Lecture 1 : *Introduction to Modeling, Analysis, and Simulation of Computer & Communication Systems*

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Modeling

- **Model**
  - **A physical, logical, or ___________ representation that mimics another object under study**
  - **Used for studying, manipulating, observing a system, and thereby __________ the behavior**
  - **Less complex but not ___________**

Modeling(cont'd)

- **Types of models**
  - **Aspect : scale / _________**
  - **Levels of representation : concrete / ________**
  - **Functional model : physical / simulation / _________**

Modeling(cont’d)

Modeling procedure

I —— process —— O

i) **Experiment (I/O measurement)**

ii) **Conjecture of a model**

iii) **Validation of the model**

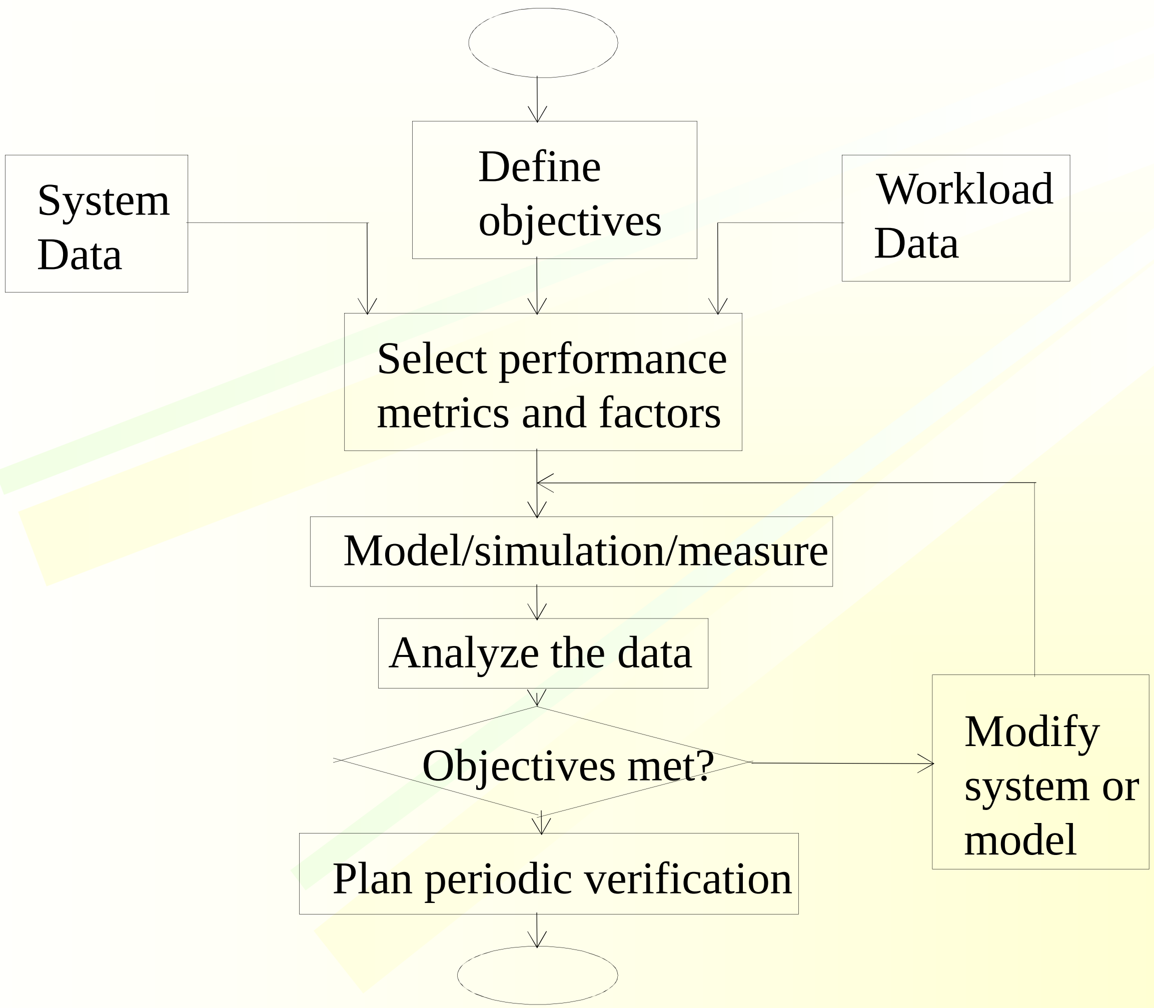
(ex) $F = ma$

Computer System Modeling and Evaluation

- **Modeling computer system**
  - **A complex process due to complicated structure and _________ (stochastic process)**
  - **Evaluation is required in _______, manufacture, purchase, use, and upgrade**
  - **Design goal : high performance and low ________**

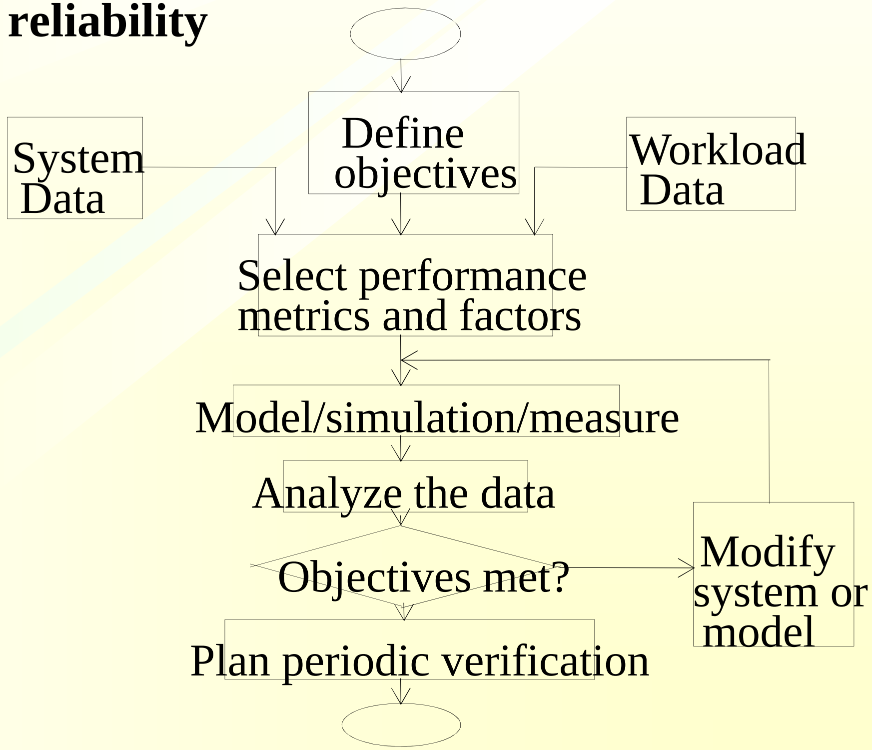
Computer System Modeling and Evaluation(cont'd)

Performance evaluation process



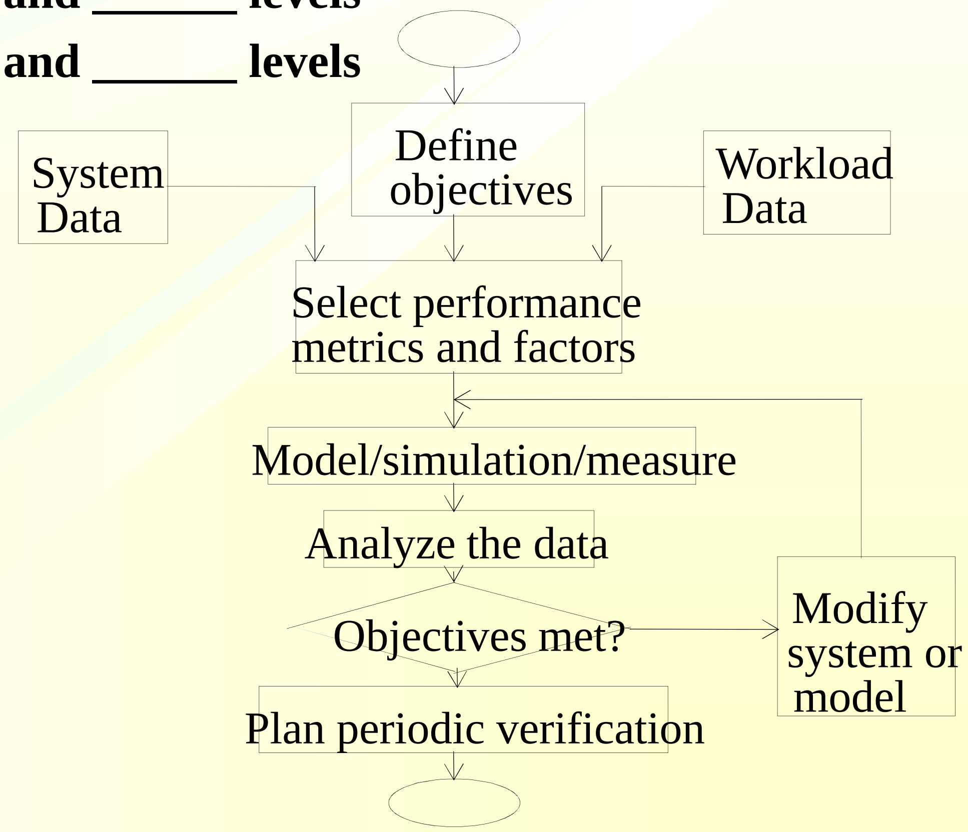
Computer System Modeling and Evaluation(cont'd)

- **Workload data: _________ from one installation to another**
  - **(ex) Interarrival time, task size, task mix**
- **System data: _________ from one installation to another**
  - **(ex) CPU type, memory size, clock speed**
- **Metrics: target performance measures**
  - **(ex) Throughput, response time, reliability**



Computer System Modeling and Evaluation(cont'd)

- **Factors: __________ data varied in the evaluation since they are believed to mostly affect the system performance**
  - **(ex) Number of users**
- **2 phase measurement:**
  - **Phase-1: ______ no. of factors and ______ levels**
  - **Phase-2: ______ no. of factors and ______ levels**



Computer System Modeling and Evaluation(cont'd)

- **Usage of performance evaluation**
  - System comparison, tuning, __________ identification, workload characterization, __________ planning
  - Important issues: selection of _________ technique/ metrics/workload, measures of data, interpretation of data, design of simulation and model providing the ______ info with the ______ effort

Computer System Modeling and Evaluation(cont'd)

- (ex) Ratio game

System	W_1	W_2
A	20	10
B	10	20

- The performance metric is throughput in terms of TPS.

  For workload-1(W_1), System-__ is 2 times better than System-__ .

  For workload-2(W_2), System-__ is 2 times better than System-__ .

  Which one is better?

System	W_1	W_2	*Avg*
A	20	10	15
B	10	20	15

System	W_1	W_2	*Avg*	*B-base*
A	20	10	15	2 .5 1.25
B	10	20	15	1 1 1

System	W_1	W_2	*Avg*	*A-base*
A	20	10	15	1 1 1
B	10	20	15	.5 2 1.25

Computer System Modeling and Evaluation(cont'd)

- **Common difficulties in performance evaluation**
  - No or biased goal where the goal is to show that _____ is better than THEIRS. Good attitude is like _____.
  - _________ understanding of the problem causing
    - incorrect metrics, workload, factors
    - improper evaluation technique
  - Inappropriate experiment, analysis of data

Computer System Modeling and Evaluation(cont'd)

- Improper presentation
- Ignoring ________ aspects
- Too _______ analysis
- Ignoring variability (mean only is not enough but needs variance study)
- No sensitivity analysis
- Solution by ___________ approach

Performance Evaluation

Evaluation techniques

Criterion	*Model*	*Simulation*	*Measurement*
Stage	**Any**	**Any**	**____________**
Time	**Small**	**Medium**	**Varies**
Accuracy	**________**	**Moderate**	**Varies**
Analysis	**Easy**	**Moderate**	**____________**
Cost	**Small**	**_________**	**High**

- **Employ two or more techniques for**
  - **validating the approaches**
  - **maximizing the efficiency (coarse/fine grain)**

Coarse: simple ____________ model for finding proper range

Fine: use _____________ for that range

Performance Evaluation(cont'd)

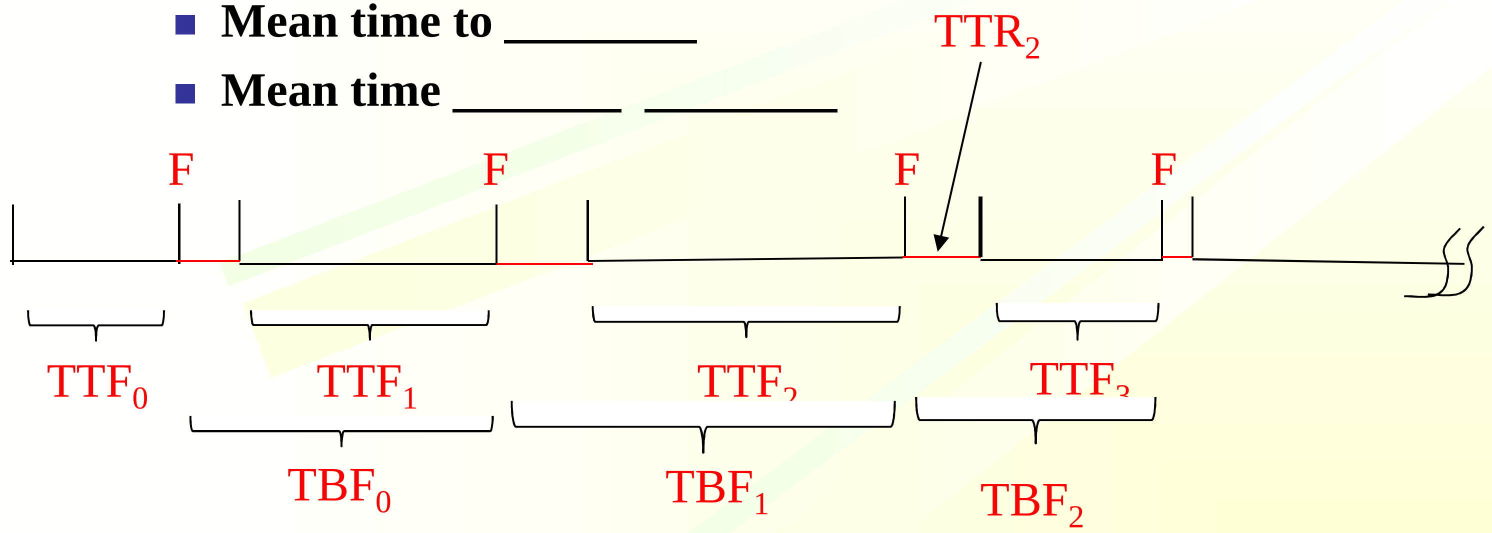
- **Selection of performance metrics**
  - **time (response)**
  - **rate (throughput)**
  - **resource (utilization)**

Bottleneck in a system: the ___________ with the highest ____________

Performance Evaluation(cont’d)

For incorrect operation

- reliability: __________ that the system operates correctly in [t_o, t], given that it was operating correctly at t_o
- MTTF/MTBF
  - Mean time to ________
  - Mean time _______ ________



$$\text{MTTF} = \frac{1}{n}\sum_{k=0}^{n} TTF_k \quad ; \text{MTBF} = \frac{1}{n}\sum_{k=0}^{n} TBF_k$$

Performance Evaluation(cont'd)

- availability: Prob. that the system operates correctly at *t*

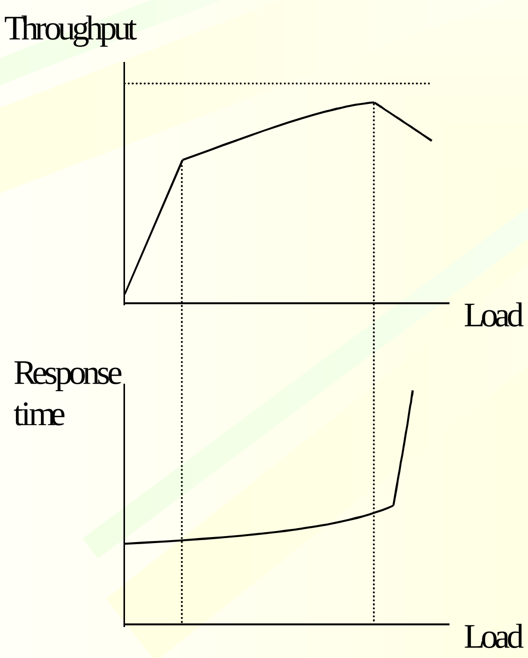
$$\frac{\text{ontime}}{\text{ontime} + \text{downtime}} = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}}$$

$$= \frac{\text{MTBF} - \text{MTTR}}{\text{MTBF}}$$

- Rule: completeness (mean & ________), both individual & _______ metrics, low variability, nonredundancy

Metrics

- **Response time (turnaround time for _____ mode)**
  - **reaction time**
  - **stretch factor = (response time at a load) / (response time at the minimum load)**
- **Throughput**



•Nominal capacity (maximum achievable ____________ under ideal workload condition)

•Usable capacity (maximum achievable ____________ without exceeding a prespecified response time limit)

•Knee capacity

•What is the optimal load?

Metrics(cont'd)

- Efficiency = usable capacity / nominal capacity
- Utilization = busy time / total time
- Reliability, Availability
- Cost/performance ratio
- Capacity
- Speedup

Workload

- Interarrival time
- Task size and mix
- I/O request and service rate
- Memory size
- Parallelism

Object-oriented Modeling & Design

- **Allows**
  - **better understanding of requirements**
  - **cleaner design**
  - **more maintainable system**
- **Applied to entire cycle from analysis through design to ______________**