

Notes on Measuring Availability, Reliability and Risk

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- http://ocw.mit.edu/resources/res-6-004-principles-of-computer-system-design-an-introduction-spring-2009/online-textbook/faults_open_5_0.pdf (Section 8.2)

Measuring Availability (I)

$$\begin{aligned} \text{Availability} &= \frac{\text{time system was running}}{\text{time system should have been running}} \\ &= \frac{\sum_{i=1}^N TTF_i}{\sum_{i=1}^N (TTF_i + TTR_i)} \end{aligned}$$

N: number of failures
TTF = time to failure
TTR = time to repair

Measuring Availability (II)

Mean \nearrow $MTTF = \frac{1}{N} \sum_{i=1}^N TTF_i$ $MTTR = \frac{1}{N} \sum_{i=1}^N TTR_i$

$$MTBF = MTTF + MTTR$$

$$Availability = \frac{MTTF}{MTBF} = \frac{MTTF}{MTTF + MTTR} = \frac{MTBF - MTTR}{MTBF}$$

$$Down\ time = (1 - Availability) = \frac{MTTR}{MTBF}$$

Meaning of Nines

Availability level	Allowed unavailability window					
	per year	per quarter	per month	per week	per day	per hour
90%	36.5 days	9 days	3 days	16.8 hours	2.4 hours	6 minutes
95%	18.25 days	4.5 days	1.5 days	8.4 hours	1.2 hours	3 minutes
99%	3.65 days	21.6 hours	7.2 hours	1.68 hours	14.4 minutes	36 seconds
99.5%	1.83 days	10.8 hours	3.6 hours	50.4 minutes	7.20 minutes	18 seconds
99.9%	8.76 hours	2.16 hours	43.2 minutes	10.1 minutes	1.44 minutes	3.6 seconds
99.95%	4.38 hours	1.08 hours	21.6 minutes	5.04 minutes	43.2 seconds	1.8 seconds
99.99%	52.6 minutes	12.96 minutes	4.32 minutes	60.5 seconds	8.64 seconds	0.36 seconds
99.999%	5.26 minutes	1.30 minutes	25.9 seconds	6.05 seconds	0.87 seconds	0.04 seconds

MTTF Values in Practice (I)

- Typically HDs have an “MTTF” of 300 000 hours (34 years)
- How they get this number?
 - Run 1 000 disks for 3 000 hours (four months)
 - 10 failed -> 1% failure
 - 1 failure per 300 000 hours
- In fact, the expected operational lifetime of a disk (according to manufacturers) is 5 years

HD example



Bathtub Curve

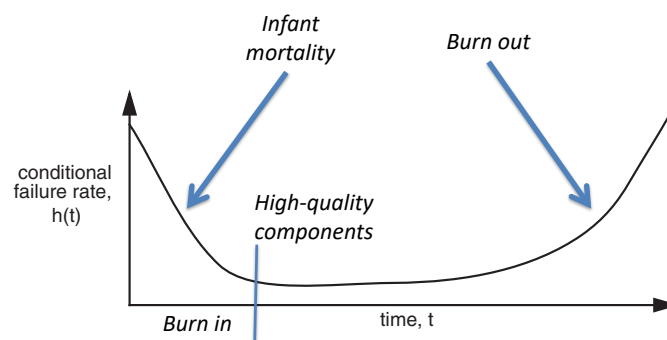


FIGURE 8.1

A bathtub curve, showing how the conditional failure rate of a component changes with time.

Reliability Functions

$$R(t) = Pr\left(\begin{array}{l} \text{the module has not yet failed at time } t, \text{ given that} \\ \text{the module was operating at time } 0 \end{array}\right)$$

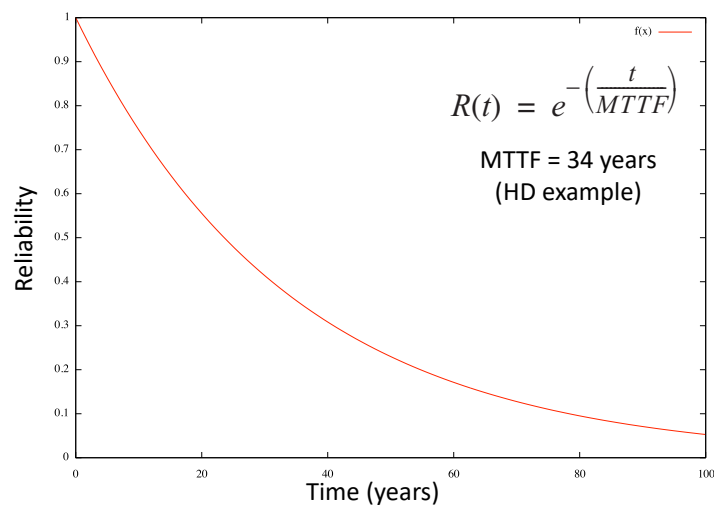
$$f(t) = Pr(\text{module fails between } t \text{ and } t + dt)$$

$$MTTF = \int_0^{\infty} t \cdot f(t) dt$$

If uniform failure rate
(memoryless failure process)

$$R(t) = e^{-\left(\frac{t}{MTTF}\right)}$$

Reliability (uniform failure rate)



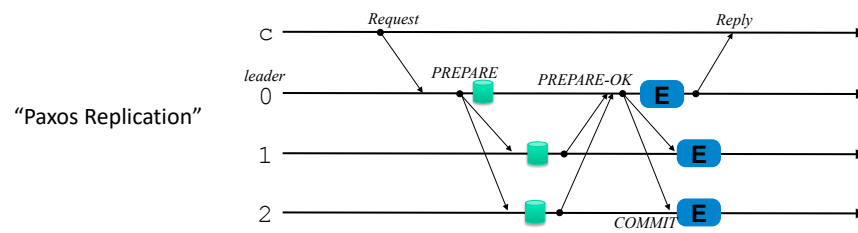
MTTF Values in Practice (II)

Consider:

- requires a majority of correct servers
- each server is connected to two networks

Assume:

- Server Availability = 99.5%
- Network Availability = 99.9%



How to calculate this?