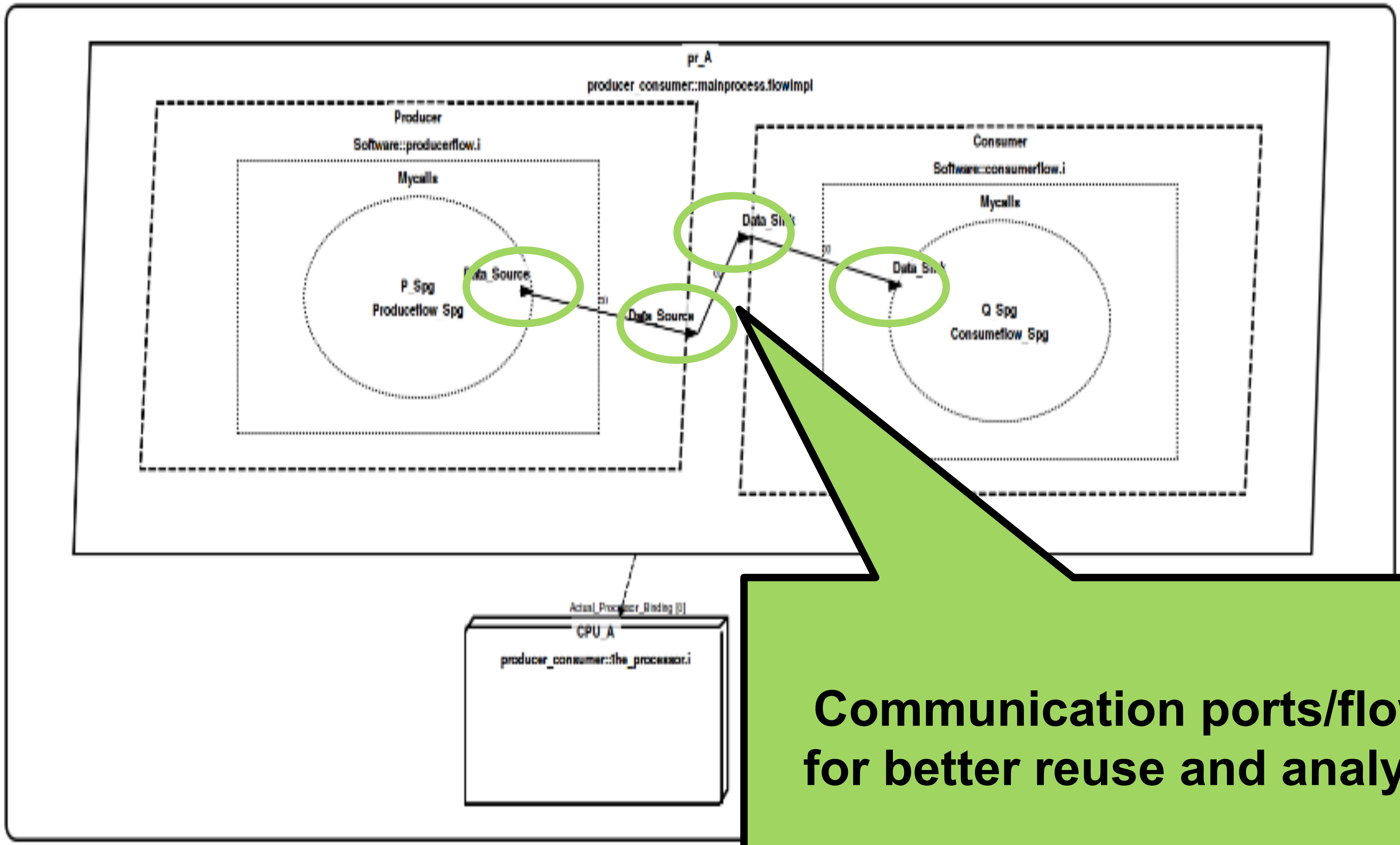
Lack of modularity

- Reuse a component must bring the variable

Potential side-effects

- Unexpected data change, must use synchronizations
- Hard to detect, analyze, might lead to catastrophic issue

Data Sharing – architecture solution



Communication ports/flows for better reuse and analysis

Data Sharing – benefits

Enable data flow analysis

Support for end to end latency analysis

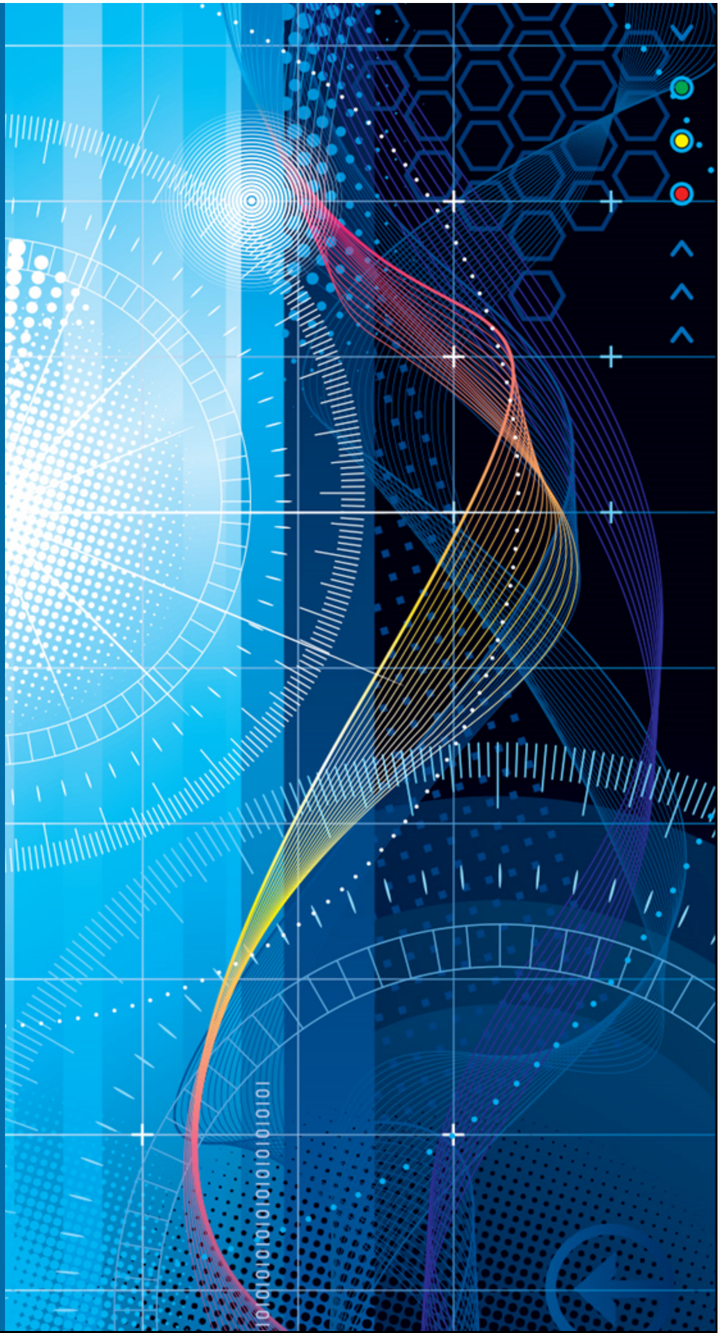
Modular design, simple component reuse

Re-import the component and connect its interface

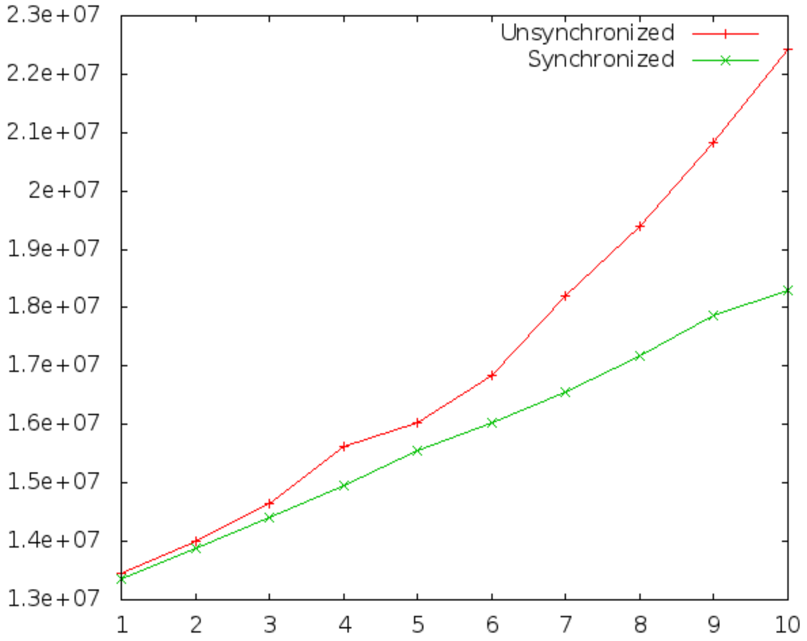
Limited side-effects

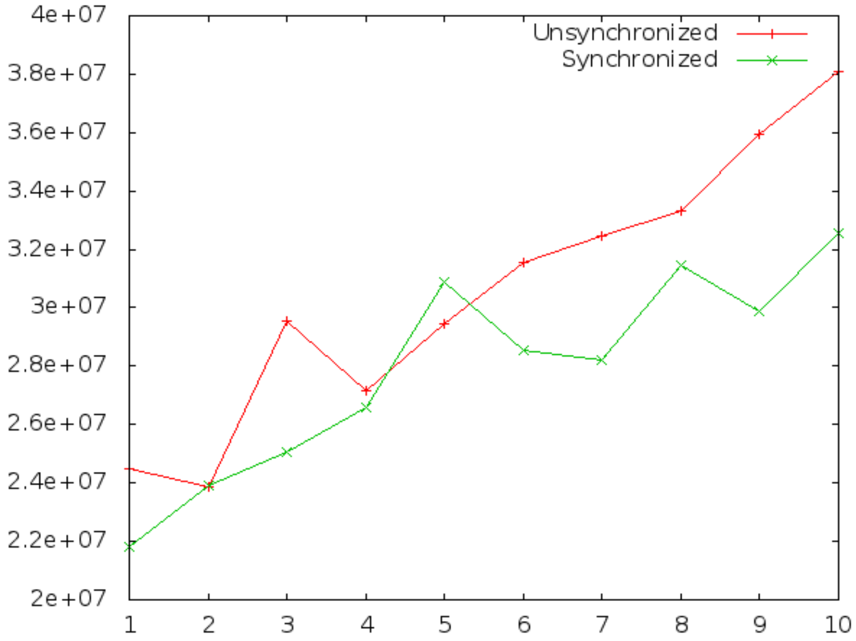
New data impact only the component

Cost of Good Designs



Synchronization - Performance

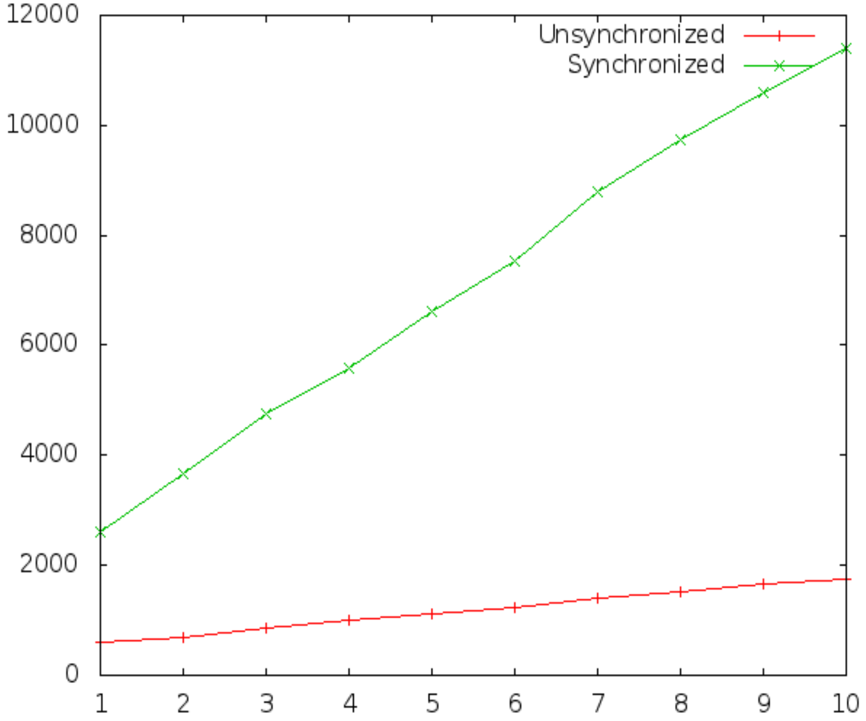




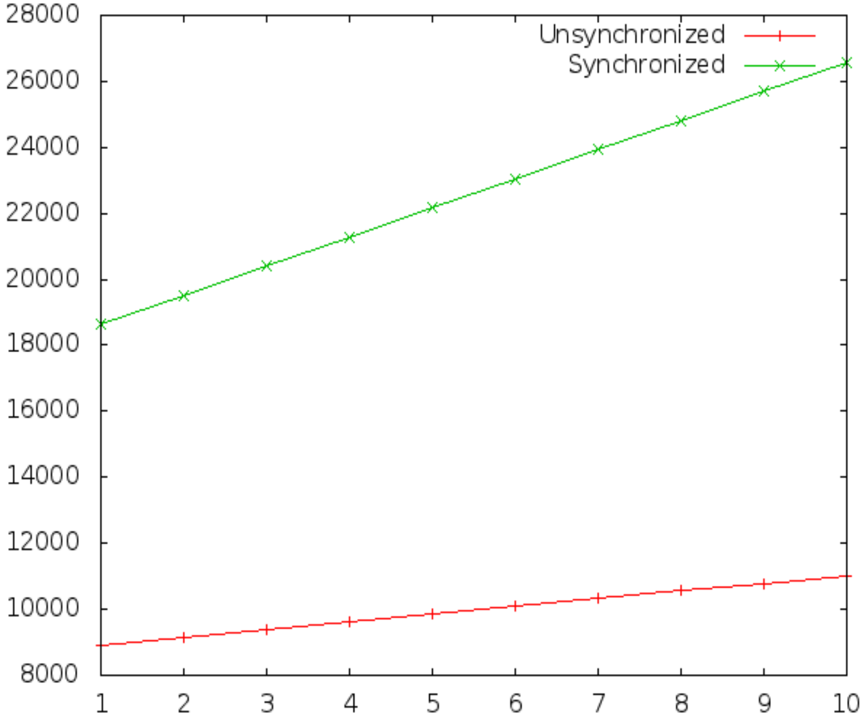
Number of Instructions

Number of CPU cycles

Synchronization - Memory

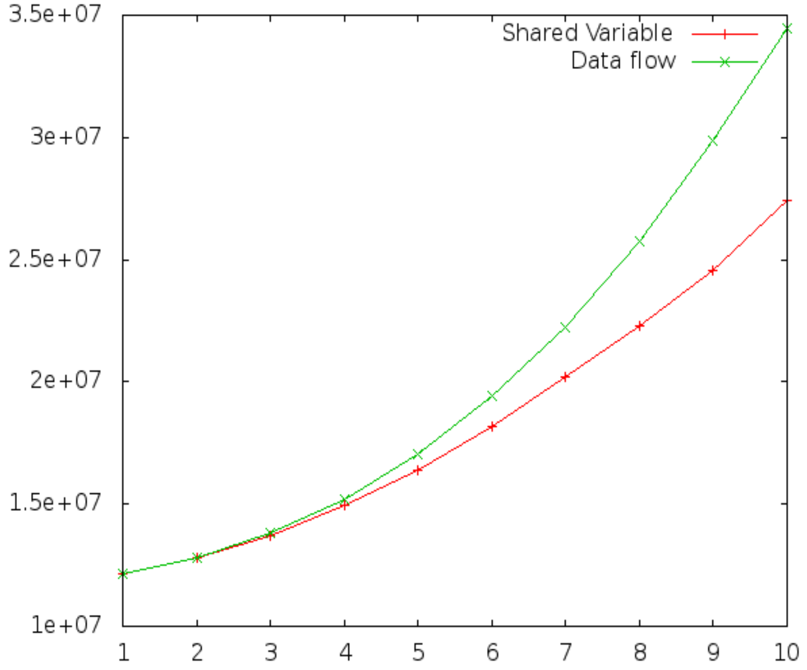


BSS size (global variables)

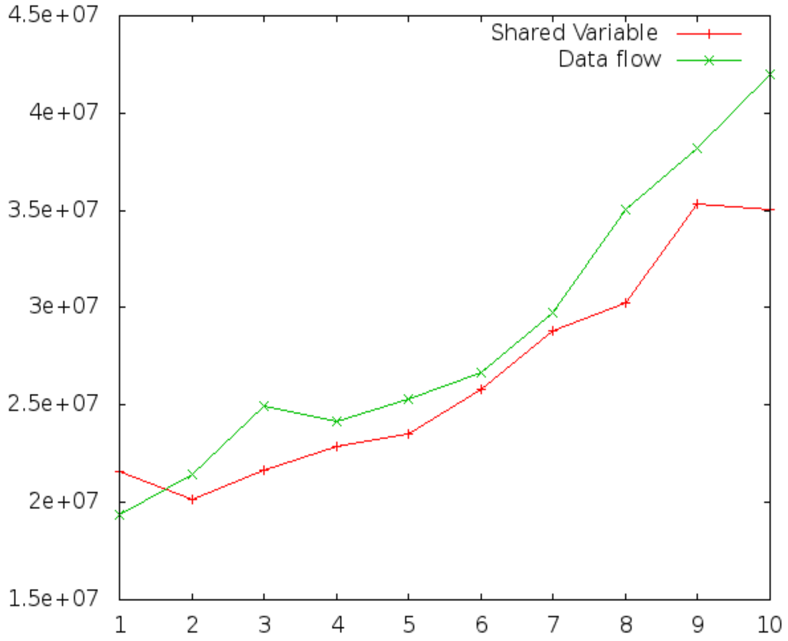


Text Size (code)

Global Variable vs. Data Flow - Performance

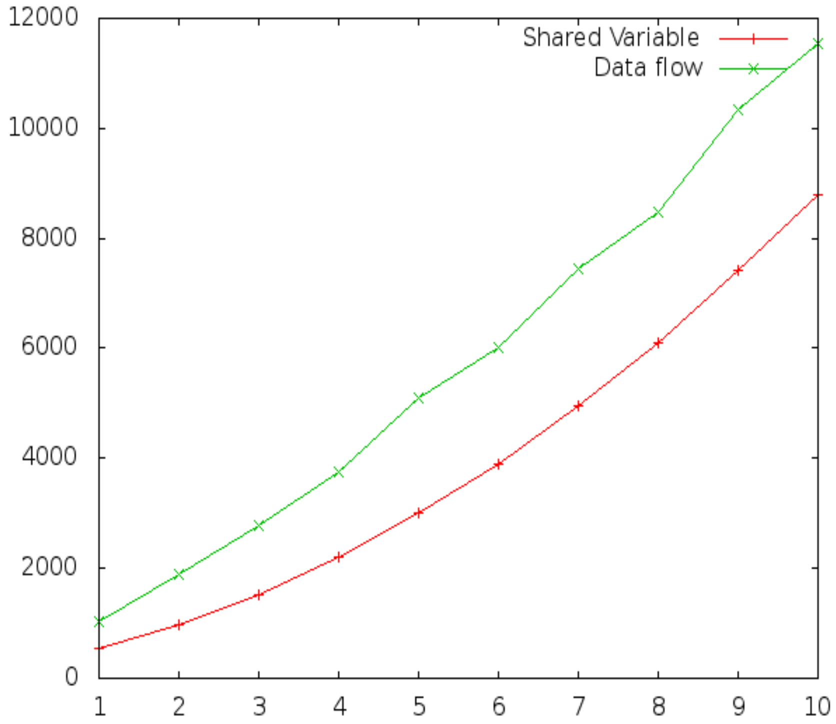


Number of Instructions

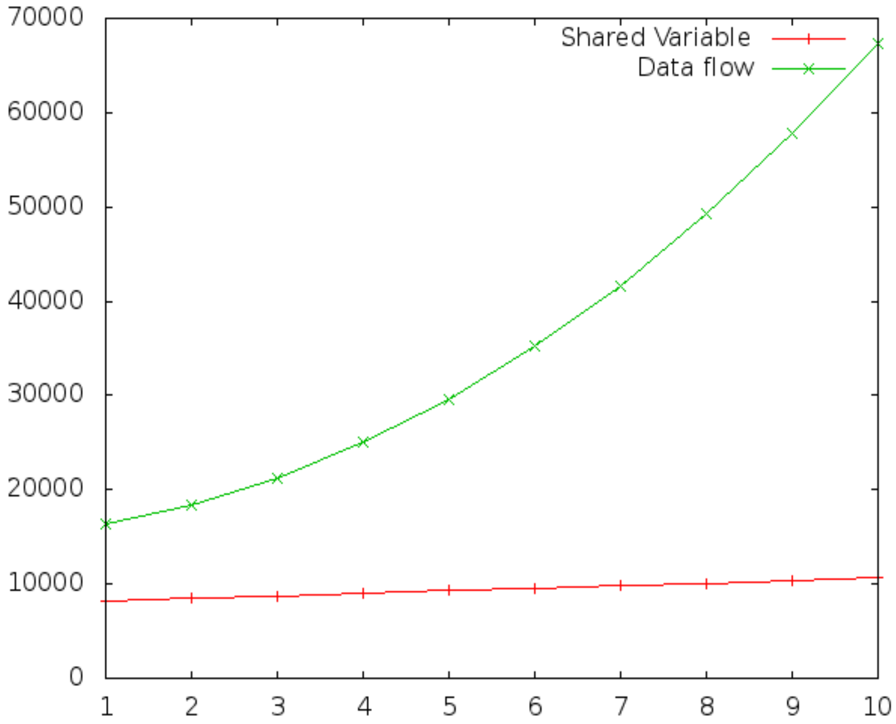


Number of CPU cycles

Global Variable vs. Data Flow - Memory

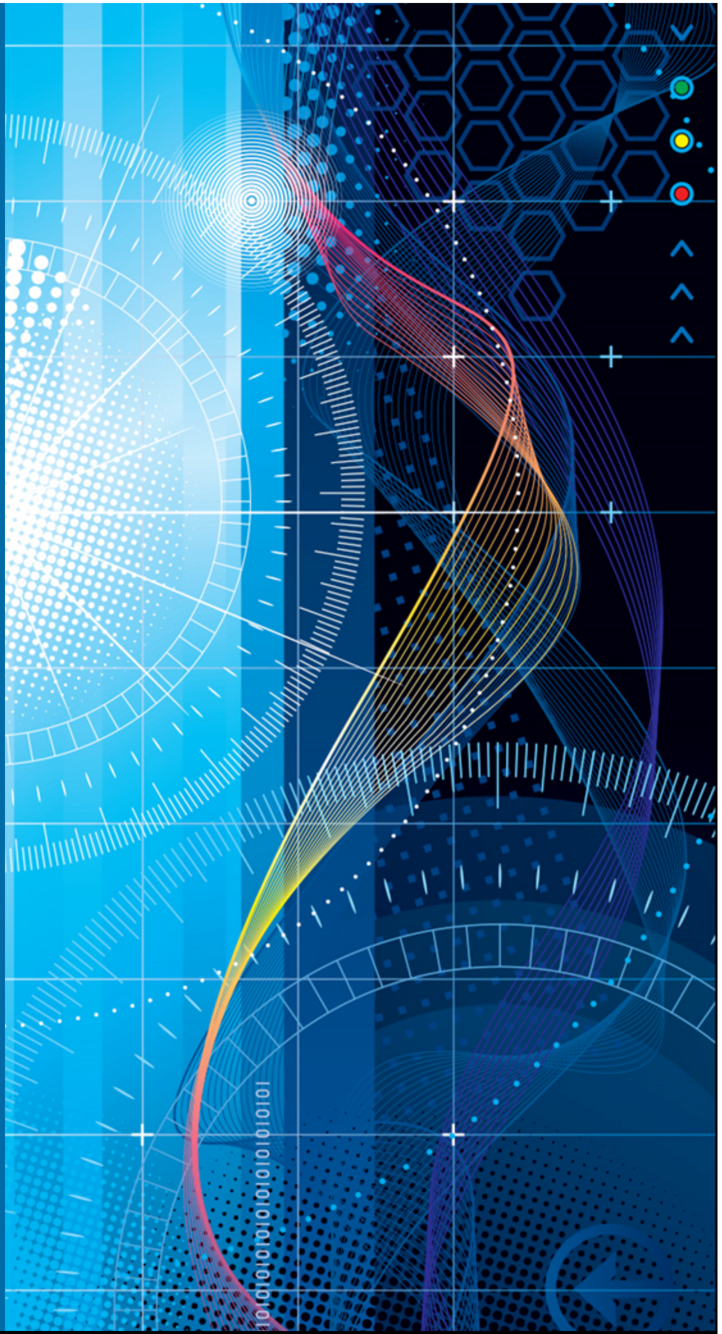


BSS size (global variables)



Text Size (code)

Conclusion



Conclusion

AADL for mitigating architecture-related complexity

Detecting complexity through architecture review

Architecture Analysis for discovering other complexity area

Reducing Development Costs

Testing efforts (e.g. DO178C, ISO26262)

Maintenance & Software reuse

Rely on Code Generator and Associated Optimizations

Avoid manual optimizations

Rely on code generator for creating efficient code