

Simulation Techniques - A primer

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Topics

- *Modeling and performance evaluation*
- *A hand simulation*
- *Random numbers and random variates*
- *Simulation design techniques*
- *Statistical estimation*
- *Validation/Simulation languages*

What is a model?

- A model is a representation of the structure of a real-life system (existing, or currently being built).
- In general, models can be classified as follows:
 - *iconic*
 - *analogue*
 - *symbolic.*

- **Iconic model:** Exact replica of the properties of the real-life system, but in smaller scale. Examples are: model airplanes, maps, etc.
- **Analogue model:** It uses a set of properties to represent the properties of a real-life system. For instance, a hydraulic system can be used as an analogue of electrical, traffic and economic systems.
- **Symbolic model:** It represent the properties of the real-life system through the means of symbols, such as mathematical equations and computer programs.

Operations Research

- OR deals with making decisions based on modelling. Its origins date back to the second world war!
- OR is applied in all sectors, to name a few:
 - Production systems
 - Operations Management
 - IT and Networking
 - Health
 - Transportation
 - Services

OR models

- Operations Research models are in general symbolic models and they can be classified into two groups:
 - *deterministic models*
 - *stochastic models.*

- Deterministic models are models which do not contain the element of probability. These are primarily optimization models, such as:
 - *Linear programming*
 - *Non-linear programming*
 - *Dynamic programming*
 - *Simulation techniques.*

- Stochastic models are models which contain the element of probability. Examples are:
 - *Queueing theory*
 - *Stochastic processes*
 - *Reliability*
 - *Simulation techniques.*

What is a simulation model?

- A simulation model is a computer program that depicts a real system.
- It uses random numbers to represent the occurrence of events and it tracks the evolution of the various events that occur in the real system.
- Statistical techniques are used to obtain estimates of performance measures.
- Typically, in the industry one uses a simulation language for rapid model building.

Why model a system?

- We model a system that does not exist in order to
 - understand its performance
 - study how various operational parameters impact on its performance
 - What-if analysis

Modelling is not ubiquitous

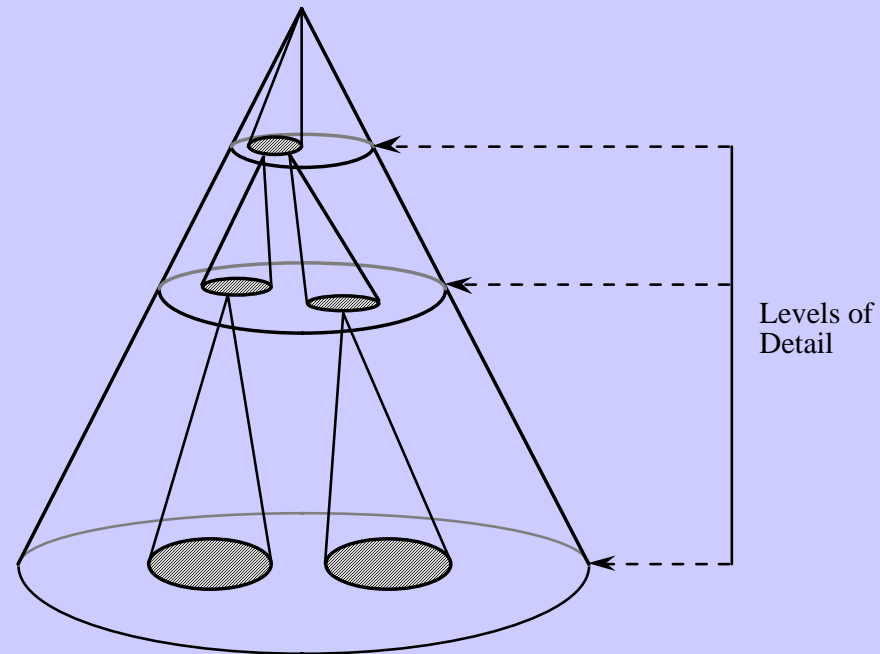
- Network design - an absolute must
- Software design - totally ignored
- Services - some
- Other sectors have in-house OR teams, such as:
 - Industrial systems
 - Transportation
 - Banking
 - Health

Effectiveness in decision making

A modelling exercise has an impact on decision making, if

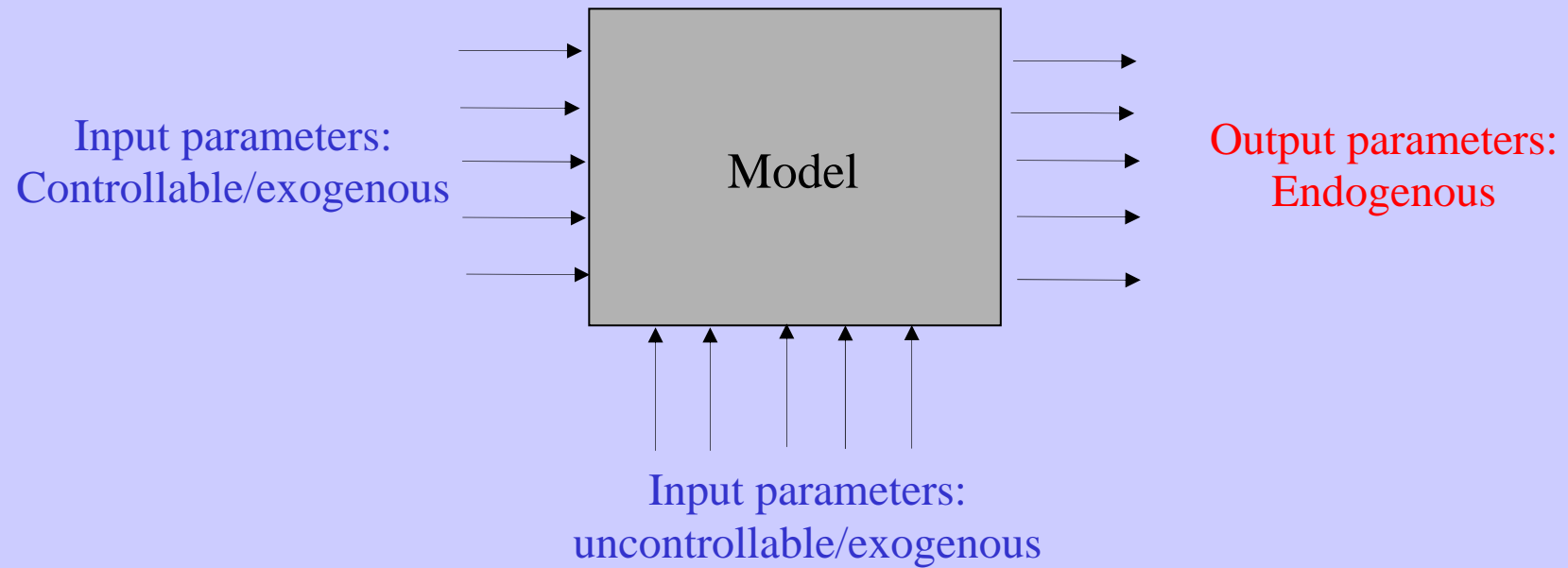
- It is developed very quickly
- Runs very quickly for what-if analysis
- Is a meaningful representation of the system under study
- Results are well communicated to the upper management.

The OR modelling approach

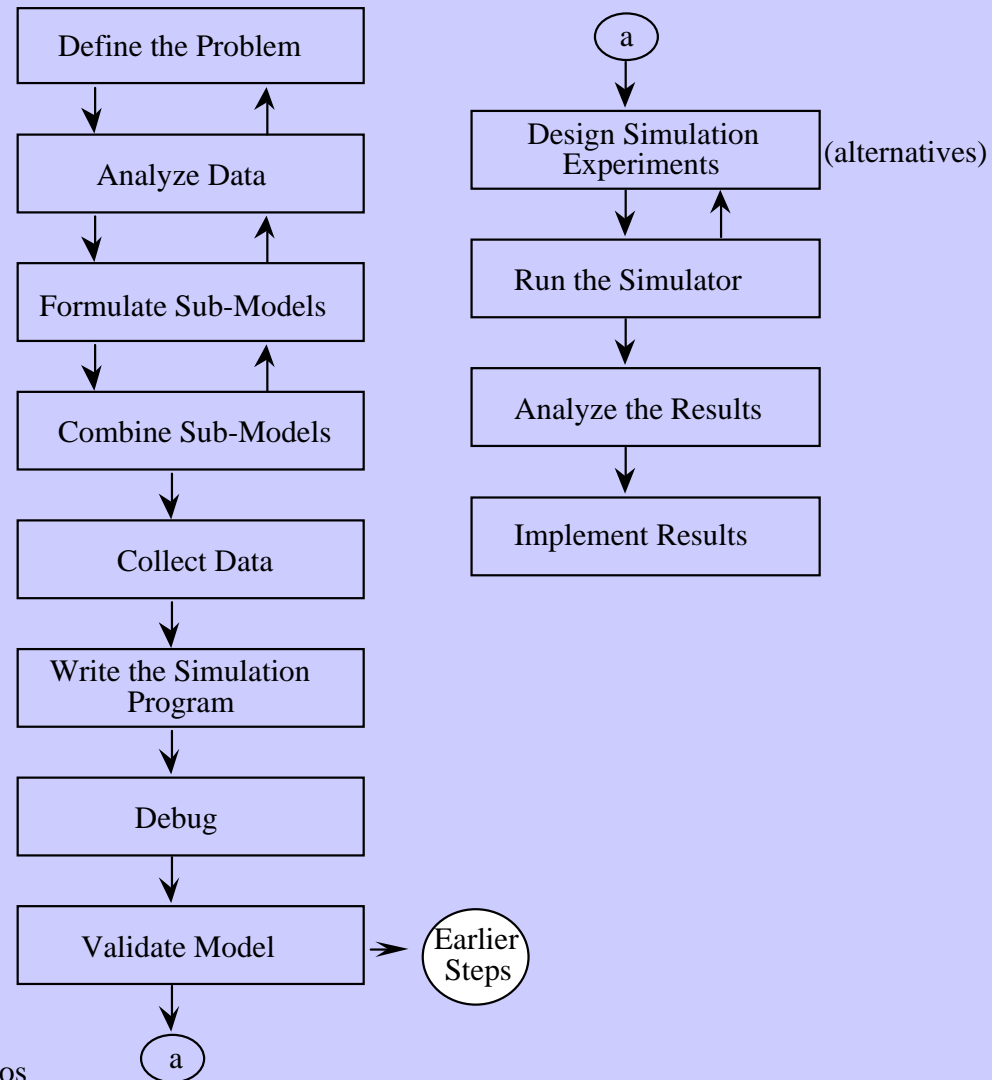


What parts of the real-system will be depicted in the model depends on what is the question that we want to answer !

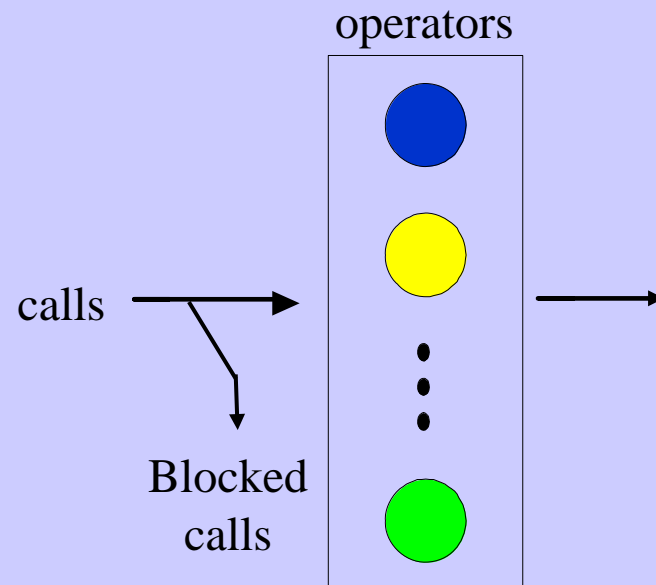
Variables



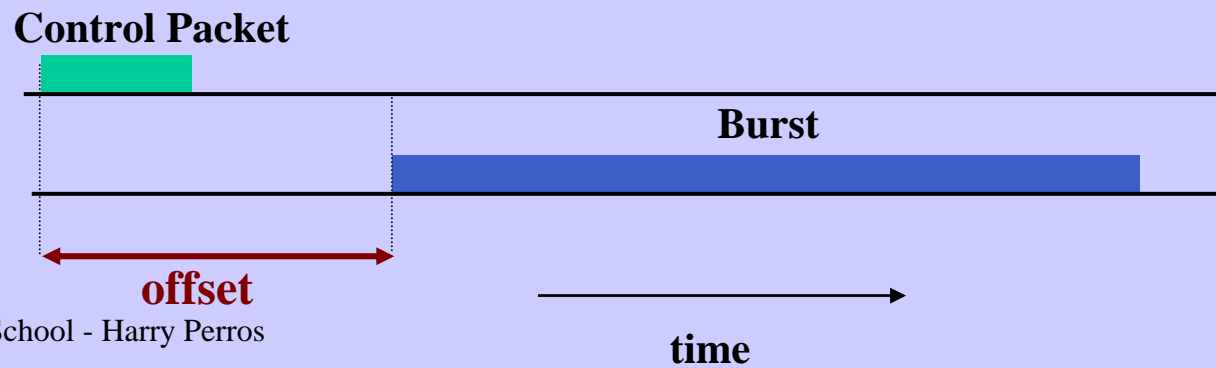
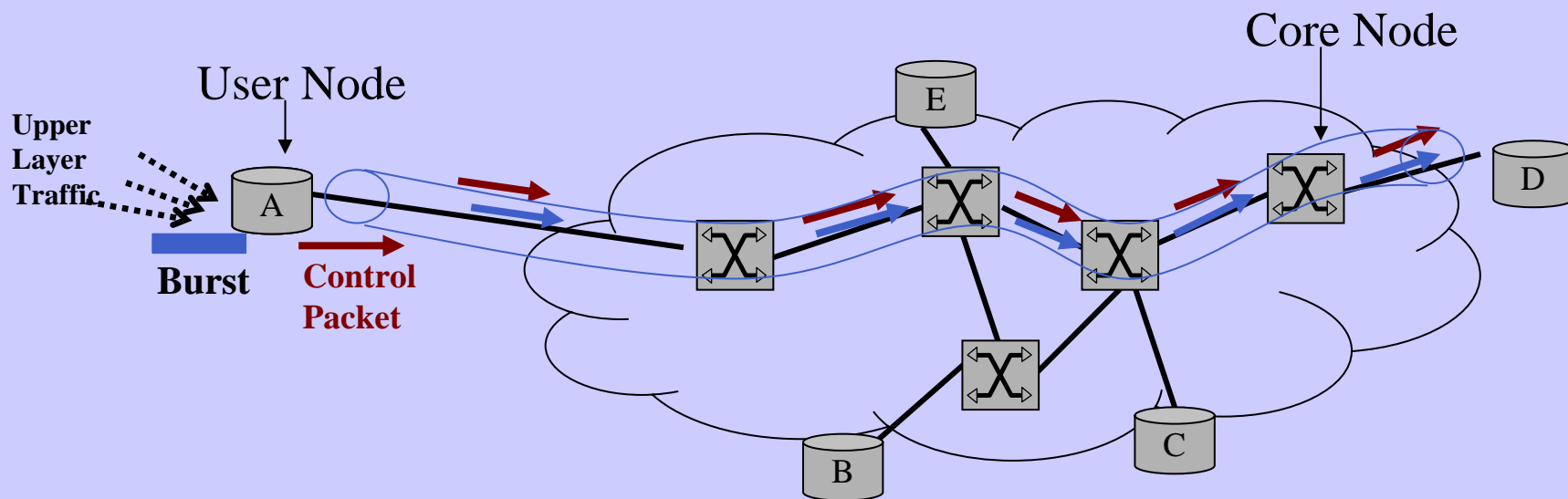
Basic steps involved in carrying out a modelling study



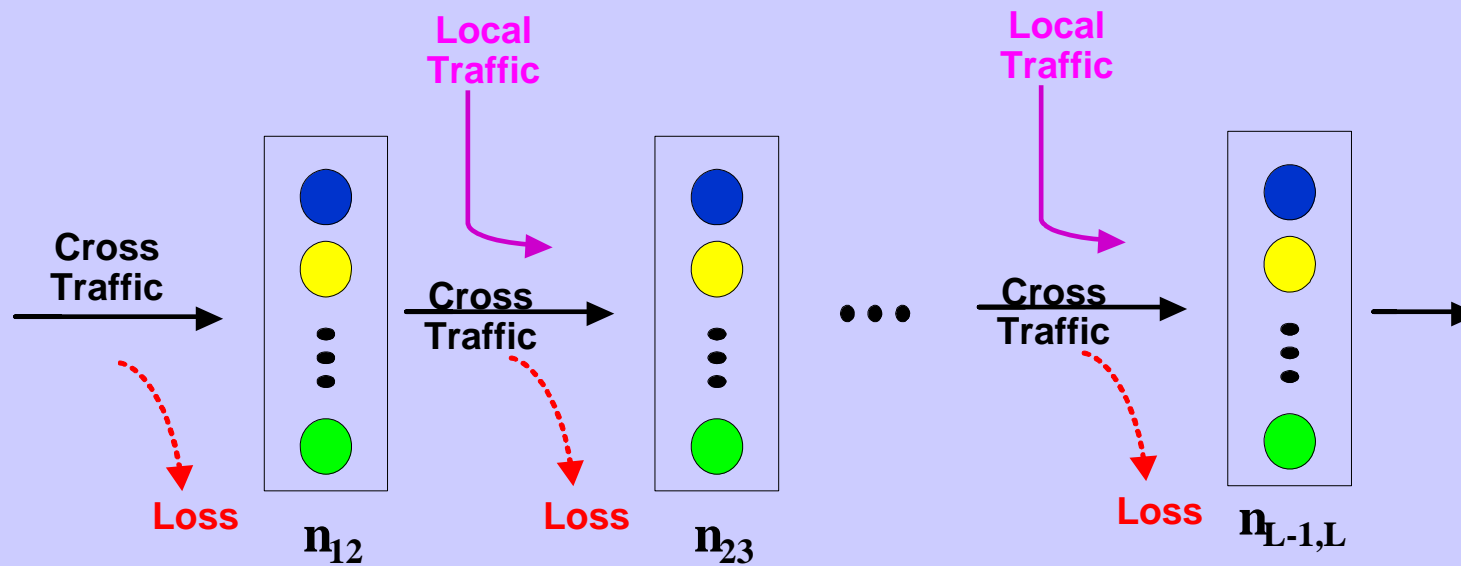
Call Blocking in a Call Center



Optical Burst Switching



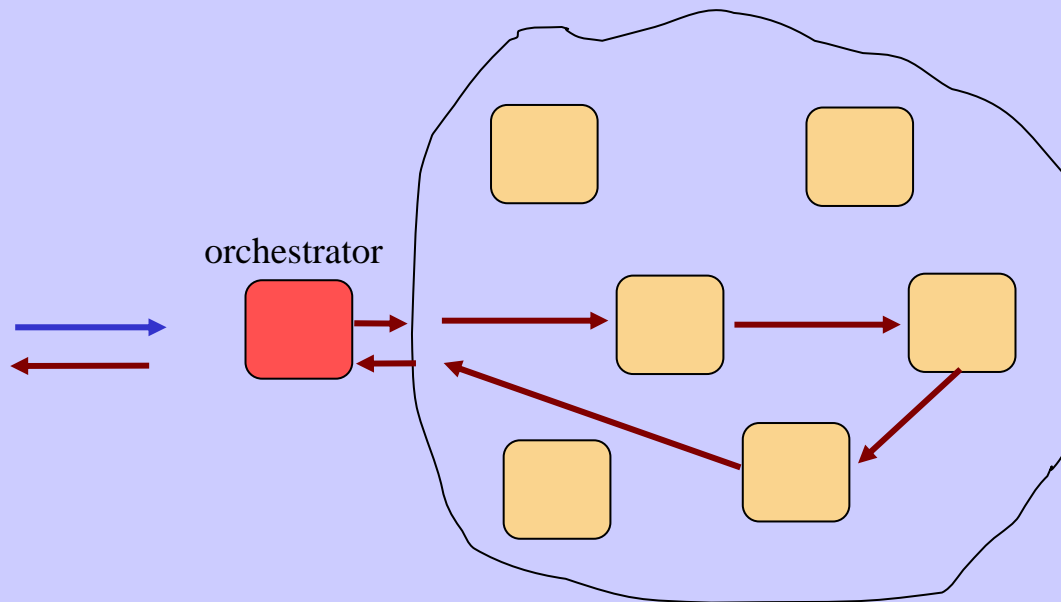
Queueing Network Model of OBS Path



Resource allocation in enterprise service computing

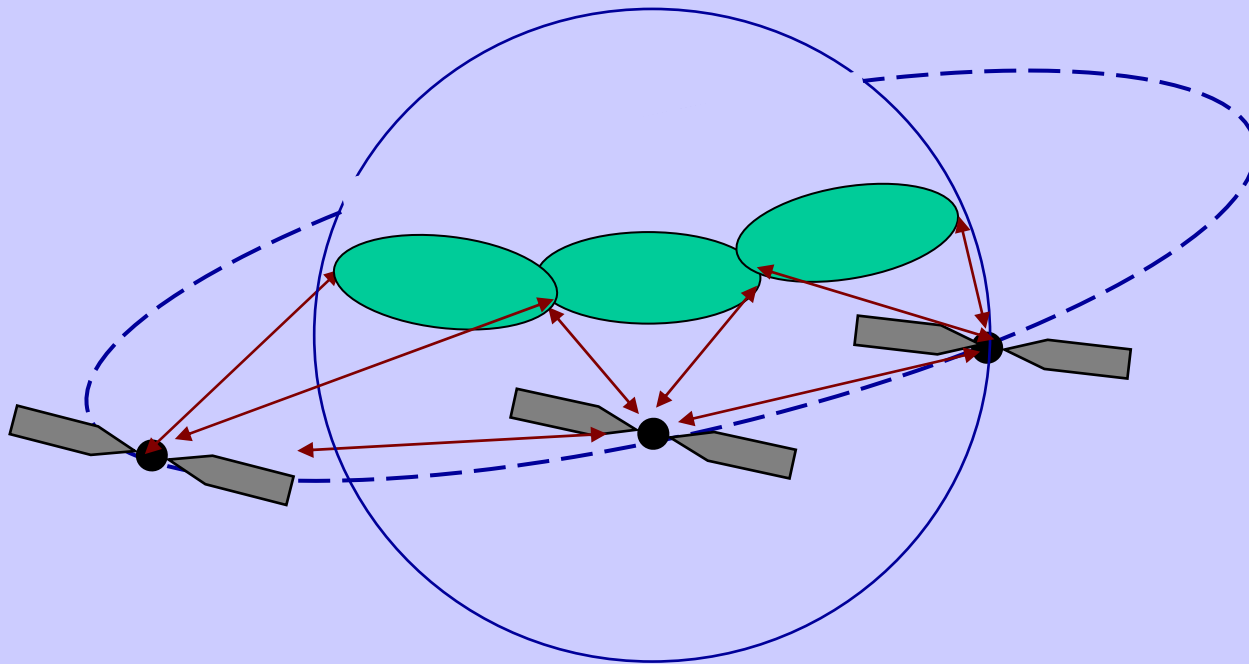
- The execution of a request follows a predefined script, known as a *workflow*.
- Typically, different software components are used to execute different parts of the workflow. They may be located in the same machine or maybe geographically dispersed.
- The SLA contract will include QoS performance measures, such as response time, availability and trustworthiness.

How many CPU should be allocated to each component, so that the SLA is met?

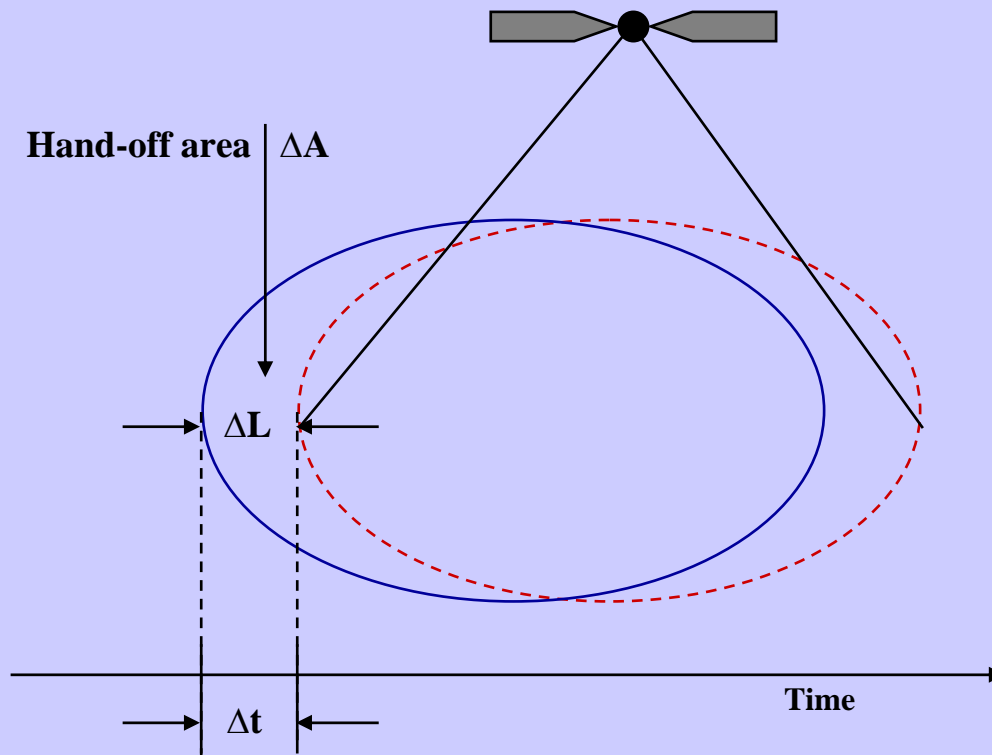


Geographically dispersed components interconnected via the Internet or dedicated high-capacity optical network

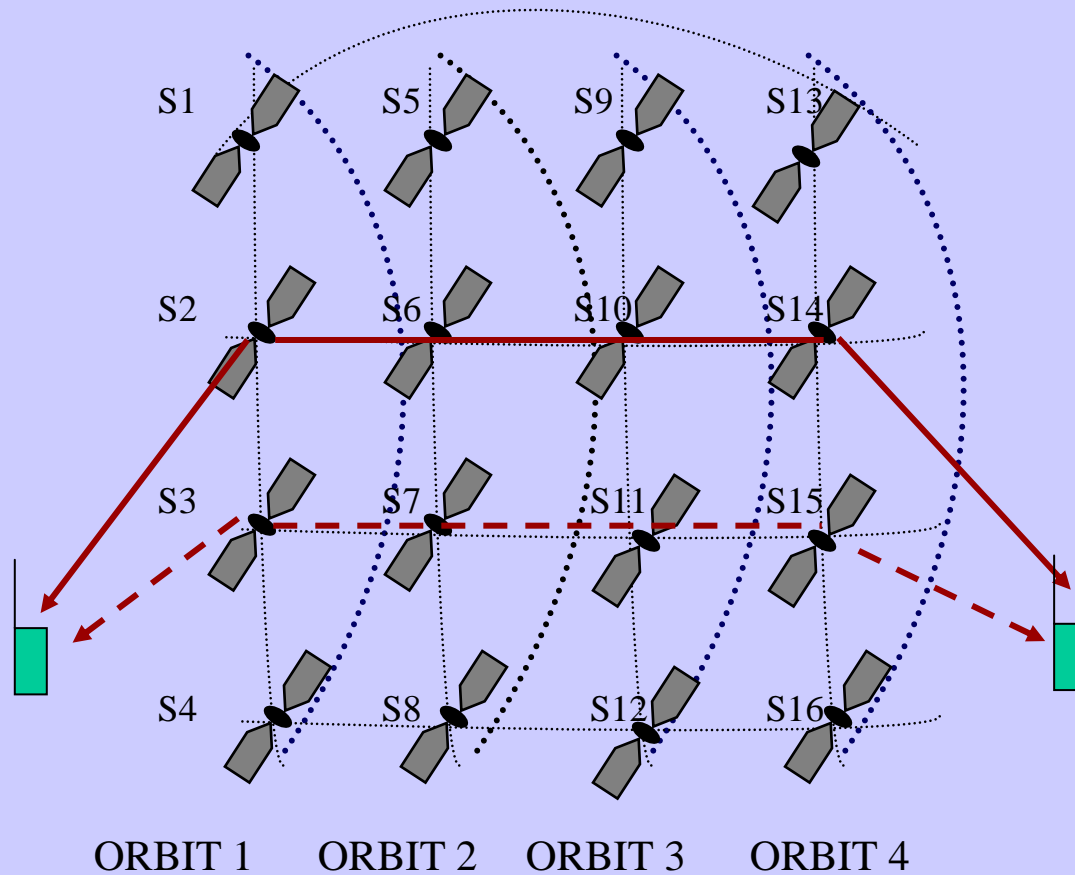
Calculation of call blocking probabilities a LEO Satellite System



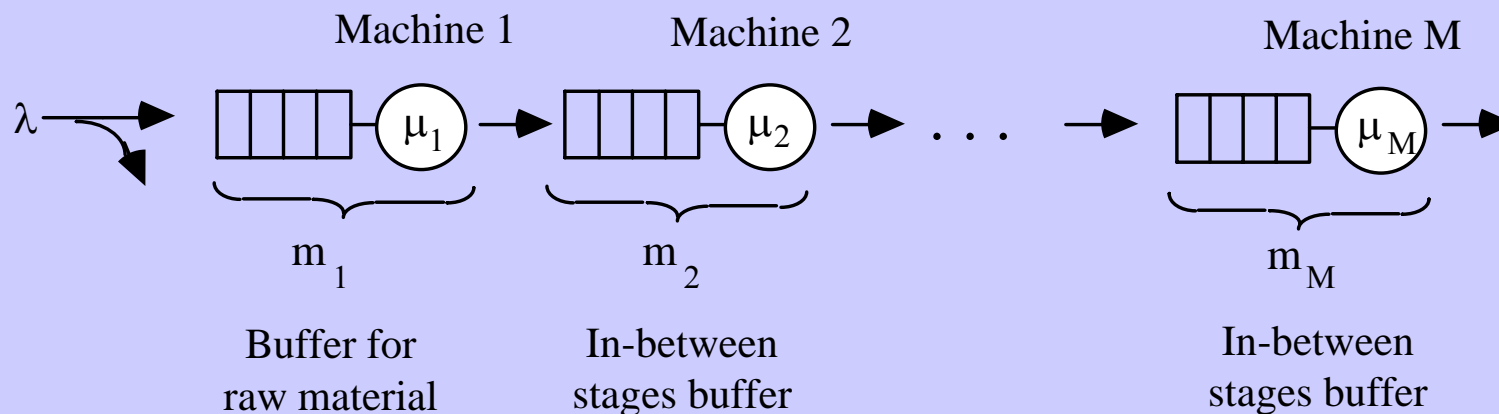
Satellite footprint



A constellation of LEO satellites



Throughput calculation of a production system



Blueprint of Hospital Services

