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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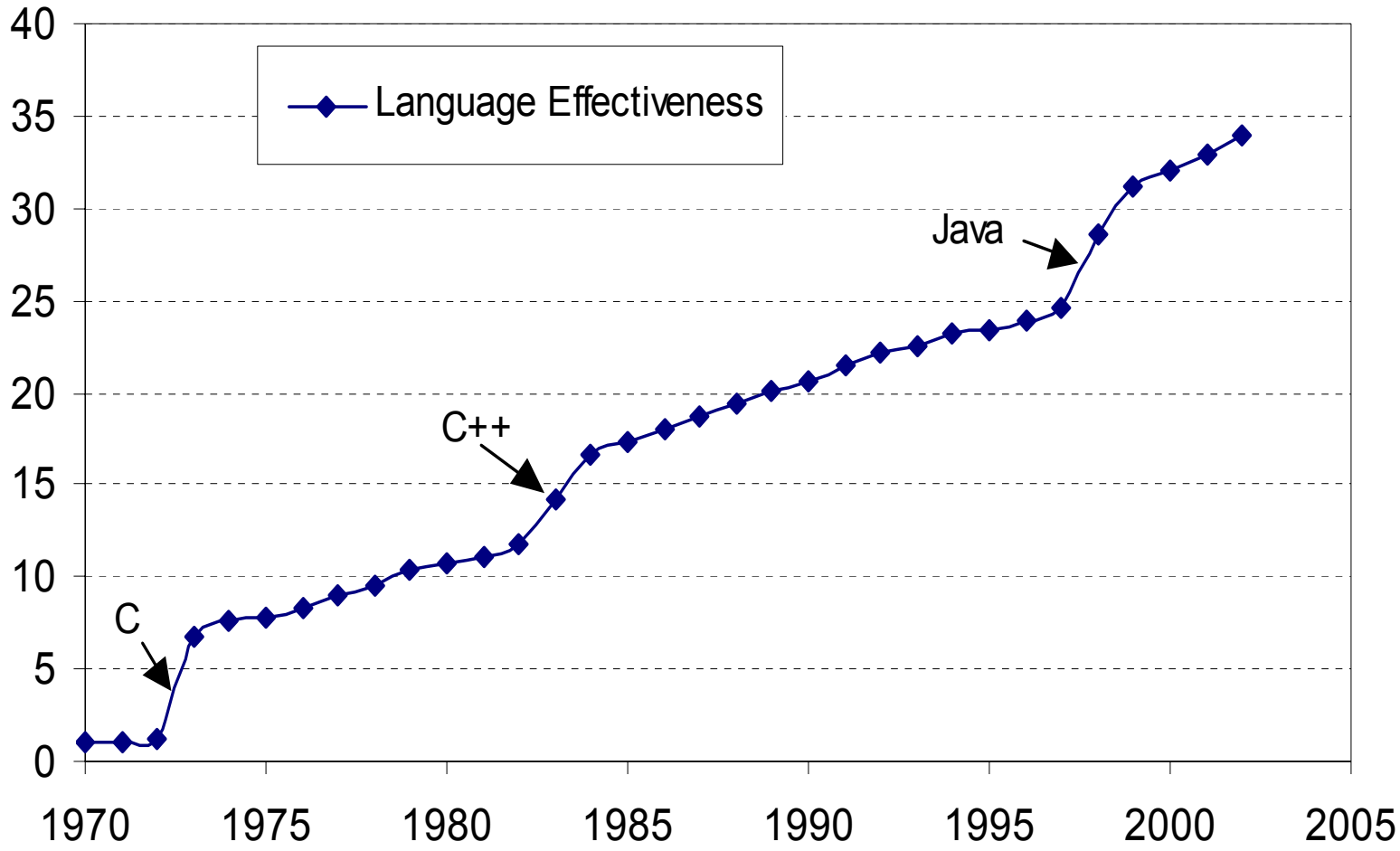
Back in The Good Old Days…

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

Programming Language Evolution



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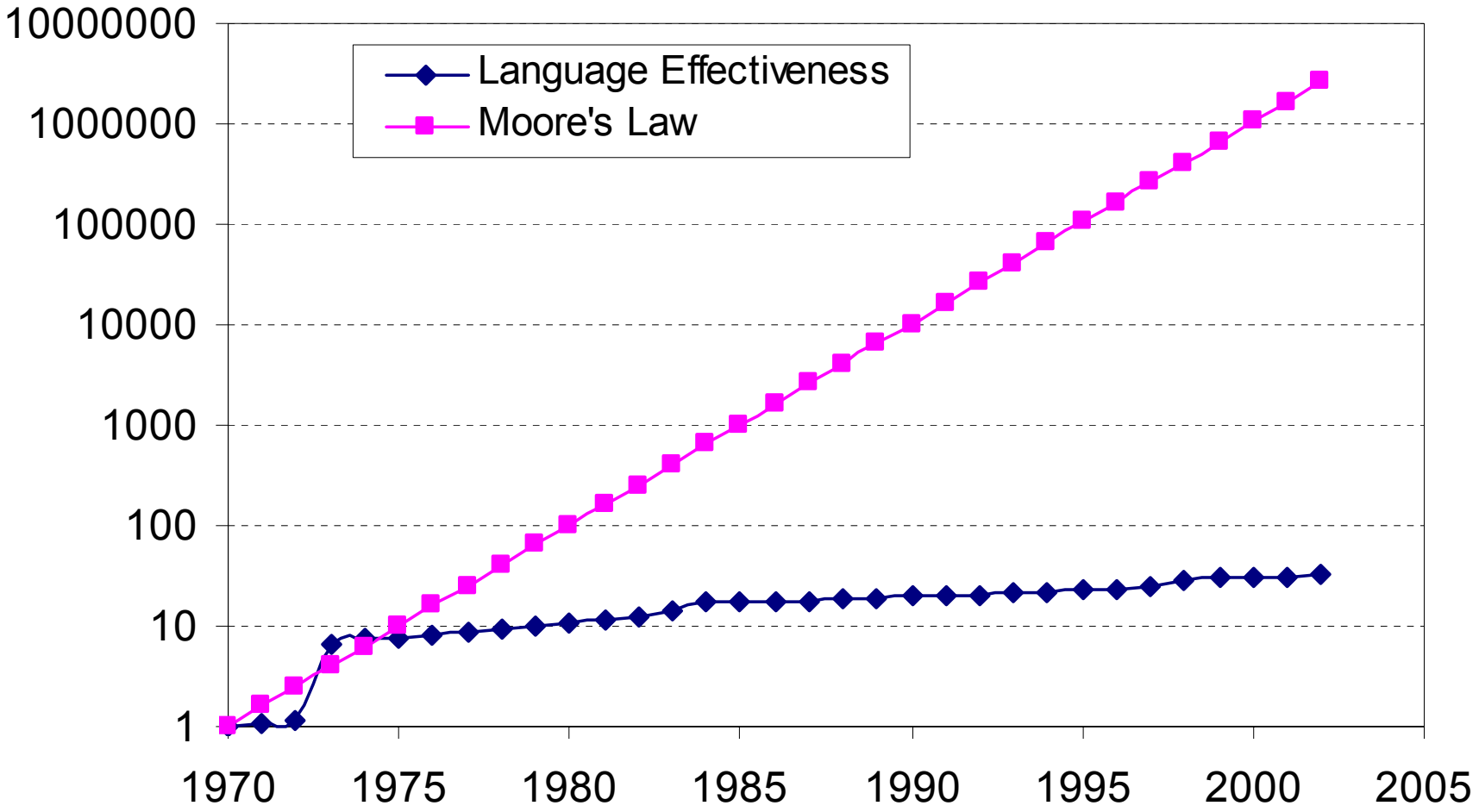


Languages Have Not Kept Up

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

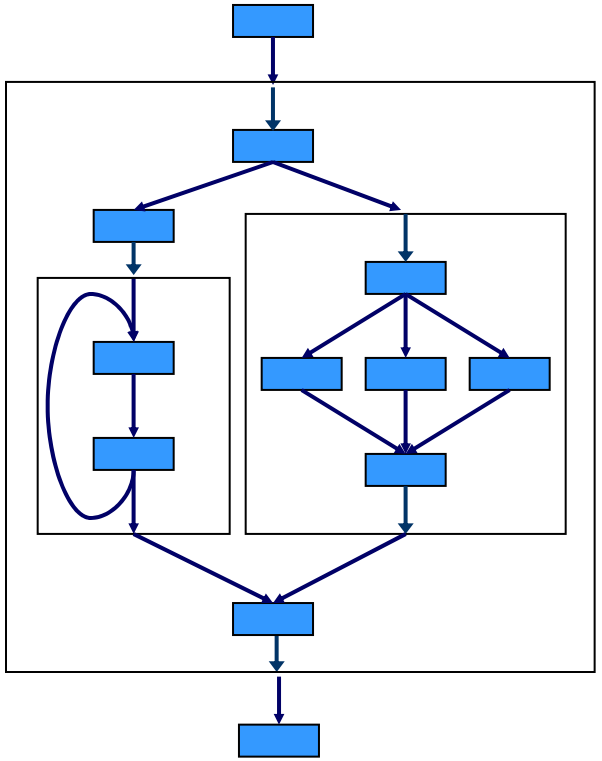
A New Common Machine Language

- 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!

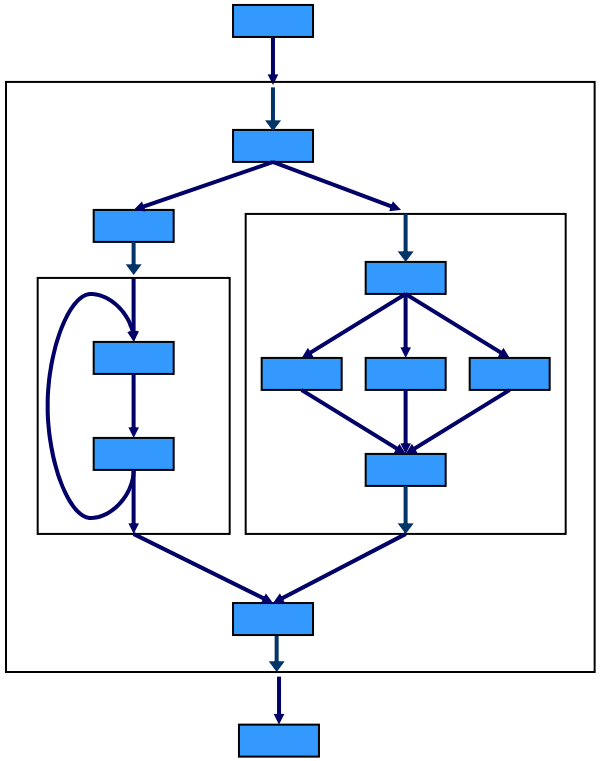
The StreamIt Language

- 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



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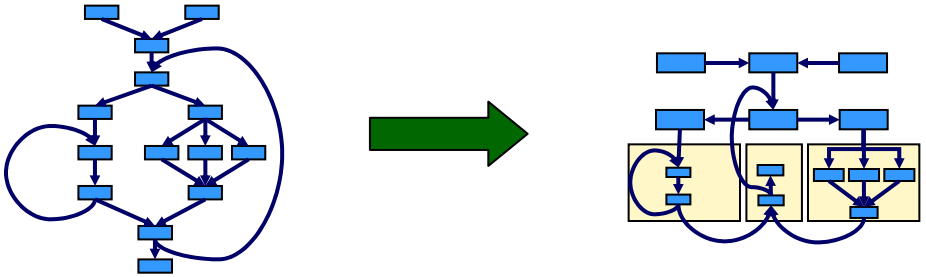
- Working on a backend for RAW
  - Fission and fusion transformations



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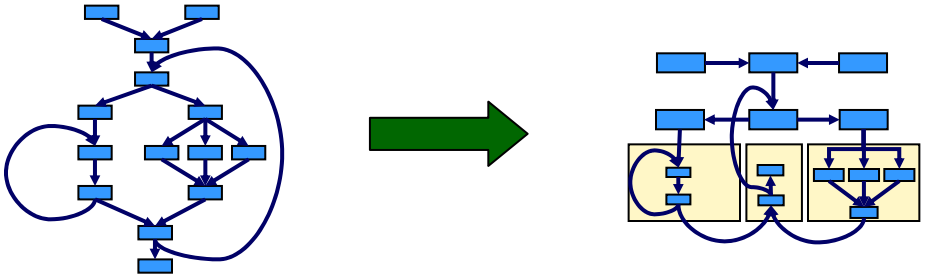

  - Many optimizations in progress
- Goal: High-performance, portable language for communication-exposed architectures

For more information, see:

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

Thank you!