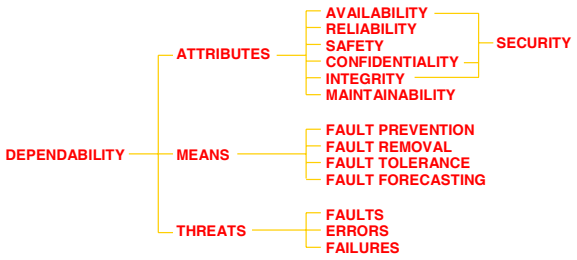
IFIP WG10.4 “Dependability– Umbrella term”



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Definition of Reliability

- Reliability is defined in International Telecommunications Union (ITU-T) recommendations E.800 as follows:

  “The ability of an item to perform a required function under given conditions for a given time interval.”

- In this definition, an item may be a circuit board, a component on a circuit board, a module consisting of several circuit boards, a base transceiver station with several modules, a fiber-optic transport-system, or a mobile switching center (MSC) and all its subtending network elements. The definition includes systems with software also.

2

Definition of Availability

- Availability is closely related to Reliability, and is also defined in ITU-T Recommendation E.800 as follows:

  "The ability of an item to be in a state to perform a required function at a given instant of time or at any instant of time within a given time interval, assuming that the external resources, if required, are provided."

- An important difference between reliability and availability is that reliability refers to failure-free operation during an interval, while availability refers to failure-free operation at a given instant of time, usually the time when a device or system is first accessed to provide a required function or service.

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High Reliability/Availability/Safety

- Traditional applications
  (long-life/life-critical/safety-critical)
  - Space missions, aircraft control, defense, nuclear systems
- New applications
  (non-life-critical/non-safety-critical, business critical)
  - Banking, airline reservation, E-commerce applications, web-hosting, telecommunication
- Scientific applications
  (non-critical)

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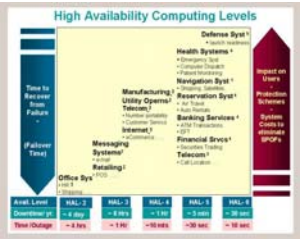
Motivation – High Availability



Industry	Business Operation	Industry Cost Range (per hour)	Average Cost Per Hour of Downtime
Financial	Brokerage Operations	$5.6M to $7.3M	$6.45M
Financial	Credit Card/Sales Authorization	$2.2M to $3.1M	$2.6M
Media	Pay-Per-View	$233K	$150K
Retail	Home Shopping Network (TV)	$87K to $140K	$113K
Retail	Home Catalog Sales	$60K to $120K	$90K
Transportation	Airline Reservations	$67K to $112K	$89.5K
Media	Tee-ticket Sales	$56K to $82K	$69K
Transportation	Package Shipping	$24K to $32K	$28K
Finance	ATM Fees	$12K to $17K	$14.5K

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IFIP WG10.4

- **Failure** occurs when the delivered service no longer complies with the desired output.
- **Error** is that part of the system state which is liable to lead to subsequent failure.
- **Fault** is adjudged or hypothesized cause of an error.

Faults are the cause of errors that may lead to failures

Fault → Error → Failure

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Software Fault Classification

- Many software bugs are easy to find and fix during the testing and debugging phase.

Bohrbugs

- Other bugs that are hard to find and fix remain in the software during the operational phase.
  - These bugs may never be fixed, but if the operation is retried or the system is rebooted, the bugs may not manifest themselves as failures.
  - Manifestation is non-deterministic and dependent on the software reaching very rare states.

Heisenbugs

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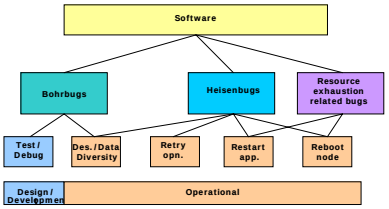
Software Fault Classification



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System measures besides performance

Probability of system being up throughout an interval without system-level repair	Reliability
Fraction of time that the system is up	Availability
System's ability to operate under abnormal conditions	Survivability
System performance under failure and repair	Performability

R.A.S.-ability concerns grow. High-R.A.S. not only a selling point for equipment vendors and service providers. Regulatory outage report are required by FCC for public switched telephone networks (PSTN), and may soon apply to wireless.

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Basic Definitions

- Reliability $R(t)$:

X : Time to failure of a system

$F(t)$: distribution function of system lifetime

$$R(t) = P(X > t) = 1 - F(t)$$

- Mean Time To system Failure:

$$MTTF = E[X] = \int_0^\infty tf(t)dt = \int_0^\infty R(t)dt$$

$f(t)$: density function of system lifetime

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Basic Definitions (Contd.)

Availability

- Instantaneous (point) Availability $A(t)$:

$A(t) = P$ (system working at t)

Let H(t) be the convolution of F and G:

- $g(t)$: density function of system repair time

$$H(t) = \int_0^t F(t-x)\,g(x)\,dx$$

Then: $$A(t) = R(t) + \int_0^t A(t-x)dH(x)$$

Inst. Availability , $A(t) \geq R(t)$, Reliability

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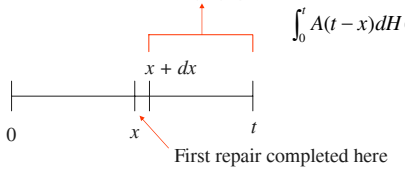
Availability

- System working at time t

Never failed in $(0,t)$, prob: $R(t)$

First failed and got repaired at time $x<t$ & UP at end of interval (x,t), prob:

$$\int_0^t A(t-x)dH(x)$$



First repair completed here

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Availability (Contd.)

- MTTR: Mean Time to Repair
- *Y*: repair period of the system

$$MTTR = E[Y] = \int_0^\infty tg(t)dt$$

- Availability and Reliability are related but different!

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Availability (Contd.)

- We can show from equation (1) that steady state Availability is:

$$A_{SS} = \frac{MTTF}{MTTF + MTTR}$$

- Also: $downtime = (1 - A_{ss}) * 8760 * 60$
  $(in \text{ minutes } per \text{ year})$

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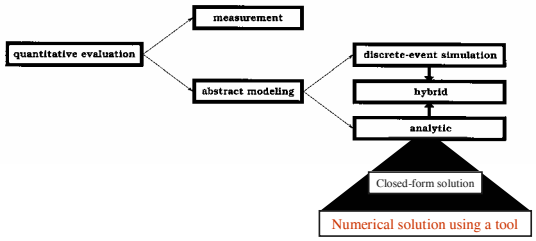
QUANTITATIVE EVALUATION TAXONOMY



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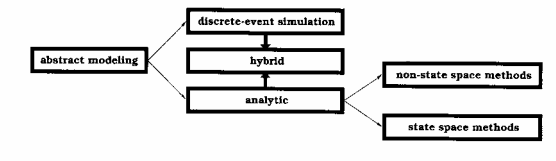
MODELING TAXONOMY



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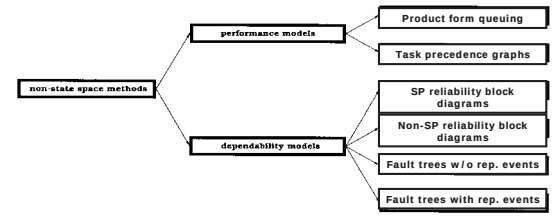
ANALYTIC MODELING TAXONOMY

NON-STATE SPACE MODELING TECHNIQUES



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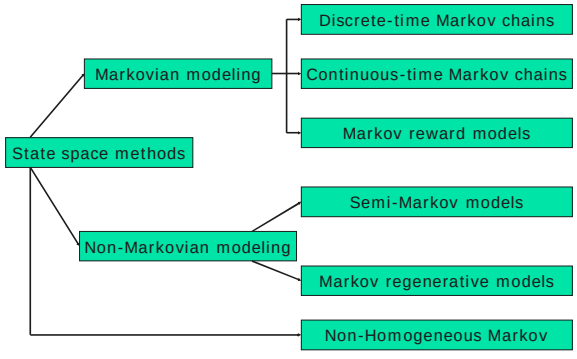
State Space Modeling Taxonomy



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