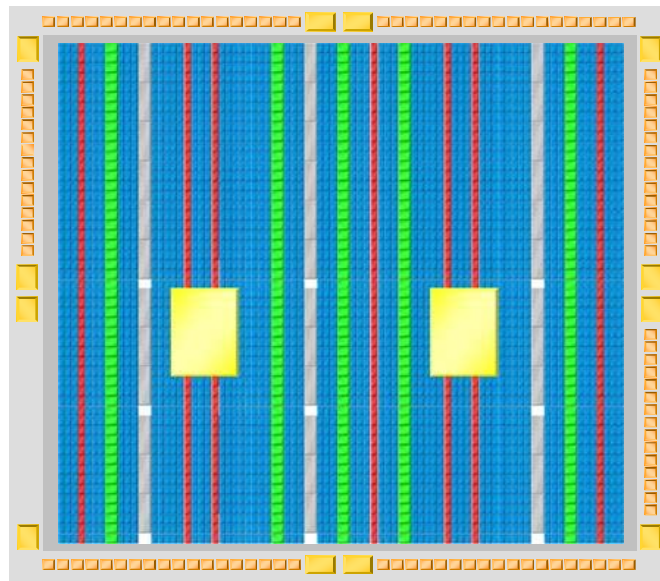

FPGA Research: Architecture, CAD, Soft Processors and Systems

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Field-Programmable Gate Arrays

- Are pre-fabricated digital chips
 - Programmed to become anything
 - Including large systems!



FPGAs vs. Custom Silicon (ASICs)

■ Advantages of FPGAs

- Instant fabrication: **Seconds vs. Months**
- Low cost prototyping; **\$100 vs. \$1M**
- Cheaper at low volume
- Don't need to sweat deep-submicron issues!

■ Disadvantages of FPGAs

- 20-30x more area
- 3-4x slower
- 10x more power consumption

If VLSI is the Technology of Our Time ...

FPGAs Democratize Technology of Our Time

- Make it accessible to everyone
 - Not just the rich who can afford ASICs
 - The small outfit in Singapore, Texas, Winnipeg
 - Small parts of large companies

My Goal

- To replace all digital silicon with FPGAs!
 - By making them better (architecture, CAD, ease of creation)
 - And using them in new ways for new applications
- The score so far:
 - \$4B FPGA, \$31B Custom Silicon (ASICs)
 - But 99% of all design is done with FPGAs!
 - Very few ASICs gather most of the market

How: FPGA Research: Architecture

- Make better FPGAs by improving their architecture
 - What is the logic
 - How to make the routing better
- Central Question of FPGA Architecture:

What logic should be made “hard”?

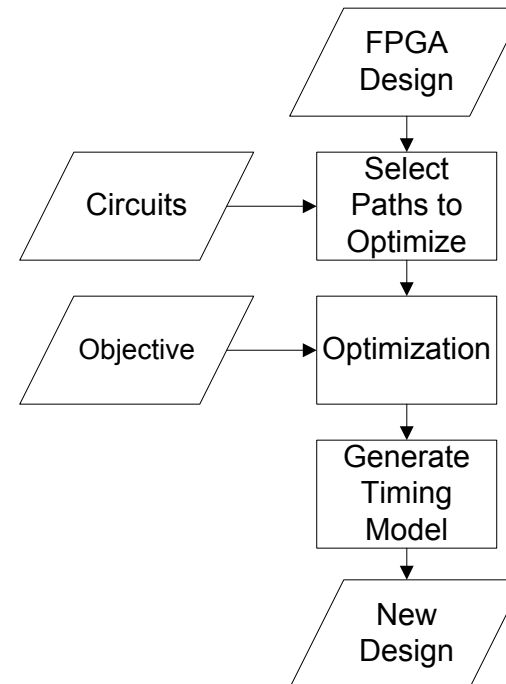
- Where can we reduce the costly flexibility?
 - Deep question with interesting theoretical & practical branches

How: Computer-Aided Design

- Better tools make FPGAs faster, smaller, lower power
- High Level Synthesis
- Logic Synthesis
- Packing (memory, special structures, logic)
- Placement
- Routing
- To optimize: area, speed, power (dynamic and static)

How: The Creation of FPGAs Themselves

- Automated Layout of *FPGAs themselves*
- Automated Circuit Design of FPGAs
- Current Project:
 - Automating the transistor-level design of FPGAs



Systems & Applications

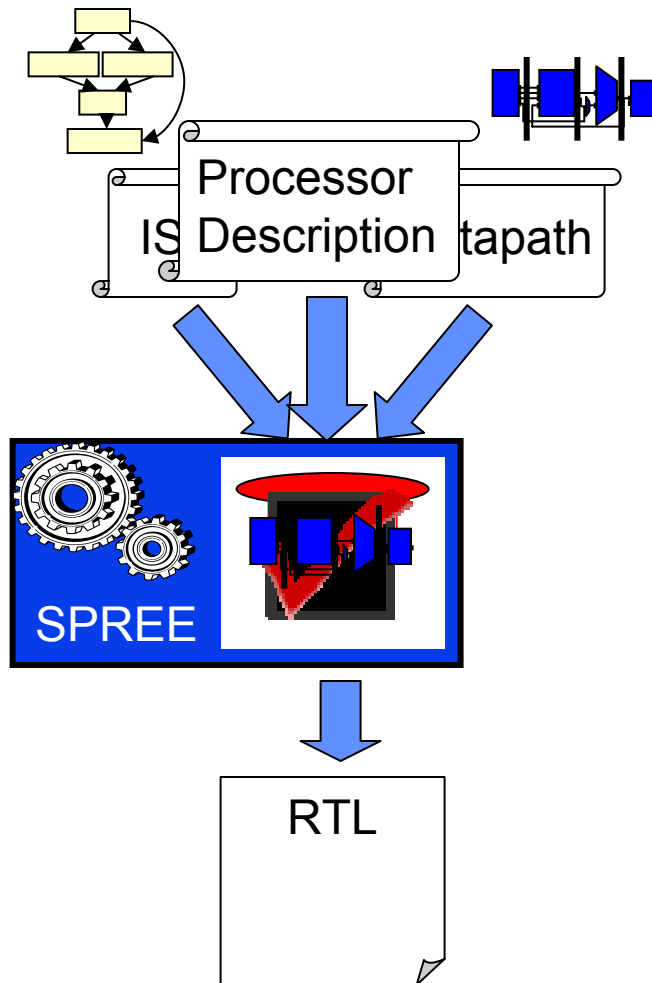
- The Transmogrifier Project
 - Creation of programmable systems
- New System: The Transmogrifier-4:
- Interested in applications on
 - Vision
 - Graphics
 - Bioinformatics – simulation
- Next Generation: Transmogrifier-5
 - Super cheap
 - Portable – wireless/full system



Soft Processors

- For FPGAs to conquer, they must have good processors
- *Soft* processors are processors built on FPGA fabric
 - Fabric makes them slower, bigger than hard processors
 - Must use FPGA's flexibility to get this back!
- Example Projects:
 - Exploration of Soft Processor Micro-architecture
 - Super Small Soft Processor
 - Super Fast Soft Processor

Soft Processor Rapid Exploration (SPREE)

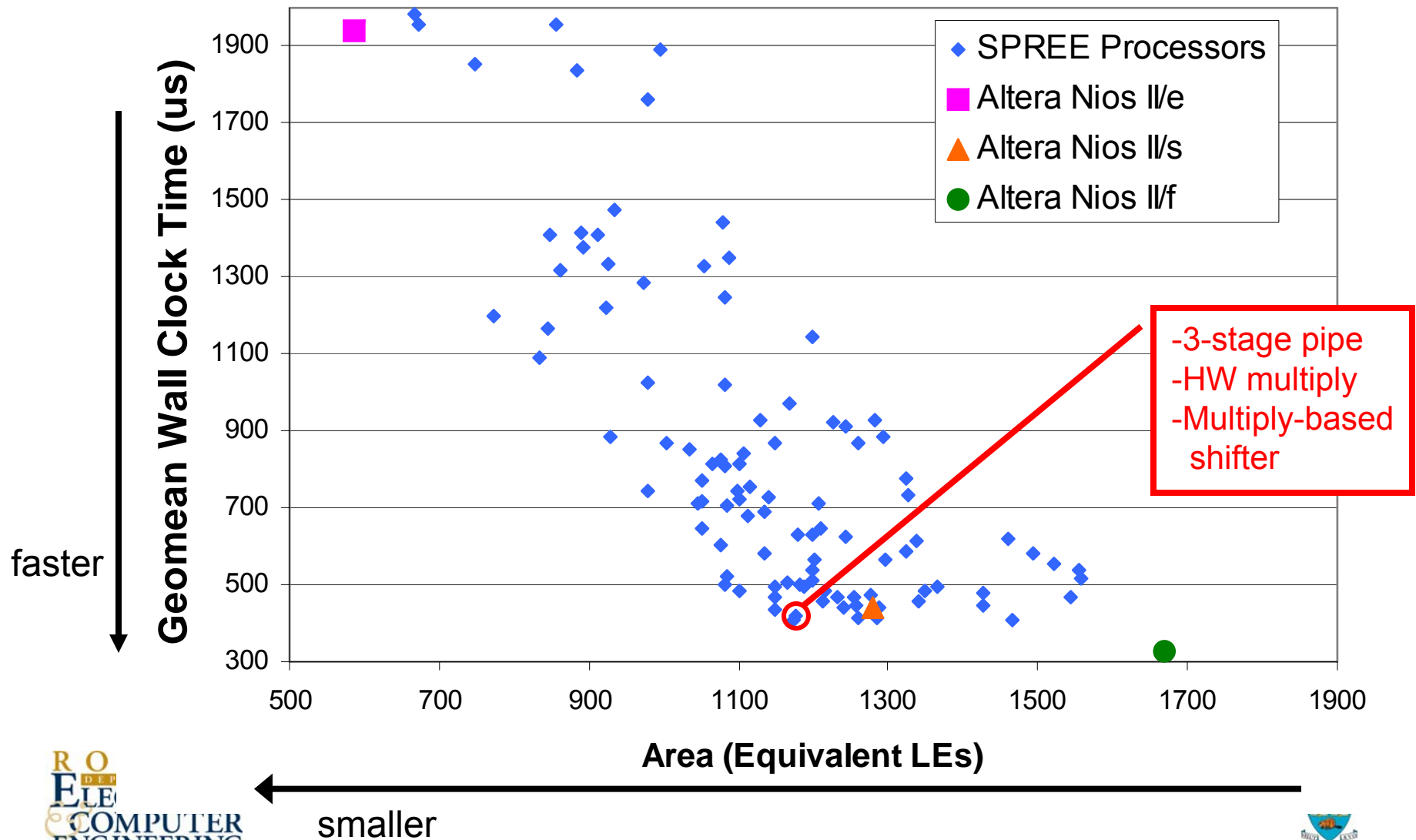


- Input: Processor Description
 - Hand-coded components, Datapath

- CAD/Compiler:
 1. Verifies ISA against datapath
 2. Instantiates Datapath
 3. Generates Control

- Output: Synthesizable Verilog

Spanning the Area/Speed Space



FPGAs: Poised To Conquer!