Radiation Effects in Digital Data Processors

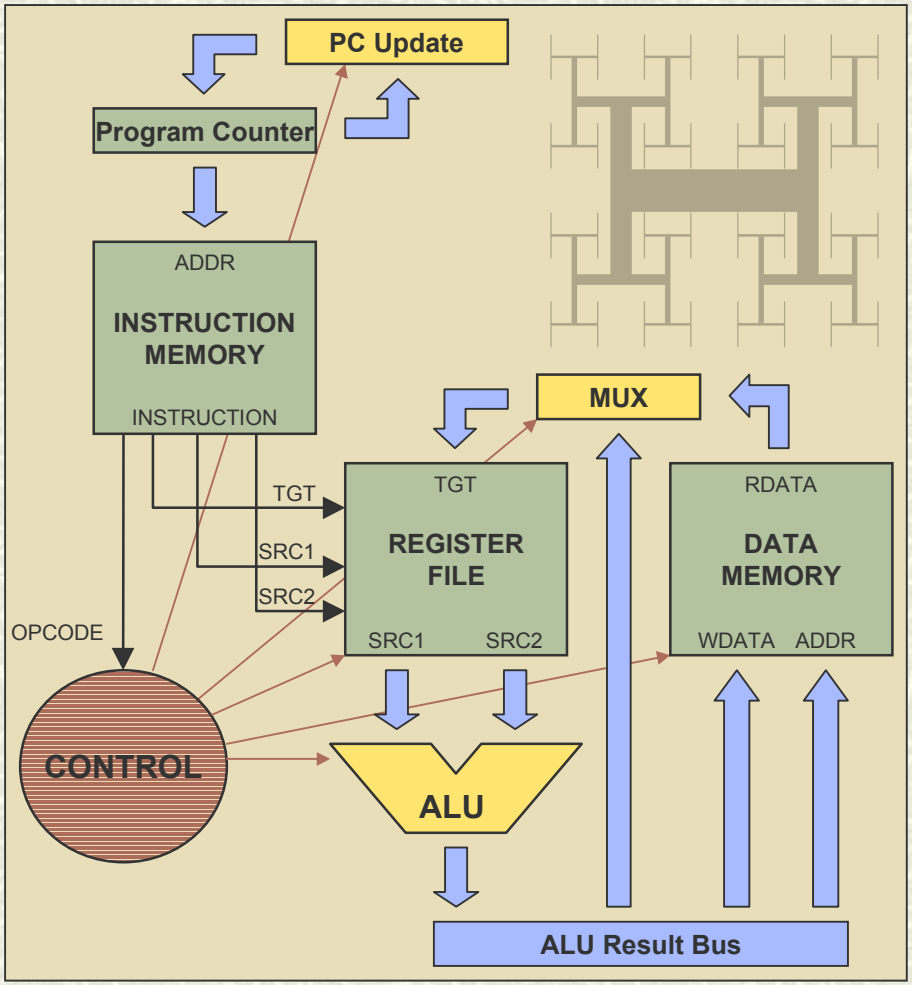
Prof. Bruce Jacob

Electrical & Computer Engineering
University of Maryland

Main Points

- By Design, Digital Microprocessors Have Many Points of Failure
- Existing Error-Detection/Correction Techniques Target Implementation Errors
- Goals of the Research
  - Characterize Failure Behavior
  - Investigate Solutions (Heterogeneous Designs?)

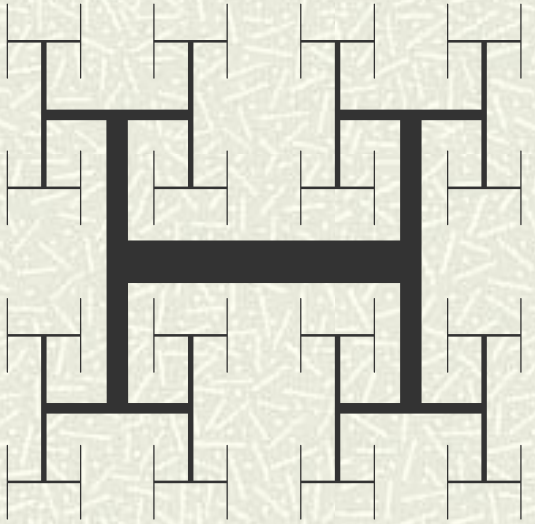
A Typical Microprocessor

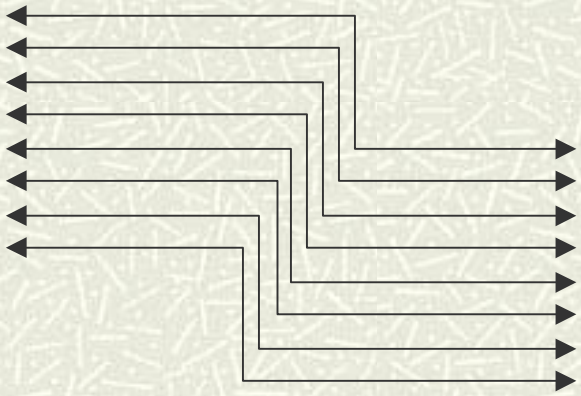


- Clock Nets
- Power Nets
- Busses
- Datapath
- Control
- Memories

CPU Components

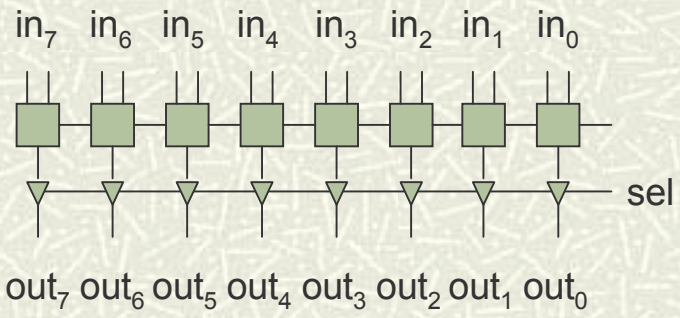
- Clock & Power Nets
  - Clock: Typically H-trees
  - Power/Ground: Less Regular
  - Make fantastic antennas
  - Extremely sensitive to variations
  - All other subsystems dependent
- Busses
  - Groupings of parallel wires
  - Encoding schemes for errors in transmission but not endpoints

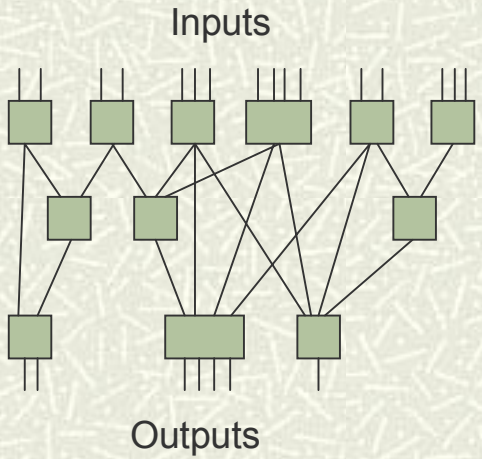




CPU Components

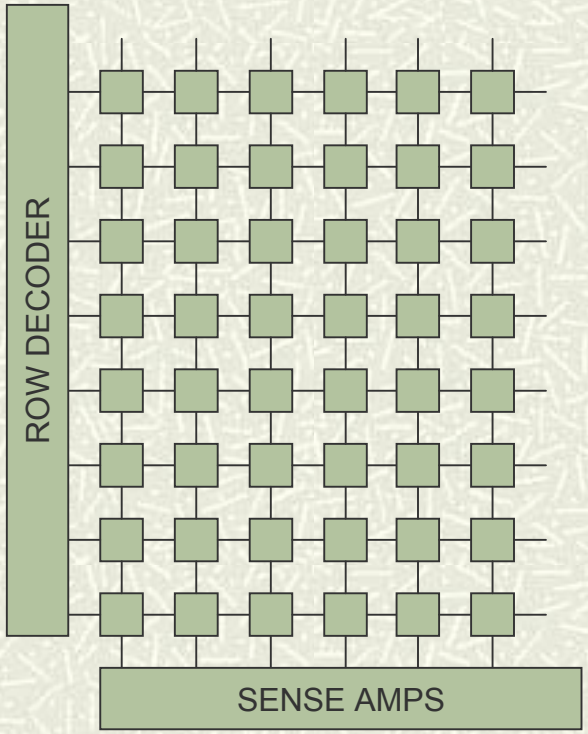
- Datapath
  - Where the data is processed (adders, multipliers, muxes)
  - Regular device arrays
  - Self-correcting logic schemes assume checker is correct
- Control
  - Represents if-then logic
  - Less regular than others
  - Self-correcting as above





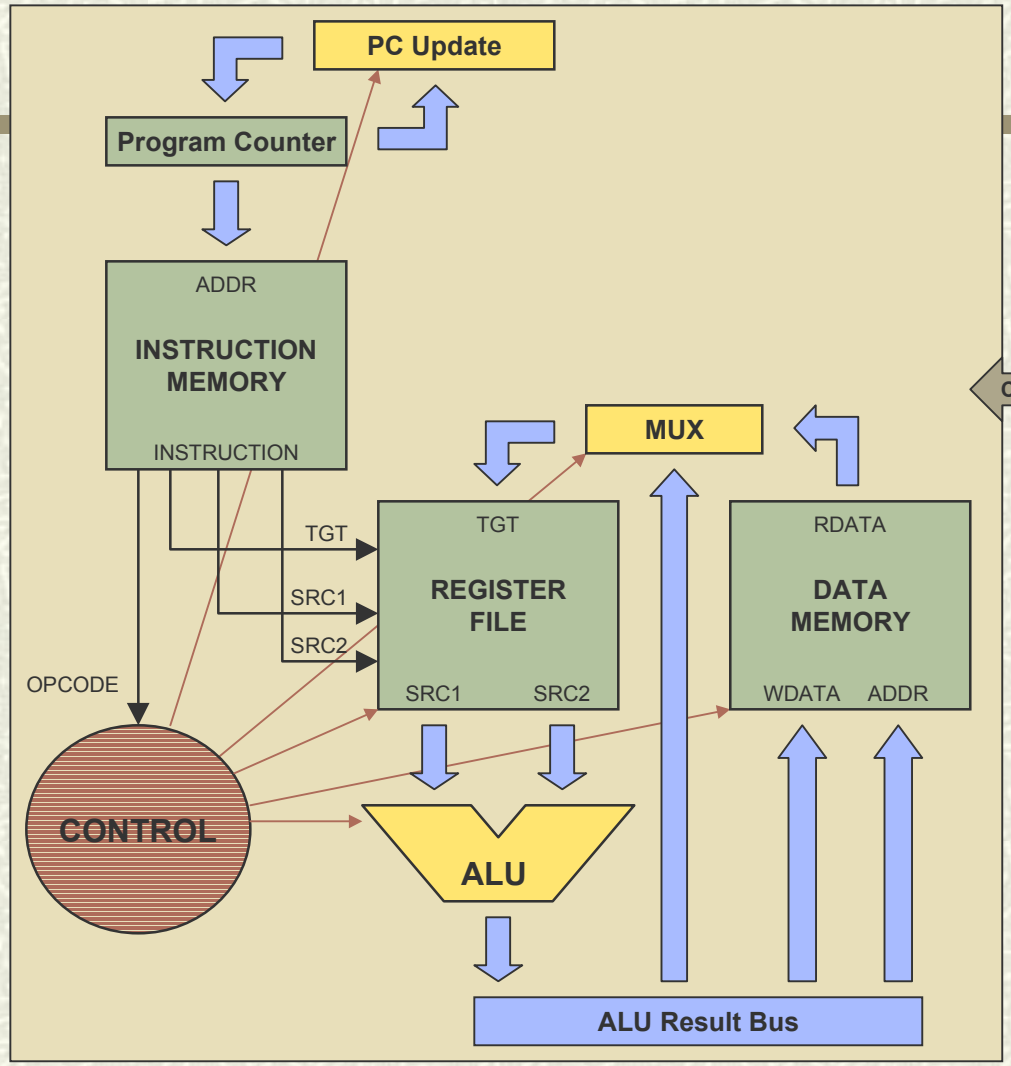
CPU Components

- Memory
  - Includes SRAM caches, DRAMs, register files, pipeline registers, etc.
  - Very regular in structure
  - Error-detecting/correcting codes target limited bit-flips in storage and/or transmission but assume correctness of checker
  - Large storage off-chip, small storage on-chip



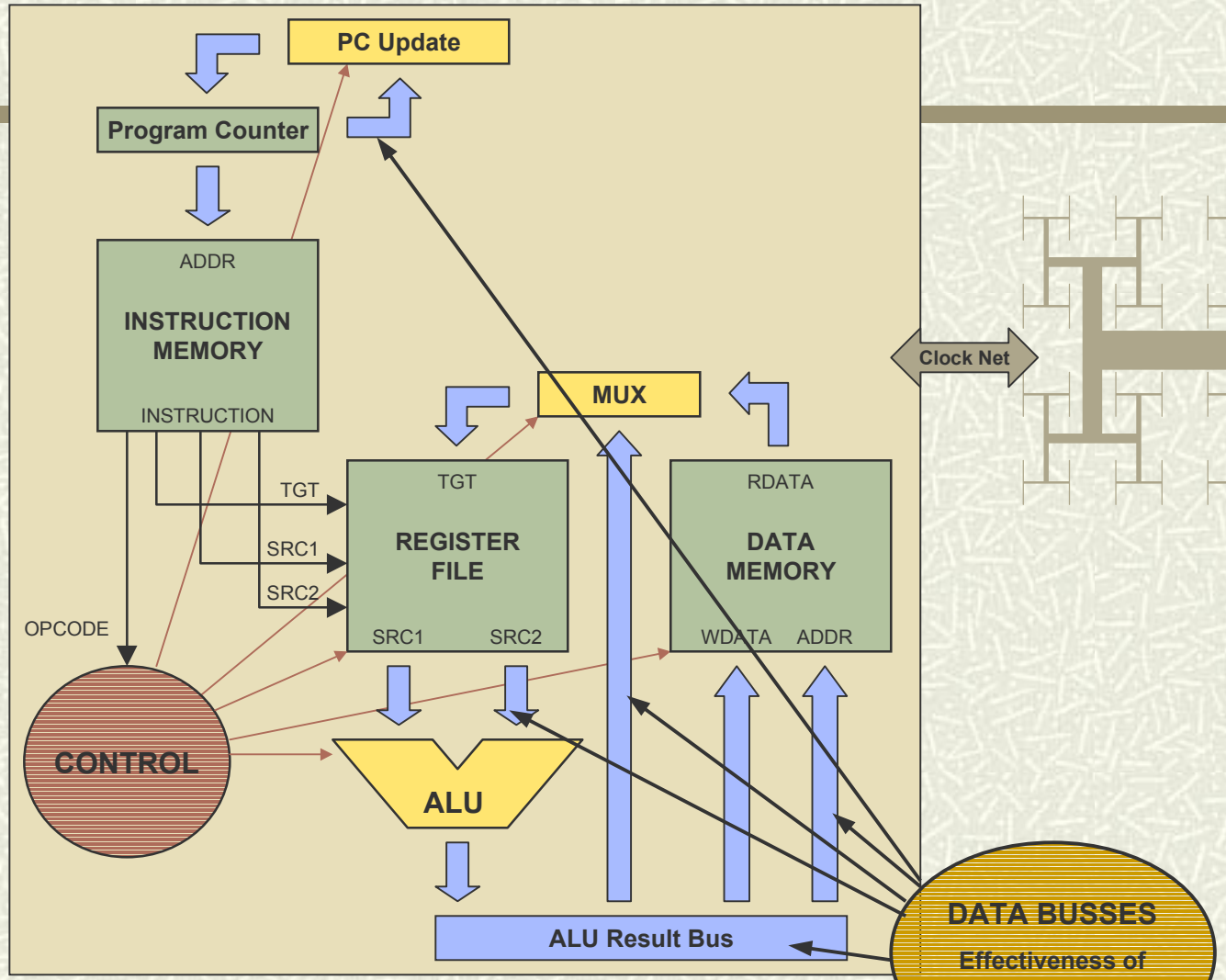
SIMPLE TEST CPU

Observations made and measurements taken at critical points



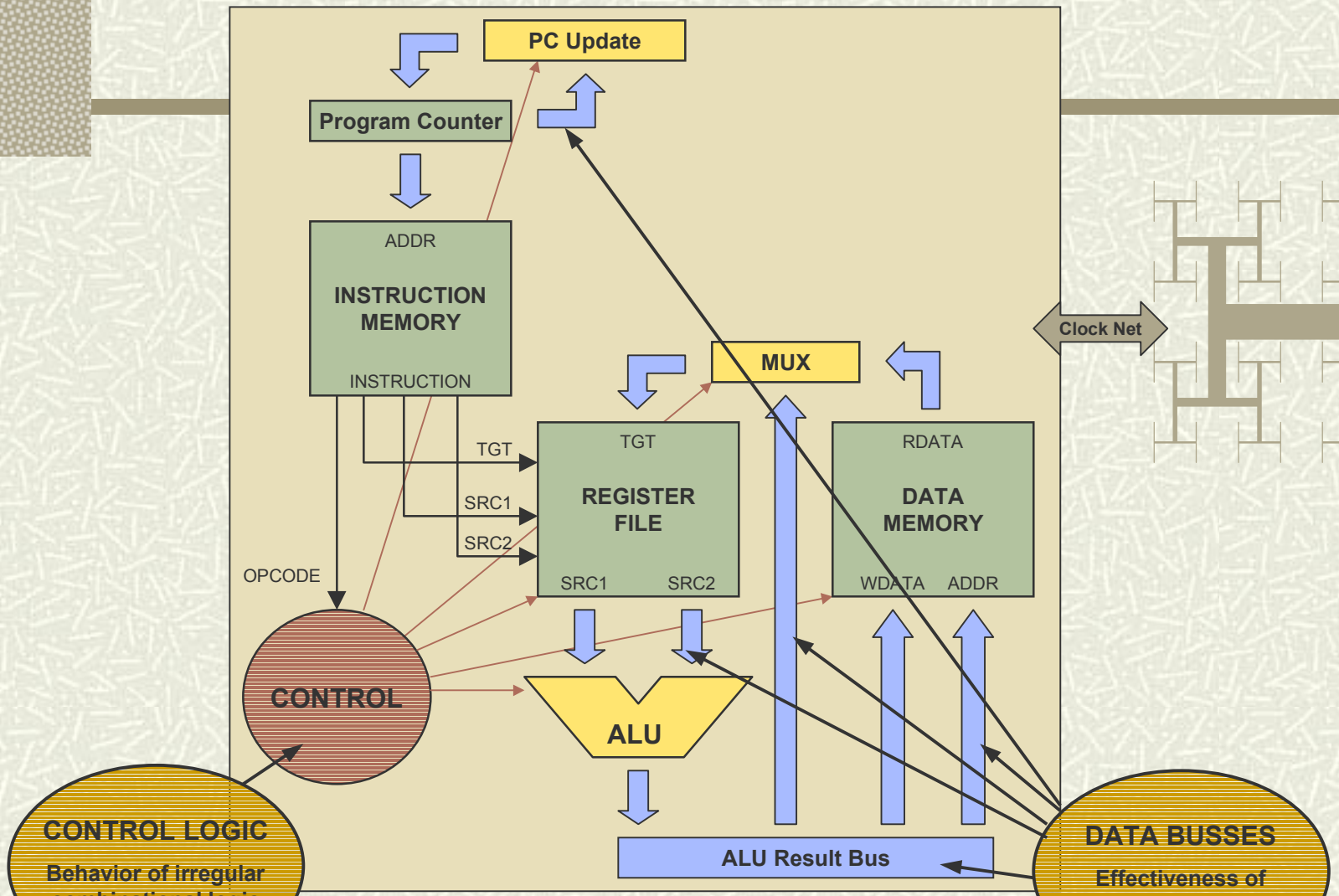
SIMPLE TEST CPU

Observations made and measurements taken at critical points



SIMPLE TEST CPU

Observations made and measurements taken at critical points



CONTROL LOGIC

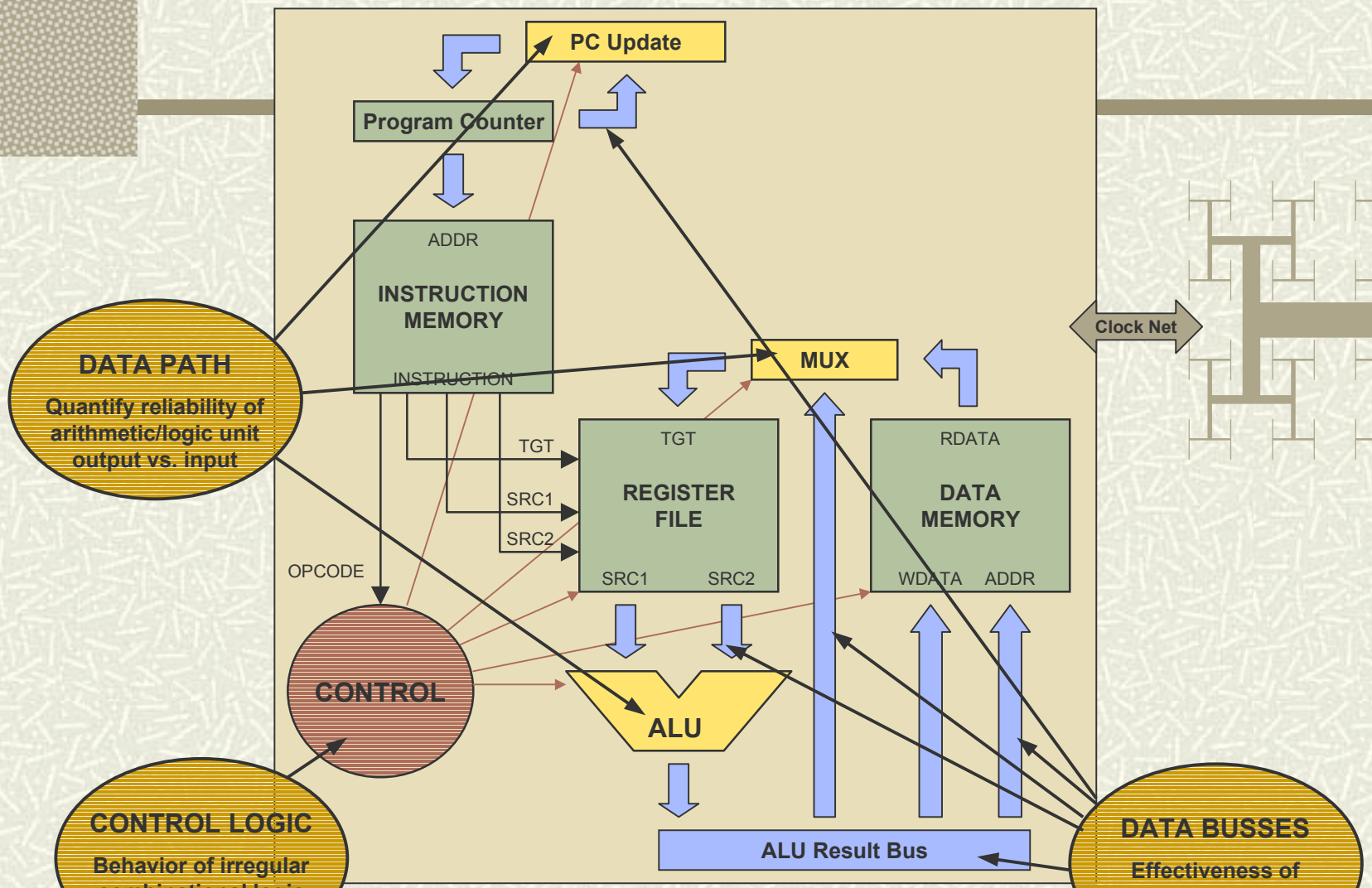
Behavior of irregular combinational logic designs

DATA BUSSES

Effectiveness of error-detection and error-correction

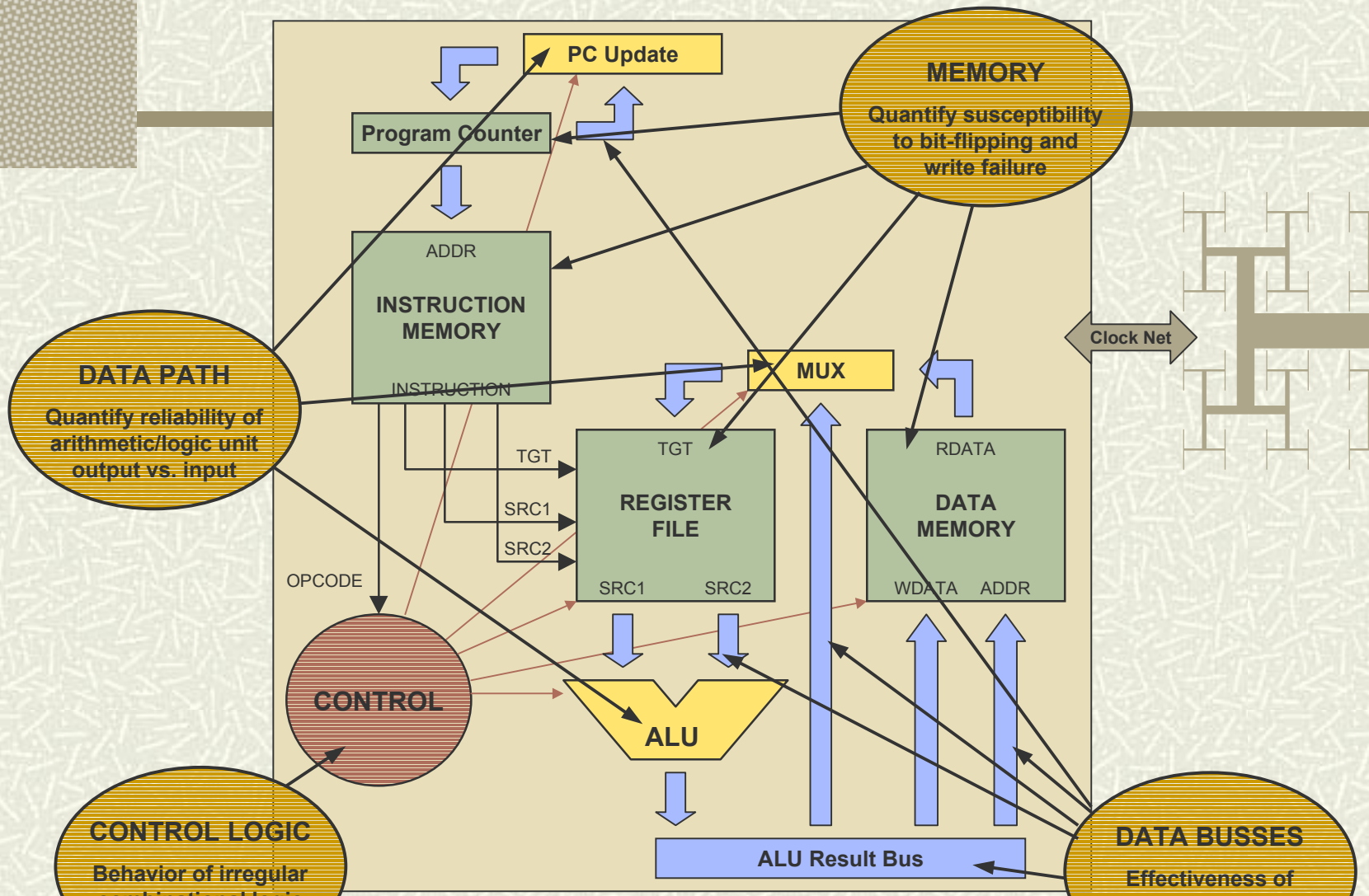
SIMPLE TEST CPU

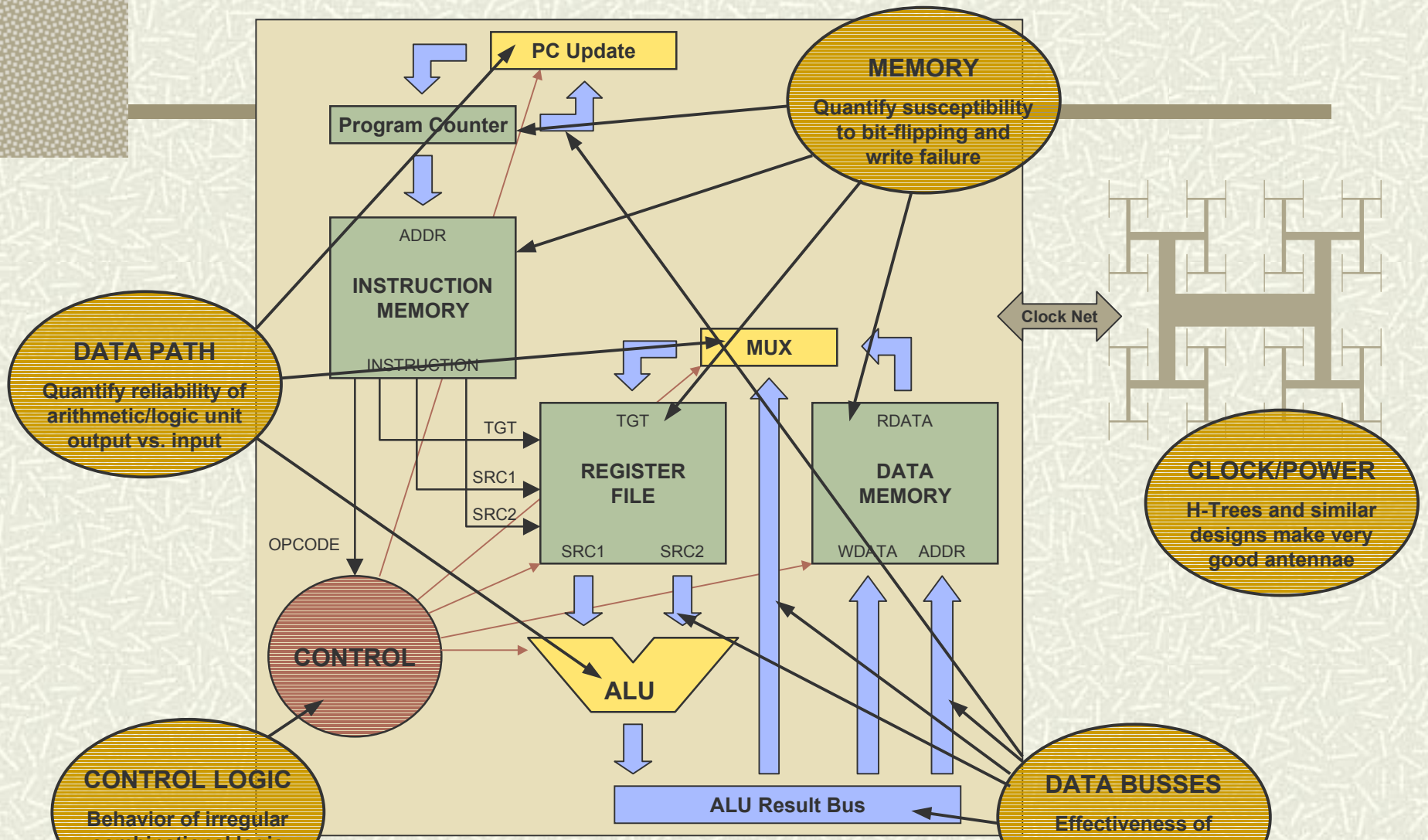
Observations made and measurements taken at critical points



SIMPLE TEST CPU

Observations made and measurements taken at critical points



SIMPLE TEST CPU

Observations made and measurements taken at critical points