Cpre 545: Fault Tolerant Systems Faults and Their Manifestations

- Five Attributes of Faults
  - Cause
  - Nature
  - Duration
  - Extent
  - Value

Fault-Error-Failure

- Fault Occurs => Fault is activated
- Error Occurs
  - Error disappears: Great!!
  - Error detected:
    - Correct error automatically
    - Inform user
  - Undetected
    - Data used leads to failures
- Failure of a subsystem => Fault at next higher level

Origin of Faults

- Phenomenological
  - Physical: adverse phenomena
  - Human made: results from human imperfection
- System Boundaries
  - Internal faults: parts of systems when invoked produce an error
  - External faults: interference or interaction with physical environment, EM perturbation, radiation, temperature, humidity, mechanical vibration, power surge, cosmic rays, a-particle hits, etc.

Origin of Faults (Contd.)

- Phase of Creation
  - Design faults: during development and modification
  - During establishment of the procedures
- Operation Faults
  - Operation faults
  - Occur during system use
  - Wear out of components
  - Over run of specification
  - Operator error

Nature of Faults and Distinction

- Accidental Faults
  - Appears to be created fortuitously
  - Damage in a power supply
- Intentional Faults
  - Deliberately created by human or non-human origins
  - Examples: Various kind of Viruses
  - Break in into computer systems

Temporal Persistence

- Permanent
  - Effect of fault stays for ever until fixed
- Intermittent
  - Temporarily present internally, off again, on again
  - Pattern sensitive, affect only when activated
- Transient
  - Temporarily external, shows up with specific interaction, rarely reproducible
- Classification has some confusion!!

Failure Domain

- Value failure
  - data value is different, no easy way to verify
- Timing failure
  - Early or late than expected
- Arbitrary failure
- Stopping failure -- constant service (Fail-Stop)
- Omission failure -- no service (Fail Silent)
- Crash failure -- a persistent omission

Errors

- Liable to lead to a subsequent failure
- Failure depends on
  - System composition: intentional or unintentional redundancy (can cover specific cases)
  - System activity: an error may be overwritten
  - User perception: bearable failure vs. tolerate any way
- Faults can be small, errors can be large
  - a sign bit change may convert your positive bank balance into negative

Failures

- Elementary failures
  - A system does not always fail in the same way
- Three point of views
  - Failure Domain
  - Failure Perception
  - Failure Consequences

Failure Perception

- Consistent failure
  - All user have the same perception
  - Easier to detect and isolate
- Inconsistent failure
  - Different users have different view
  - Example: A weak signal on a bus line is read differently by different devices
  - Such failures are called Byzantine Failures

Consequence of Failures

- Benign failures
  - Fail-safe systems
- Catastrophic failures
  - Critical systems
  - Life or large economic loss
- Benign and catastrophic failures are highly application dependent classification

Data Measurement and Collection

Source	# of Faults	Mean-time to Occur
Permanent	29	6552
Intermittent	610	58
Transient	446	354
System Crashes	298	689

Classification by nature of faults for data from a 21-workstation-year study