

A Common Machine Language for Communication-Exposed Architectures

Bill Thies, Michal Karczmarek, Michael
Gordon, David Maze and Saman Amarasinghe

MIT Laboratory for Computer Science

HPCA Work-in-Progress Session, February 2002

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Language Designers Have
Been Ignoring Architects

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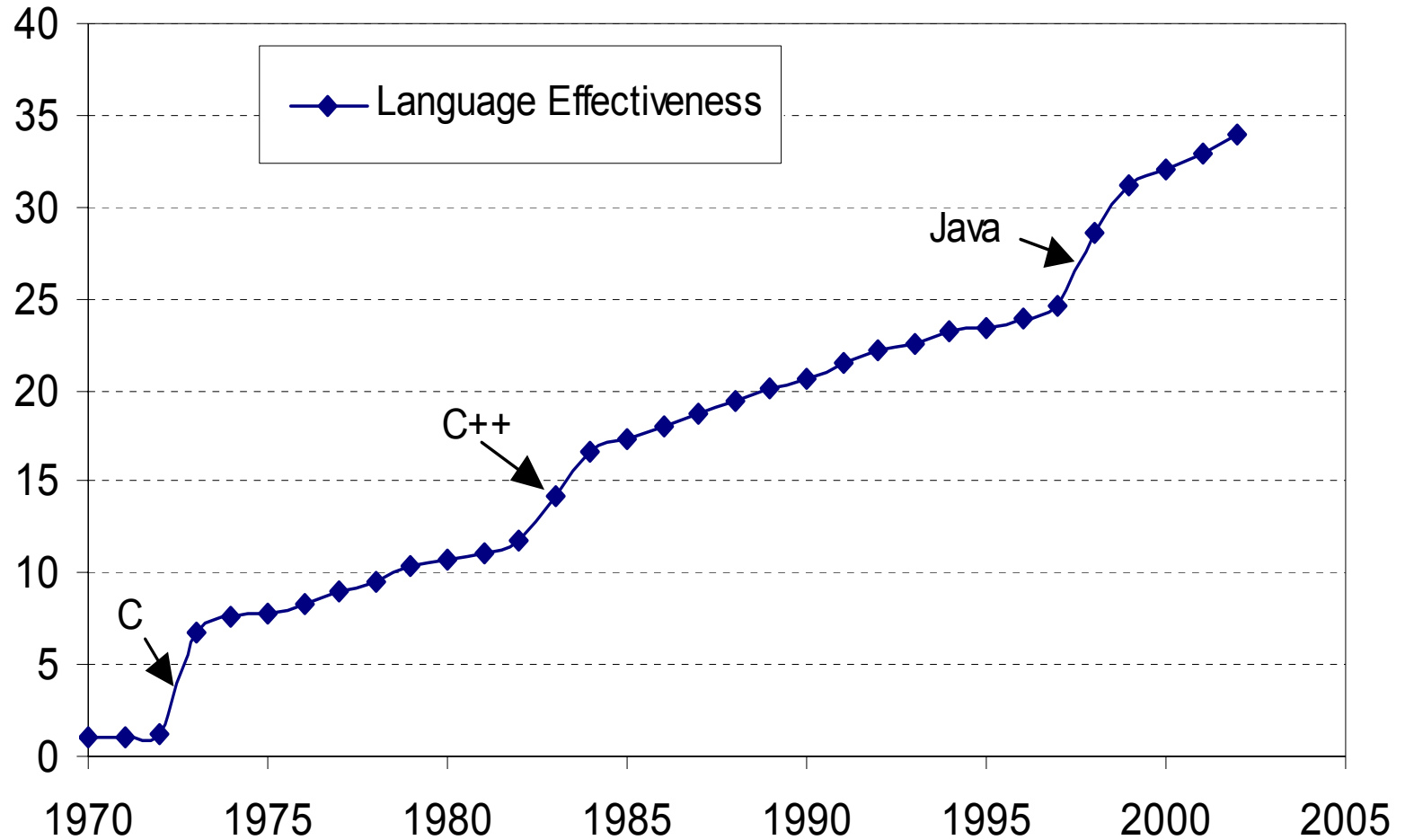
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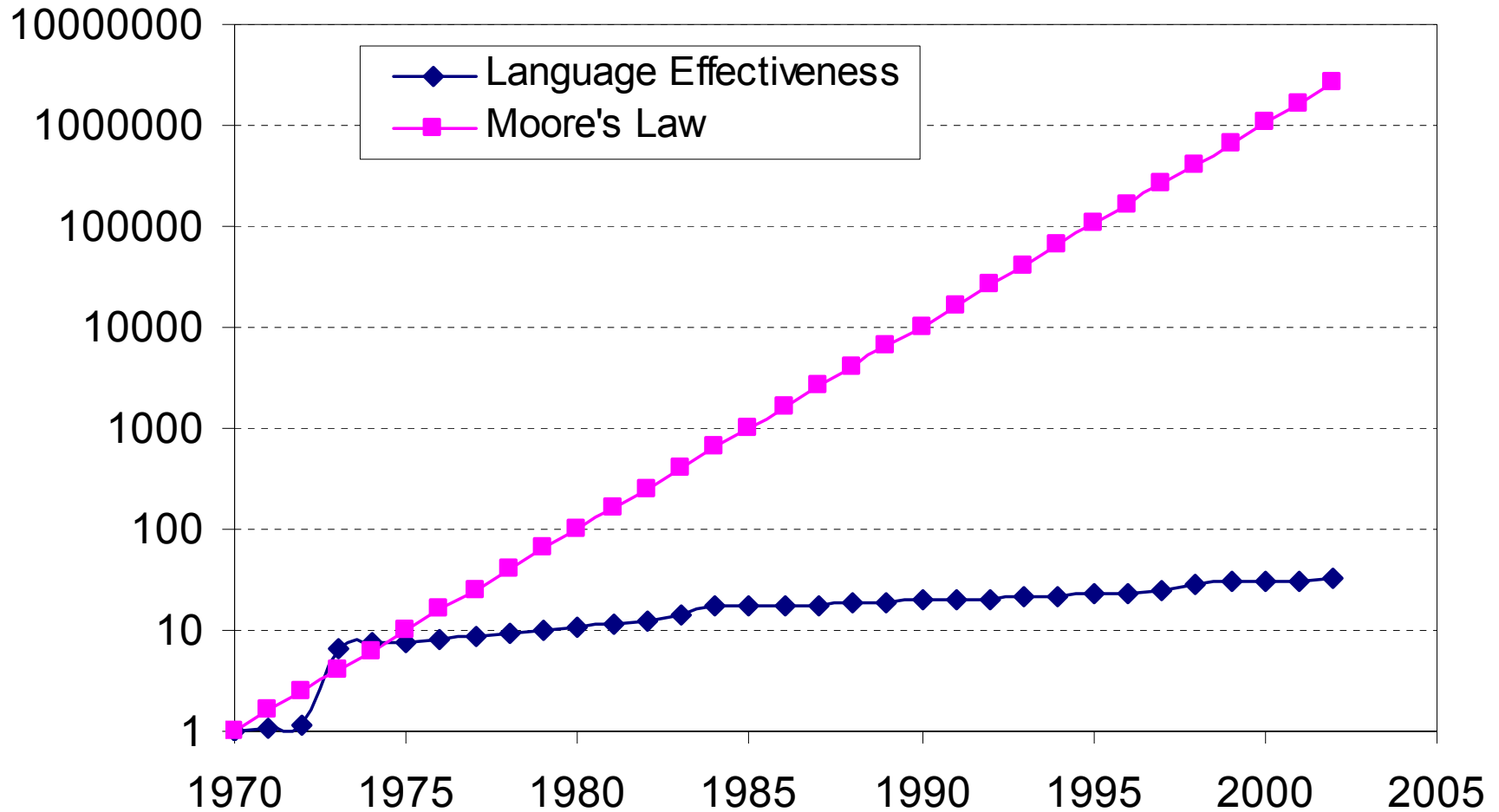
Back in The Good Old Days...

- Architecture: simple von-Neumann
- "Common Machine Language": C
 - Abstracts away idiosyncratic differences
 - Instruction set
 - Pipeline depth
 - Cache configuration
 - Register layout
 - Exposes common properties
 - Program counter
 - Arithmetic instructions
 - Monolithic memory
 - Efficient implementations on many machines
 - Portable: everyone uses it

Programming Language Evolution



Programming Language Evolution



Languages Have Not Kept Up



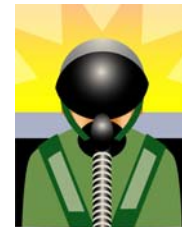
C ↔ von-Neumann
machine



Modern
architecture

- Two choices:

- Develop cool architecture with complicated, ad-hoc language
- Bend over backwards to support old languages like C/C++



Evidence: Superscalars

- Huge effort into improving performance of sequential instruction stream
- Complexity has grown unmanageable
- Even with 1 billion transistors on a chip, what more can be done?

Pipelining

Out-of-Order
Execution

Renaming

Branch
Prediction

Prefetching

Speculative
Execution

Value
Prediction



A New Era of Architectures

- Facing new design parameters
 - Transistors are in excess
 - Wire delays will dominate
- "Communication-exposed" architectures
 - Explicitly parallel hardware
 - Compiler-controlled communication
 - e.g. RAW, Smart Memories, TRIPS, Imagine, the Grid Processor, Blue Gene

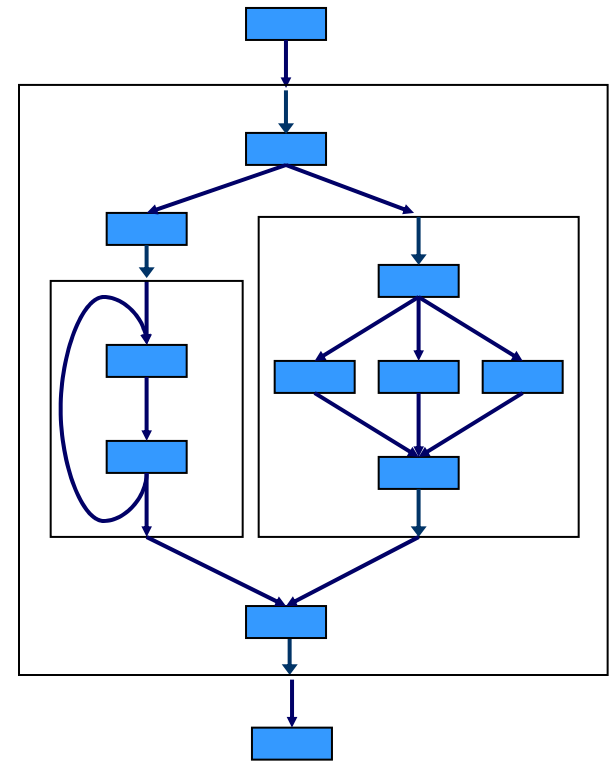
A New Common Machine Language

- Should expose shared properties:
 - Explicit parallelism (multiple program counters)
 - Regular communication patterns
 - Distributed memory banks
 - No global clock
- Should hide small differences:
 - Granularity of computation elements
 - Topology of network interconnect
 - Interface to memory units

→ C does not qualify!

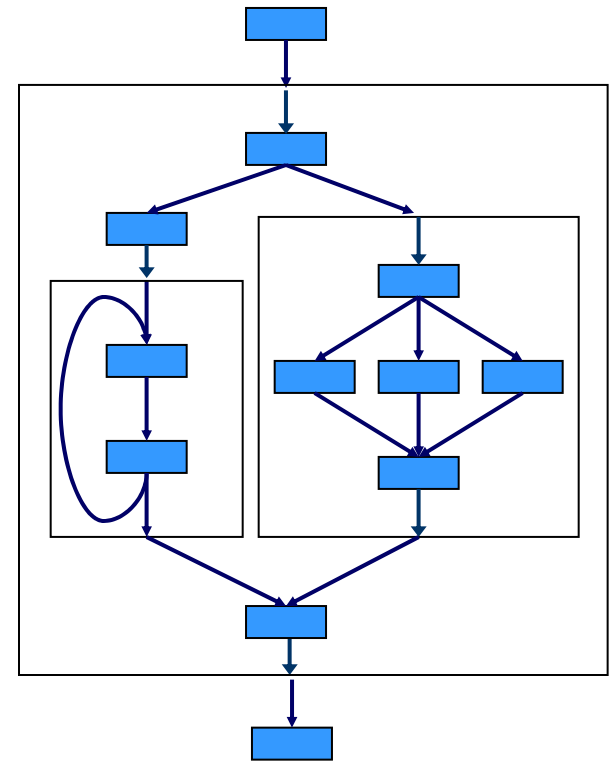
The StreamIt Language

- A high-level language for communication-exposed architectures
- Computation is expressed as a hierarchical composition of independent filters



The StreamIt Language

- A high-level language for communication-exposed architectures
- Computation is expressed as a hierarchical composition of independent filters
- Features:
 - High-bandwidth channels
 - Low-bandwidth messaging
 - Re-initialization

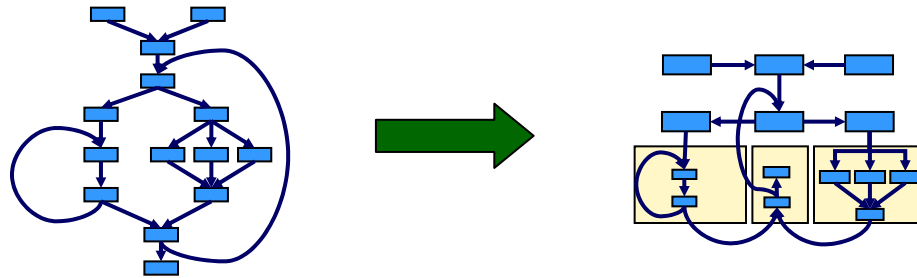


The StreamIt Compiler

- We have a compiler for a uniprocessor
 - Performs comparably to C++ runtime system

The StreamIt Compiler

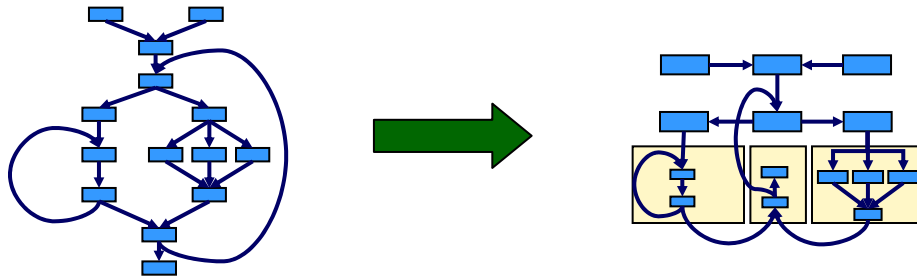
- We have a compiler for a uniprocessor
 - Performs comparably to C++ runtime system
- Working on a backend for RAW
 - Fission and fusion transformations



- Many optimizations in progress

The StreamIt Compiler

- We have a compiler for a uniprocessor
 - Performs comparably to C++ runtime system
- Working on a backend for RAW
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- Many optimizations in progress
- Goal: High-performance, portable language for communication-exposed architectures

For more information, see:

<http://cag.lcs.mit.edu/streamit/>

Thank you!