


Performance Modeling of Computer Systems and Networks

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Next Event Simulation

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Potenzialmente posso scegliere tema e mettere su un modello.

DE simulation
Next-Event Simulation

Next-Event Simulation

Next-event simulation is a more general approach to discrete-event simulation

- system state
- events
- simulation clock
- event scheduling
- event list

5 concetti alla base della Next Event

eventi da schedulare in ordine di tempo

lista degli eventi

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Con la Discrete Event vista finora, l'evolvere del tempo non c'è. Qui simuliamo veramente il tempo. Devo simularlo per davvero, non tutto insieme.

Definitions and Terminology – State

The *state* of a system is a complete characterization of the system at an instance in time

Ci mette in condizione di capire come il sistema evolverà all'istante che segue, all'istante del prossimo evento.

Ricordiamoci di avere tre modelli, lo stato sarà per ciascuno di questi tre livelli.

Algorithm 1.1: how to develop a model

1. Goals and objectives
2. *Conceptual model* (cm)
 - very high level
 - which are the state variables, how they are related, which can be ignored and which not
3. Convert cm into a *specification model* (sm)
 - important: collecting and statistically analyzing data to provide the input models that drive the simulation
4. Convert sm into a *computational model* (cptm)
5. Verification
 - Is cptm consistent with sm?
6. Validation
 - Is cptm consistent with the system being analyzed?
 - Can an expert distinguish simulation output from system output?

Definitions and Terminology – State

- **Conceptual model:**
abstract collection of variables and how they evolve over time
- **Specification model:**
collection of mathematical variables together with logic and equations
- **Computational model:**
collection of program variables systematically updated

devo caratterizzare sistema ad un istante di tempo e dire come evolve.

- **Example ssq:** the state is number of jobs in the node (a livello concettuale)
- **Example inventory system:** the state is current inventory level
caratterizza in un determinato tempo lo stato del sistema,
posso anche dire come cambiava tale stato in presenza di un ordine

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Definitions and Terminology - Events

An **event** is an occurrence that may change the state of the system.

By definition, state cannot change except at an event time.

Each event has an associated **event type**.

- We can define **artificial events (do not change system state)**
 - Statistically sample the state of the system
 - Schedule an event at a prescribed time
(block arrival flow into the node, an inventory review without orders etc.)

esempio: voglio campionare le statistiche, oppure riporto il sistema allo stato iniziale.
In quest ultimo caso sto cambiando lo 'stato', ma non è un evento che naturalmente cambia lo stato, è un evento forzato.

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Definitions and Terminology - Simulation Clock

The *simulation clock* represents the current value of simulated time

- Discrete-event simulations lack definitive simulated time
As a result, it is difficult to generalize or embellish models

Prima era difficile aggiungere fattori come delivery lag etc, perchè prima non ragionavamo in base ad eventi, adesso è più facile!

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Definitions and Terminology - Event Scheduling & Event List

scheduler

- a *time-advance mechanism* avanzamento del tempo
to guarantee that events occur in the correct order
- *next-event* time advance is typically used in discrete-event simulation

event list

- the data structure containing the time of next occurrence for each event type mantiene l'ordine in cui gli eventi devono accadere

To build a *next-event* simulation:

- construct a set of state variables definire set variabili stato
- identify the event types identificare tipi di eventi
- construct a set of algorithms that define state changes for each event type algoritmi che, in base all'evento, portano al cambiamento dello stato.

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Next-Event Simulation

Algorithm 1

1. **Initialize** - set simulation clock and first time of occurrence for each event type
2. **Process current event** - scan event list to determine most imminent event; advance simulation clock; update state
3. **Schedule new events** - new events (if any) are placed in the event list
4. **Terminate** - Continue advancing the clock and handling events until termination condition is satisfied

Note that the simulation clock runs asynchronously; inactive periods are ignored

Tale orologio è asincrono, salta da 'evento' a 'evento', se ho $t=1$ evento1, e $t=5$ evento2, salto da $t=1$ a $t=5$, non scansiono $t=2,3,4$.

scansiono e processo il prossimo evento in lista

Quando consumo un evento di un certo tipo, genero il prossimo di quel tipo, altrimenti il processo si chiude!

definisco first time PER OGNI evento ove possibile, altrimenti lo setto ad 'impossibile' (es: evento completamente a $t=0$ lo è) in un servere singolo, partendo da sistema vuoto.

termino se raggiungo una condizione di terminazione, altrimenti ritorno allo step 2.

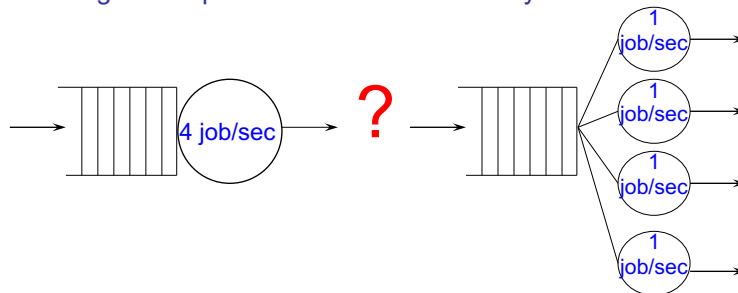
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Model extensions

Design Example 4: One machine or many?



A Multi-Server Service Node

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sto cercando di definire cosa includere nella definizione dello stato.

Conceptual model: MSQ

Definition 1

A multi-server service node consists of

- A single queue (if any)
- Two or more servers operating in parallel

- **Conceptual model:**
abstract collection of
variables and how they
evolve over time

At any instant in time, poichè siamo al concettuale, ancora non parliamo di stati!

- Each server is either *busy* or *idle*
- The queue is either *empty* or *not empty*
- If one or more servers is idle, the queue must be empty
- If the queue is not empty, all servers must be busy

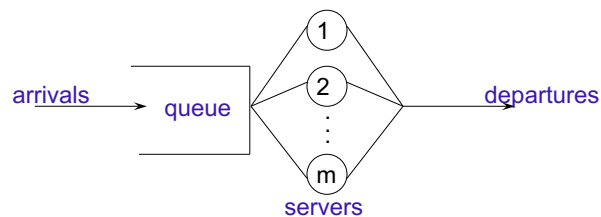
come fosse
un controllo di
consistenza

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Conceptual model: MSQ



When a job arrives:

- If all servers are busy, the job enters the queue
- Else an idle server is selected and the job enters service

When a job departs:

- If the queue is empty, the server becomes idle
- Else a job is removed from the queue, served by server

Servers process jobs independently altrimenti sarebbe un altro modello.

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Conceptual model: Server Selection Rule

Definition 2

The algorithm used to select an idle server is called the *server selection rule*

Common selection rules:

- *random*: at random from the idle servers
- *in order*: lowest-numbered idle server
- *cyclic*: first available, starting after last selected (circular search may be required)
- *equity*: use longest-idle or lowest-utilized
- *priority*: choose the “best” idle server (modeler specifies how to determine “best”)

Se i server sono diversi tra loro, le diverse politiche possono influire sulle prestazioni.