Processors in Embedded Systems

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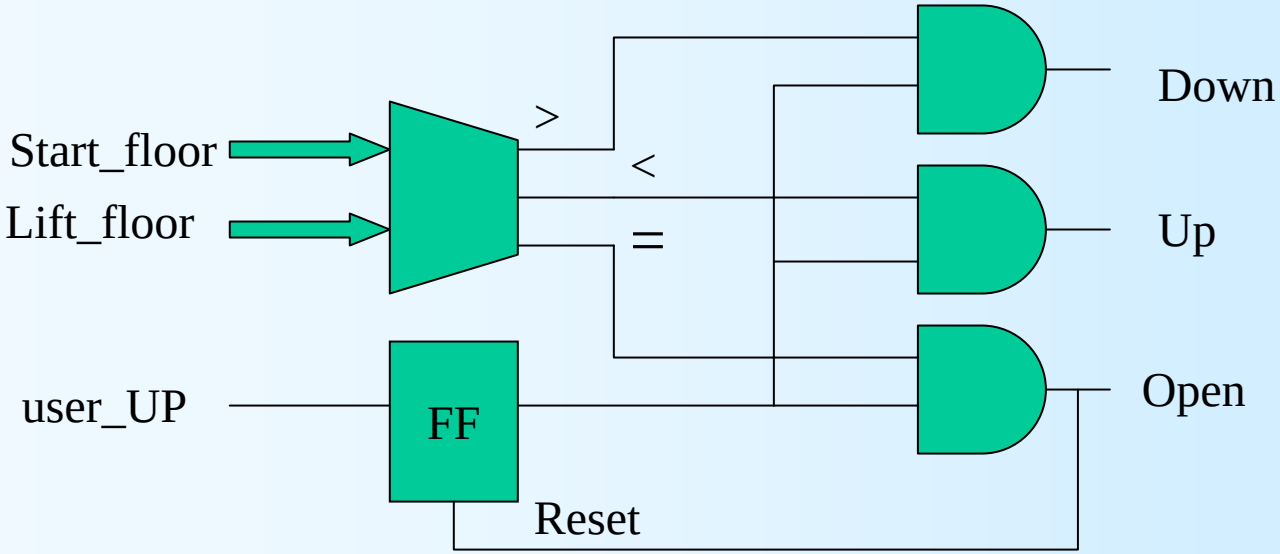
Introduction

- Embedded System
  - Computer which is not used for computing
- Examples
  - TV, VCD Player, MP3 player, Control system in Automobiles, Washing machine, Lift

Introduction

- Lift as an embedded system
  - If user press UP button, lift should come down and open
  - Pressing floor number, lift should move and go to that floor and open
  - Same thing for down buttons

Design of Lift system (approach 1)



❑Design of Lift System (approach 2)

```
While(1){
If (user_UP =1)
{
  if(lift_floor > user_floor)
      down = 1;
  else if (lift_floor = user_floor)
      open = 1;
   else
       up = 1;
 }
If up = 1
   user_UP = 0;
```

Embedded System Design

- ASIC Design
  - Application specific
  - Low area
  - Low Power
  - More design time
- Processor design
  - Flexibility
  - Generic => Easy to design
  - More power and area

Processor selection

- Various options available
  - High performance processor (P4, Athlon64 etc)
  - Low power processor PowerPC
  - ARM
  - DSP Processor
  - Multi cores (Dual and quad cores)

Processor Selection

- Power/Energy
  - Battery power (size of battery)
- Cost
  - Processor cost and size
- Performance
  - How much computation required
- Size

Application Specific Processor Design

- To match application needs
- Possibilities of customization
  - Register file (port and size)
  - Number of Functional units
  - Instruction set modification/extension
  - Additional memory structures
- Example:
  - DSP processor
  - Media processor
  - Micro-controllers

ASIP Design Methodology

Instruction set modification

- Reduced instruction set
  - Instructions that are not user regularly are removed (example, floating point unit for some applications)
- Instruction set extension
  - New application specific instruction example MAC

ASIP Design Methodology

- Reduce instruction set
  - Less area
    - Less control because of less instruction
    - Data path area can also be reduces
  - Less power
- A few facts
  - Number of instructions in Pentium 4 are order of few hundreds
  - Number of instructions in DSP processor are order of 50

ASIP Design Methodologies

Instruction set extension

- Application specific instructions
- More performance
  - Vector add – Add two vectors of length 8 into third
  - 8 times faster
  - If such addition constitute 50% of computation, application would be around 40% faster
- Example – MAC instruction in DSP, MMX instruction in media processors

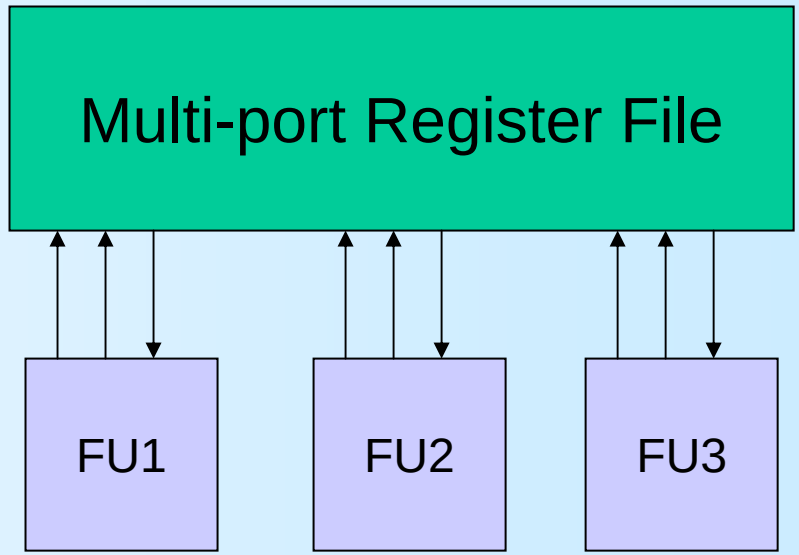
ASIP Design methodologies (IITD Approach)

Instruction set extension

- Methodology
  - Use profiling tools to find patterns which may be suitable candidates for new instruction
  - Constraints: Area, number of input/output, latency, load/store exclusion
- Tools
  - Suif compiler is used for profiling
  - New instruction are written as function
  - In code generation, replace function calls by new instruction
  - Trimaran compiler is used for backend

ASIP Design methodologies (IITD Approach)

- Multiple function unit
  - VLIW processor is used as base architecture
  - Trimaran compiler
- VLIW processor
  - Multiple function units
  - Complier controlled execution
- VLIW Design space
  - Number of FUs
  - Register file ports
  - RF Cluster interconnect
  - Register file bypass



Recap

- Understand the application requirement
- Choose between ASIC and processor
- Which processor
  - RISC, ASIP or Multiprocessor
- Processor customization
  - According to application
  - Need application analysis
- Compiler is important in design space exploration of a custom processor