Embedded Systems Engineering

System Reliability - 3

- Processor Problems
  - Power-on aspects
  - Run-time issues
- Hardware-based Fault Tolerance
  - Fault-tolerant structures
  - Matching structures to requirements

Michael Brockway

Processor Problems

- Techniques to answer these questions:
    - Is it OK to use the processor system at all?
    - Is it safe to continue using it in its normal running mode?
    - If problems *are* detected, can we recover?
- We want as far as possible *graceful* recovery from failures
- Power-on Aspects
    - CPU Tests
        - Verify processor correctly executes its range of instructions
        - Ensure condition flags can be set and read correctly
        - Check on-chip registers etc can be written and read correctly
        - Verify numeric coprocessors
    - You can write your own code to perform these test insofar as applicable to your application code

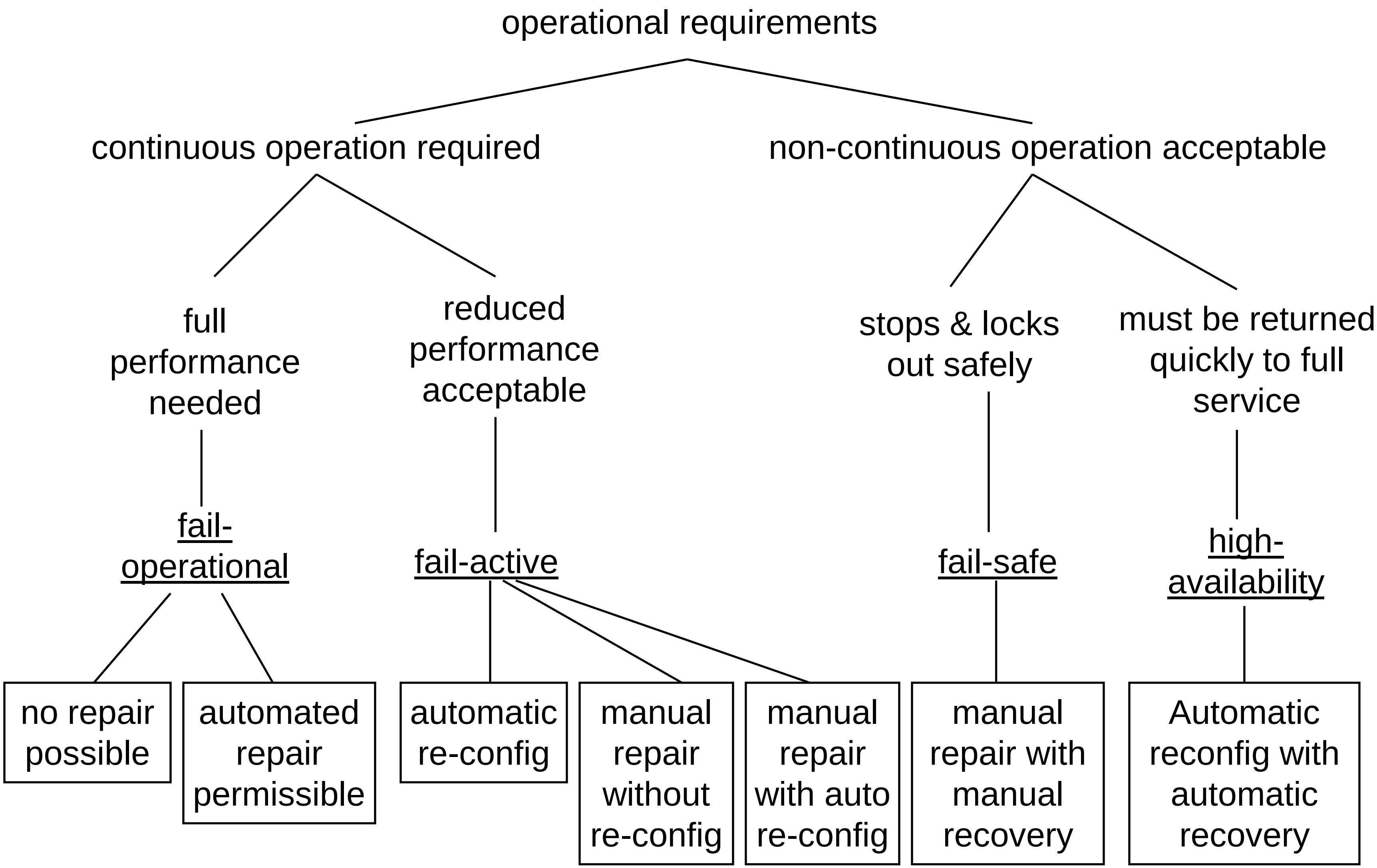
Processor Problems

- Power-on Aspects
  - ROM Tests
    - ROM contents could become corrupted by EM pulses / radiation
    - Flash can be “accidentally” reprogrammed
  - Write tests to check for validity on power-up
- Run-time Issues
  - Stack overflow
    - Inhibit interrupts until current one is serviced (not always feasible)
    - Service the interruptr before the next arrives (not always possible)
    - Monitor with software
    - Hardware-based monitoring (eg ARM)

Processor Problems

- Run-time Issues
  - Corruption of critical variables
    - Causes by electrical noise, power supply fluctuations, …
    - Use check summing
    - Make a (check summed copy), compare with original
    - Make 3 copies, use majority voting
  - Instruction pointer corruption
    - PC may point to unprogrammed locations
      - Fill with No-op codes
    - or it may point to programmed memory locations
      - More difficult to deal with

Hardware-based Fault Tolerance



operational requirements

continuous operation required

full performance needed

fail-operational

no repair possible

automated repair permissible

reduced performance acceptable

fail-active

automatic re-config

manual repair without re-config

manual repair with auto re-config

non-continuous operation acceptable

stops & locks out safely

fail-safe

manual repair with manual recovery

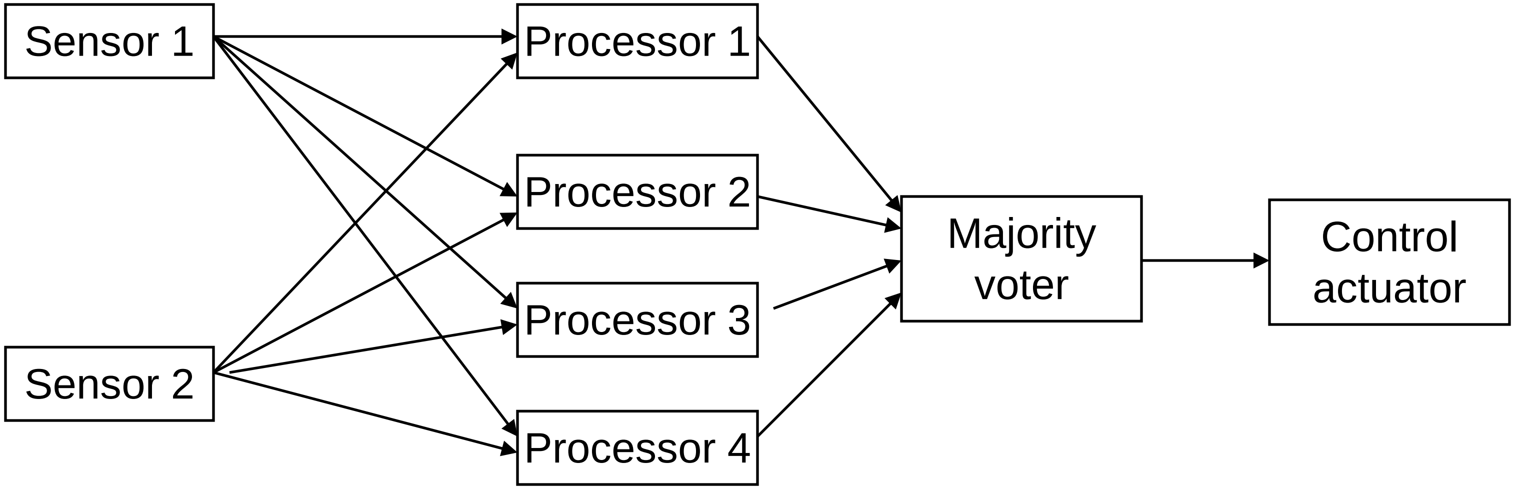
must be returned quickly to full service

high-availability

Automatic reconfig with automatic recovery

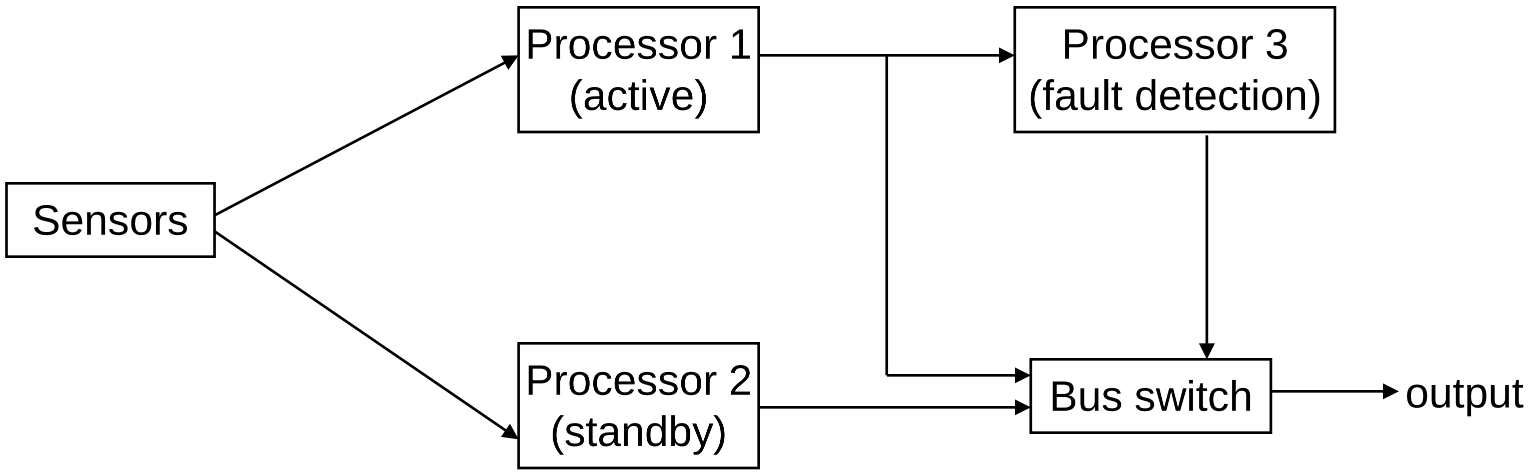
Hardware-based Fault Tolerance

- Fault-tolerant structures
  - Passive redundant systems



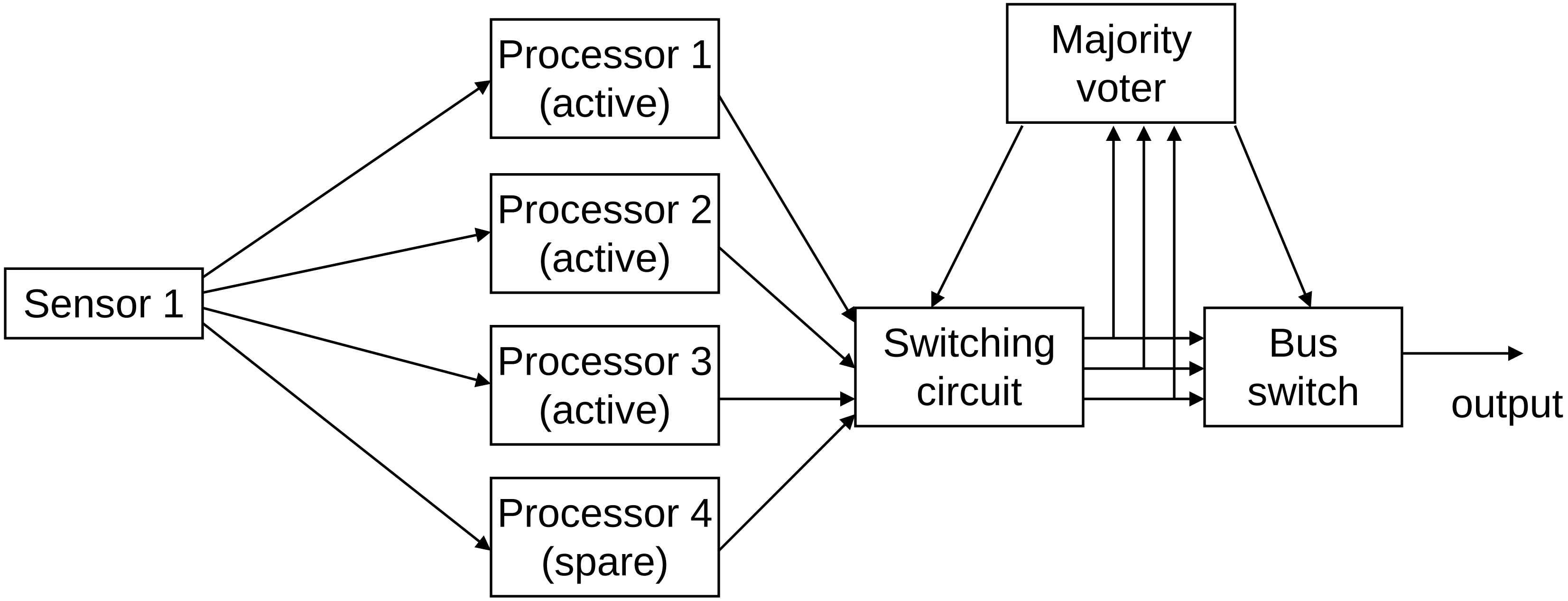
Hardware-based Fault Tolerance

- Fault-tolerant structures
  - Active redundant systems
    - Standby processor could be running “cold” or “hot”, in the latter case perhaps fully synchronised with the active processor



Hardware-based Fault Tolerance

- Fault-tolerant structures
  - Hybrid redundant systems

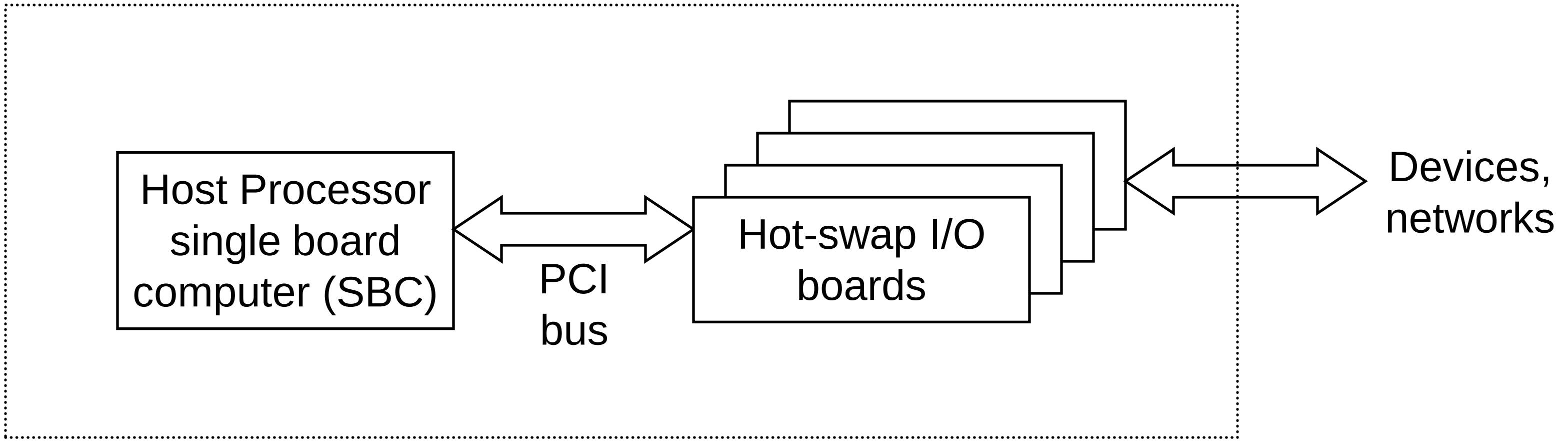


Hardware-based Fault Tolerance

- Fault-tolerant structures
  - Very high availability systems
    - Active redundant structures
    - DB servers etc
    - Very fast “failover” times
    - Ready availability of disk data to standby systems
  - Hot-swap systems
    - Replacement of boards while system is on-line, without disturbing operations
    - CompactPCI standard: four levels of capability
      - Basic hot-swap
      - Full hotswap
      - High-availability hot-swap (single processor)
      - High-availability hot-swap (multiple processor)

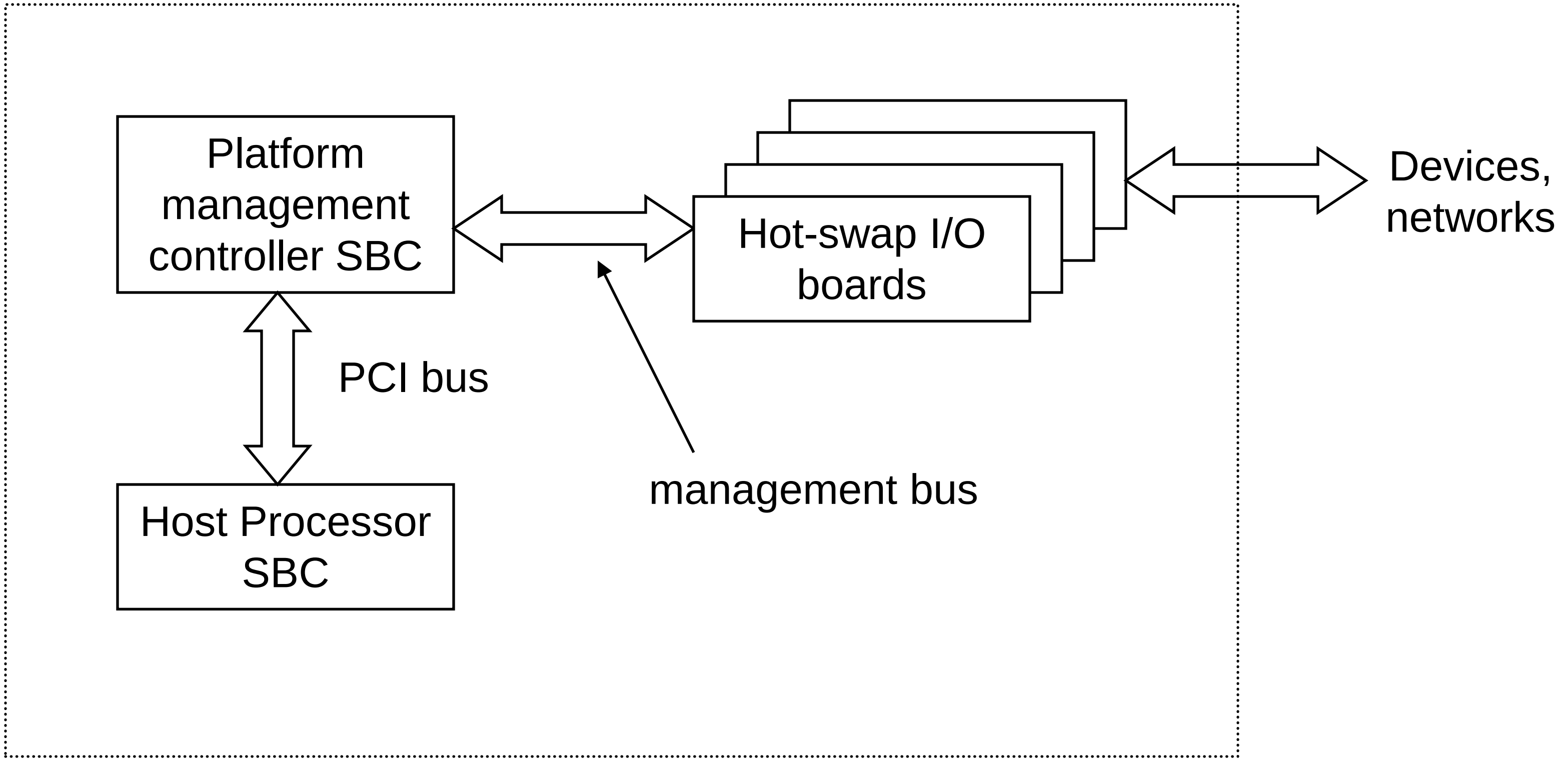
Hardware-based Fault Tolerance

- Fault-tolerant structures
  - CompactPCI - Basic hot-swap



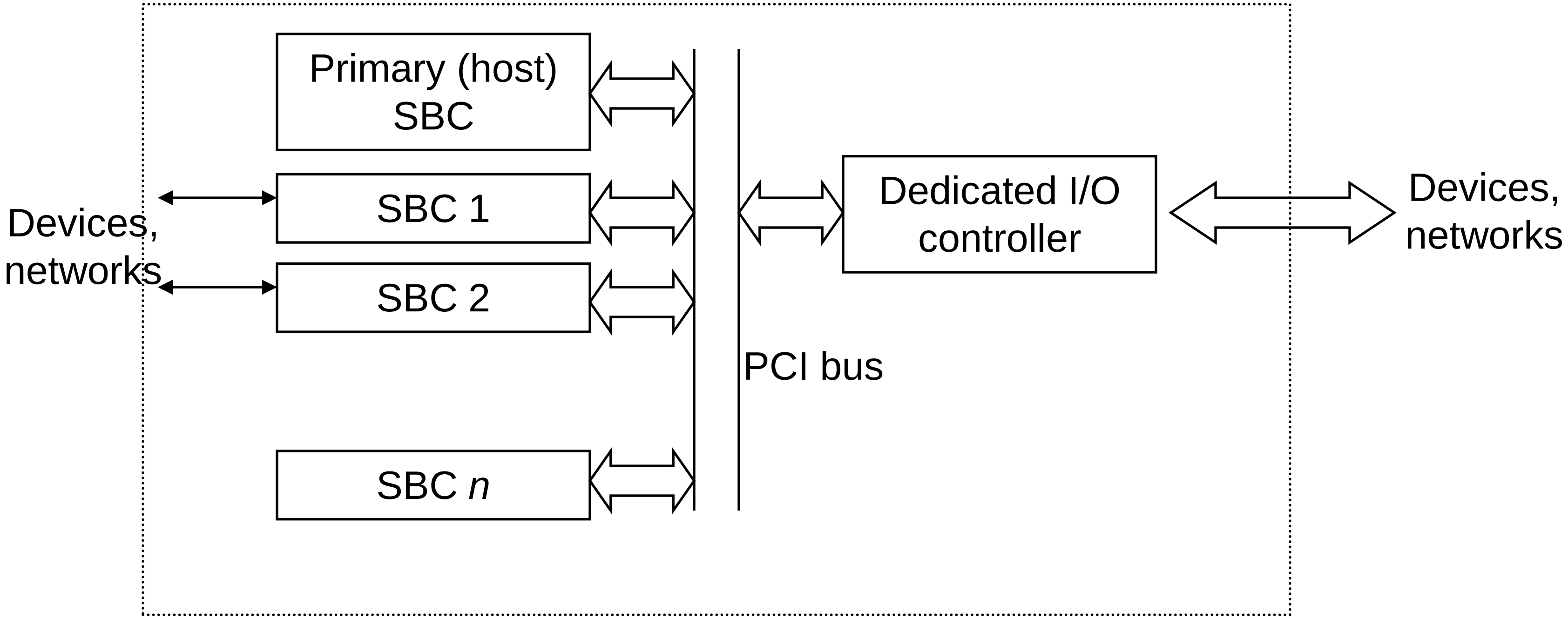
Hardware-based Fault Tolerance

- Fault-tolerant structures
  - CompactPCI - Full & high-availability (single processor) hot-swap
    - Full: interface to system software allowing it to oversee swap of boards
    - HA: system monitors/controls boards with platform management software

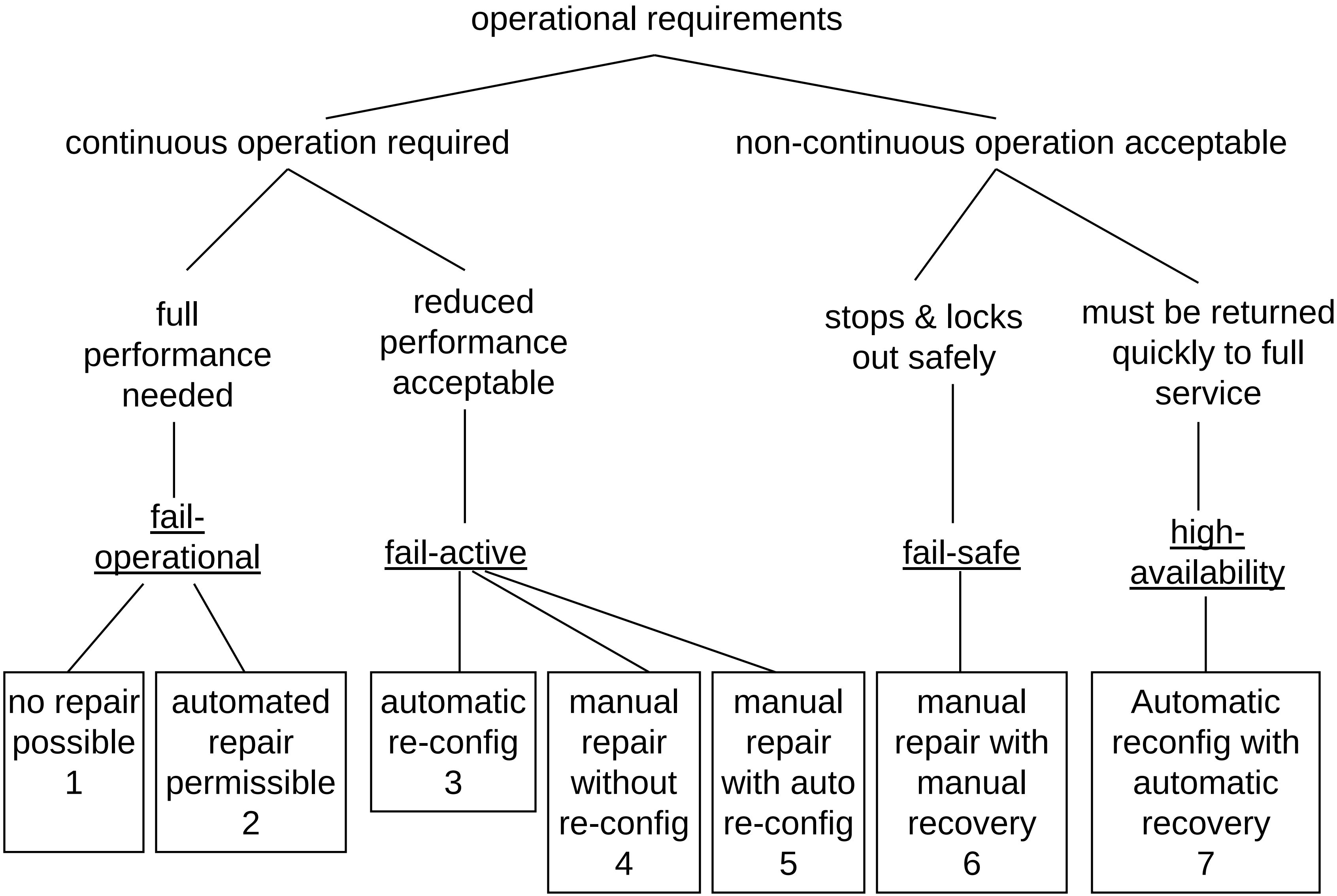


Hardware-based Fault Tolerance

- Fault-tolerant structures
  - CompactPCI - Full & high-availability (multiple processor) hot-swap
    - Distributed computing:
      - load balancing
      - Re-allocation of work from a failed processor
    - Fault diagnosis, repair managed by the host SBC



Hardware-based Fault Tolerance



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manual repair without re-config 4

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fail-safe

manual repair with manual recovery 6

must be returned quickly to full service

high-availability

Automatic reconfig with automatic recovery 7

Hardware-based Fault Tolerance

Matching structures to Requirements

	Hybrid redundancy	Passive redundancy	Active redundancy	High avail hot-swap	Full hot-swap	Basic hot-swap	Fail-safe	
1		X						
2	X							
3			X					
4						X		
5				X	X			
6							X	
7				X	X			