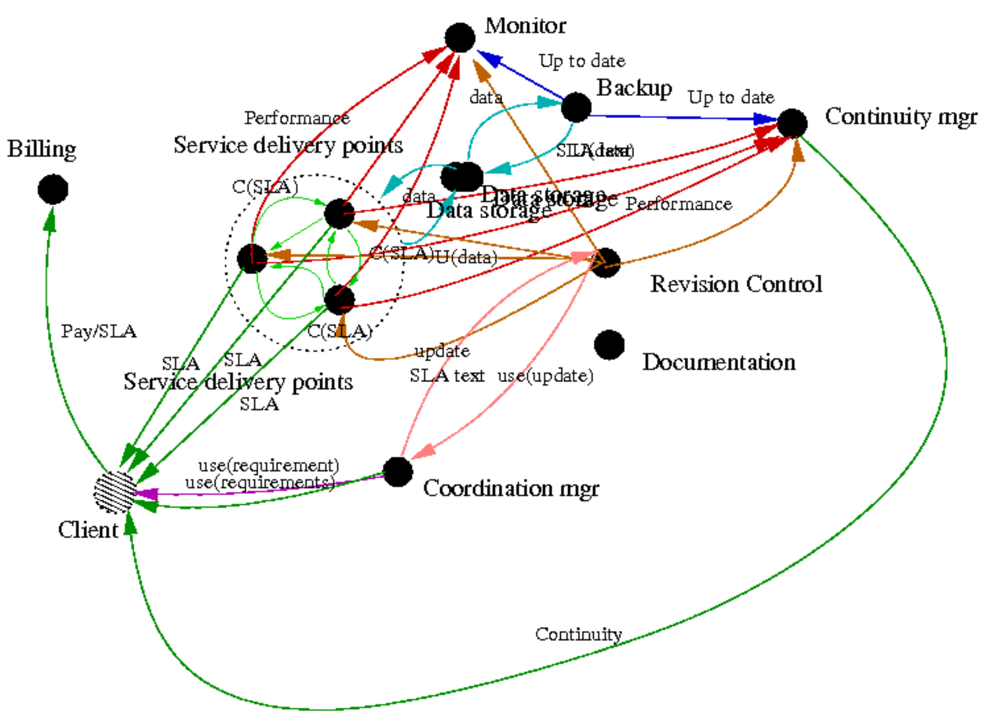
Analytical System Administration
and
Business Driven IT



HC Systems....

- A business is a system, with both human and computer machinery – how does it compare to a human-computer system?
  - It is one!
  - Put into a consistent view
  - Put the scientific method to work for us!
  - Use abstraction to address problems

Autonomous entities

- A business is composed of employees who operate by voluntary cooperation
  - Just because you pay them does not make their behaviour controlled
  - They need to have a clear idea what to do.
- Organization is designed or emerges
  - Centralized (leader of group)
  - Peer groups (project teams)

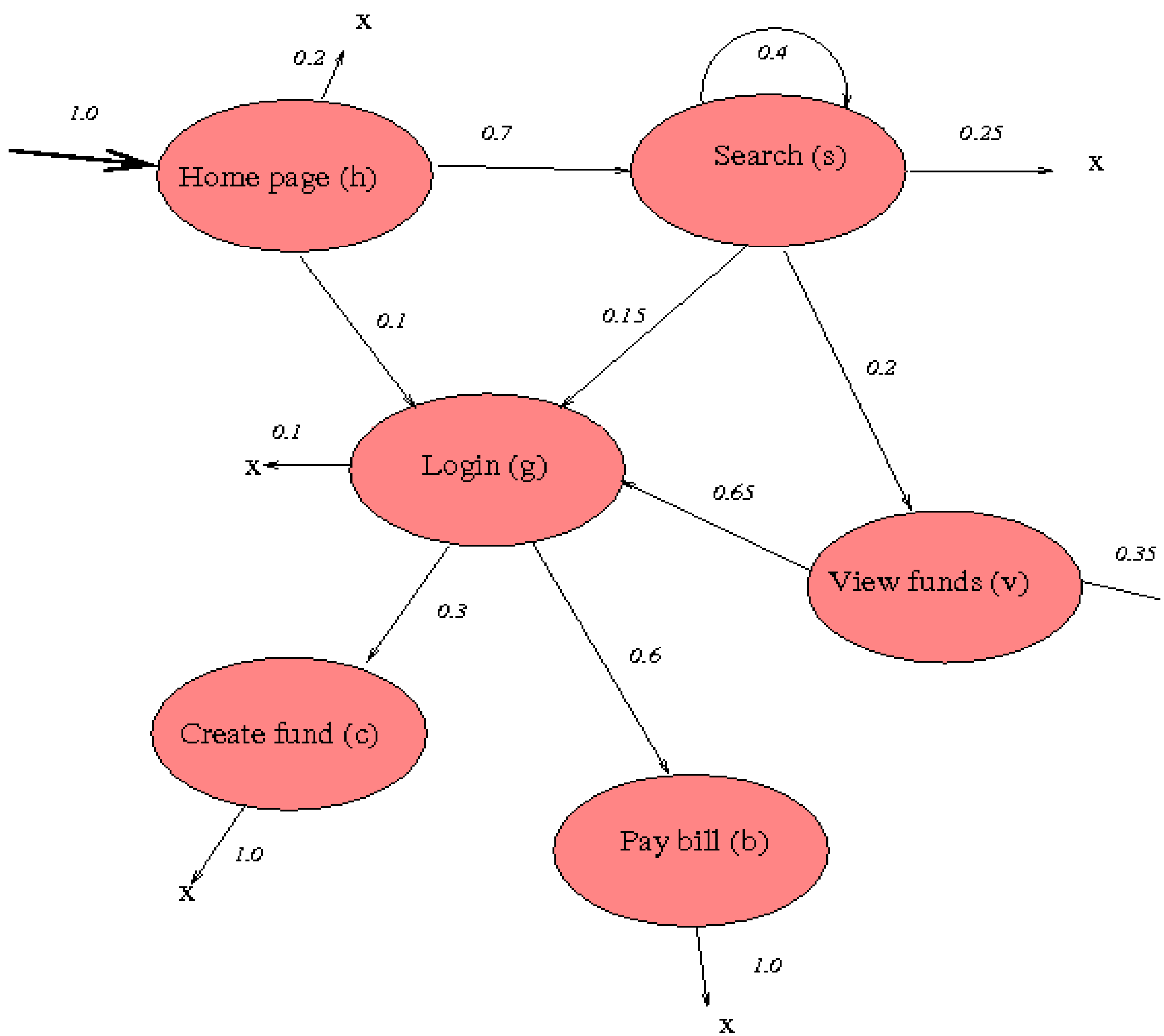
Configuration Management

- The parts/players of a system have to be related and set up in a way that supports the operation of the business
- Can the available resources be configured to do the required work?
  - This is not obvious
  - BDIM is usually about optimization, but optimization is a luxury
- e.g. lab-work group working together
  - Are you doing what is necessary to deliver?

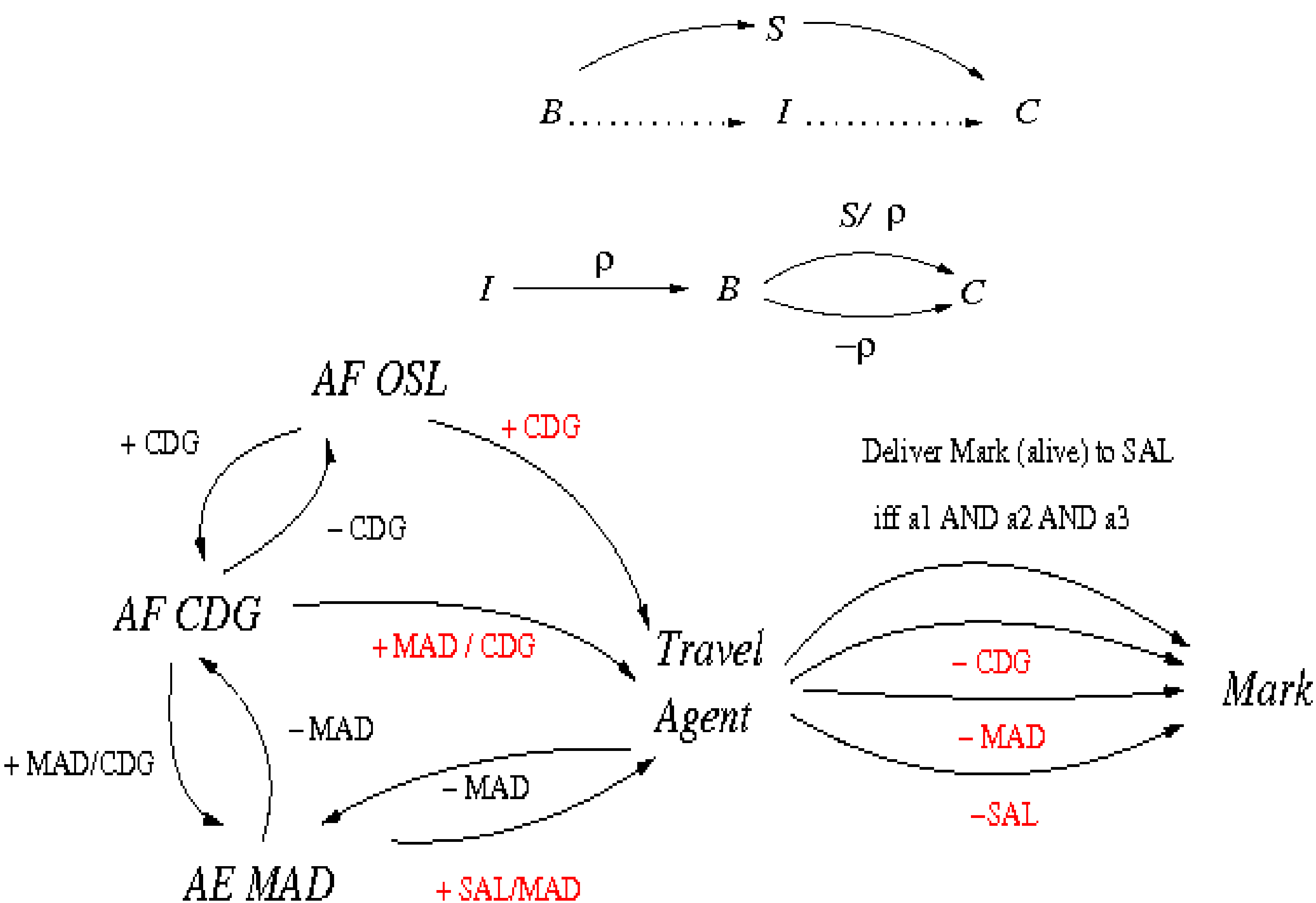
Process Management

- The low level details of services include processes / recipes
  - Businesses spend a lot of time modelling processes
  - Too low level (like procedural programming)
  - Do we need some idea of convergence?
  - Do we need some idea of processes above convergence?

Discrete transitions



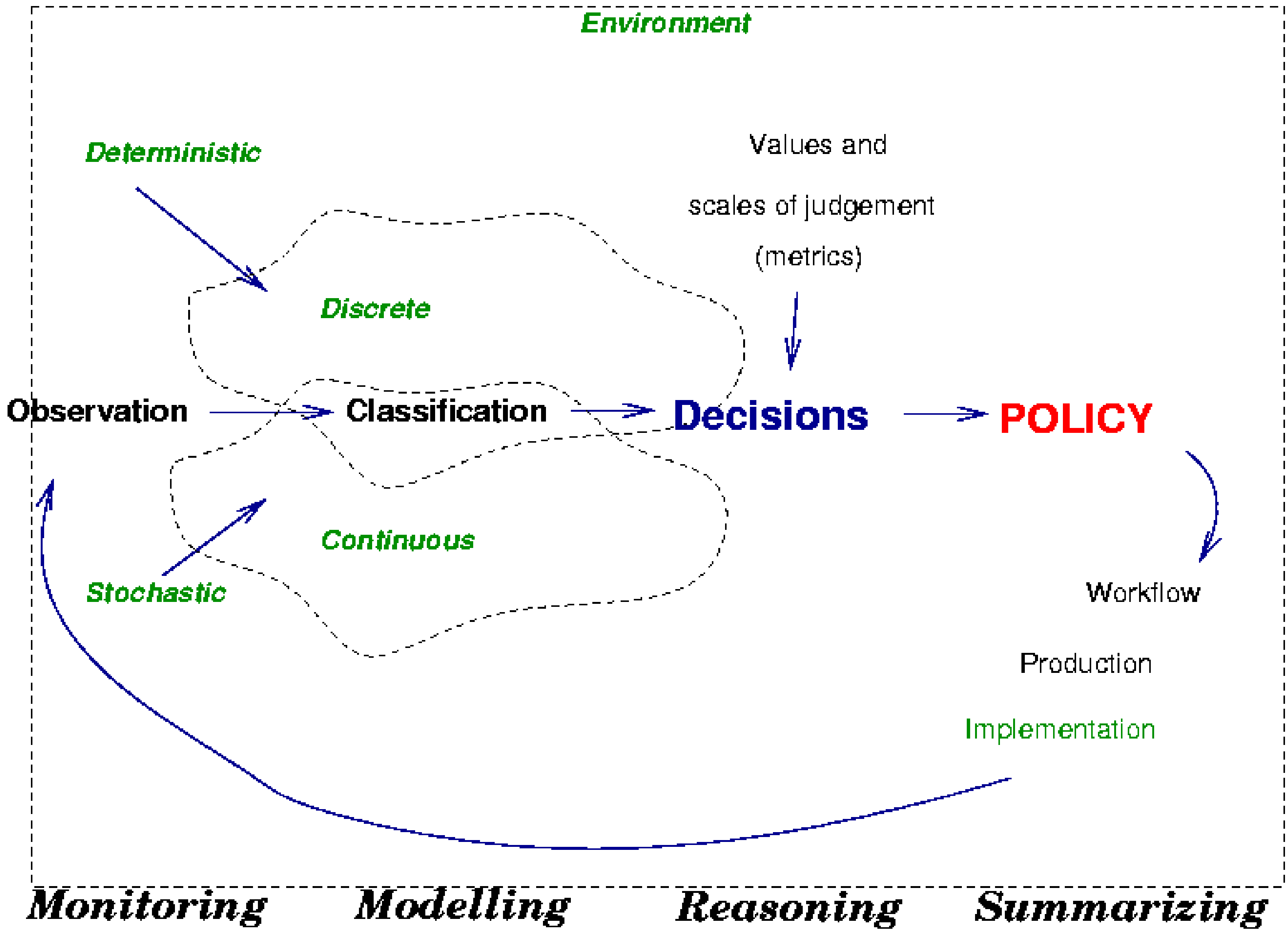
End-to-end promises: certainty



Business goals: BDIM

- Define the scope and services at the right cost
  - Minimize cost, risk
  - Maximize profit
- Find service rates (SLA) – can they be achieved?
- Business relationships – suppliers, partners, customers
- Potential disasters, losses (risk/security)
- Logistics of production
- Arbitrary (soft) business goals

The plan for rational inquiry



Dimensions - Basic scales

- Numbers of potential customers (arrivals) λ
- Probability of sale (expectation value)
- Rate of delivery μ
- Rate of work μ?
- Hidden costs (of ownership)
- Response time per request
- Cost of work, or cost per unit -
- Price per unit +
- Risk – probability of loss

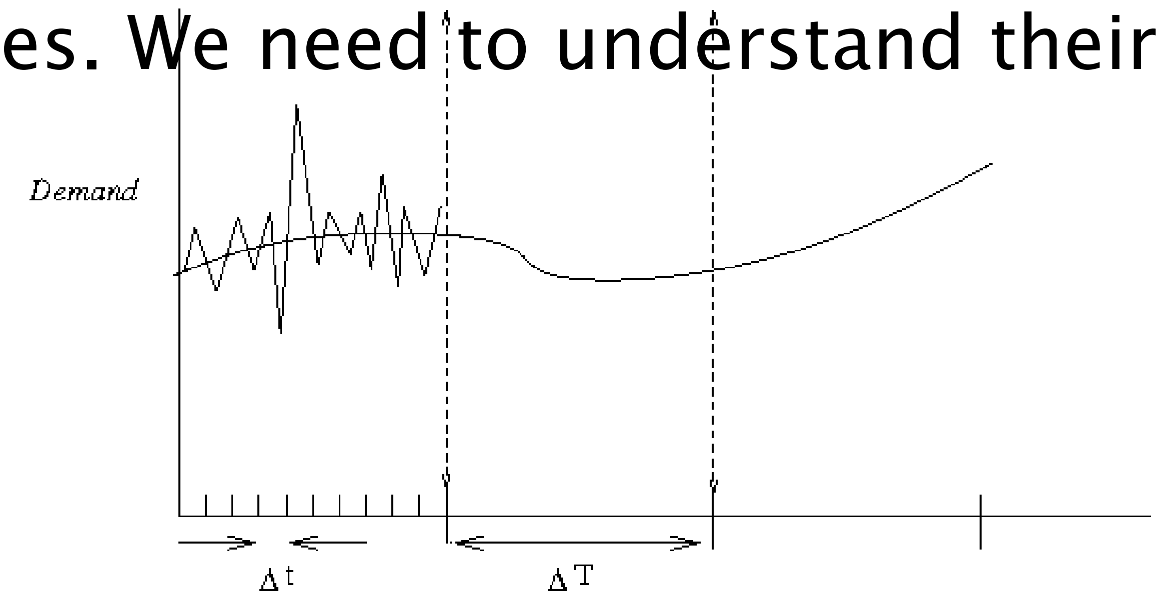
Supply and Demand

- Economics revolve around the law of supply and demand.
- A business *receives* demand (input) and *generates* supply (output).
- Income = work done x price / work
  - Essentially Little's Law

$$(profit, produce) = Business(Income(produce), Materials(profit))$$

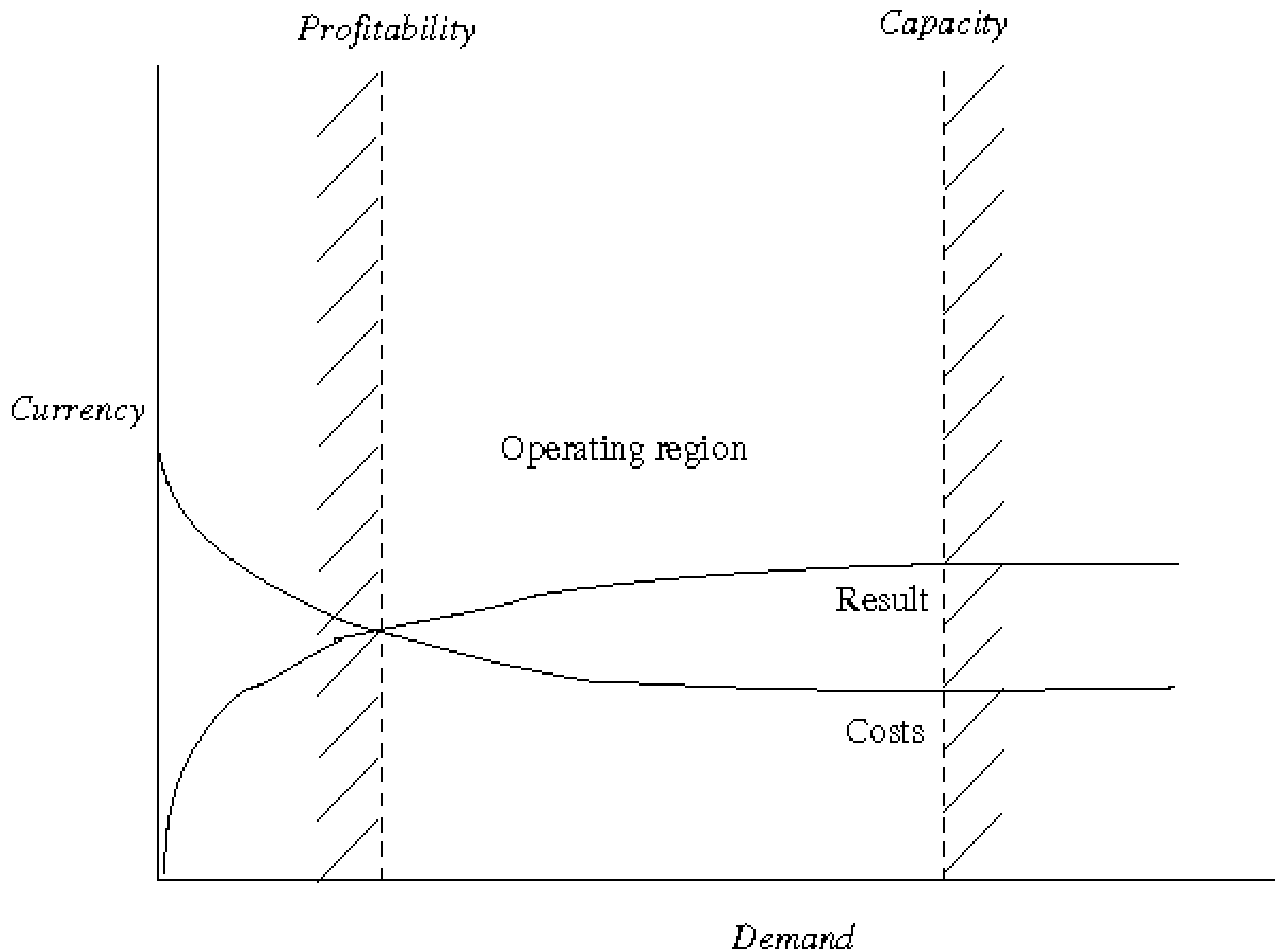
Sales and Values

- We cannot model the economics of business here:
  - Policy can affect this, but too much beyond our control
  - Just make sure that *expected* costs are less than *expected* result
- Demand (hence sales/income) are random variables. We need to understand their trends.



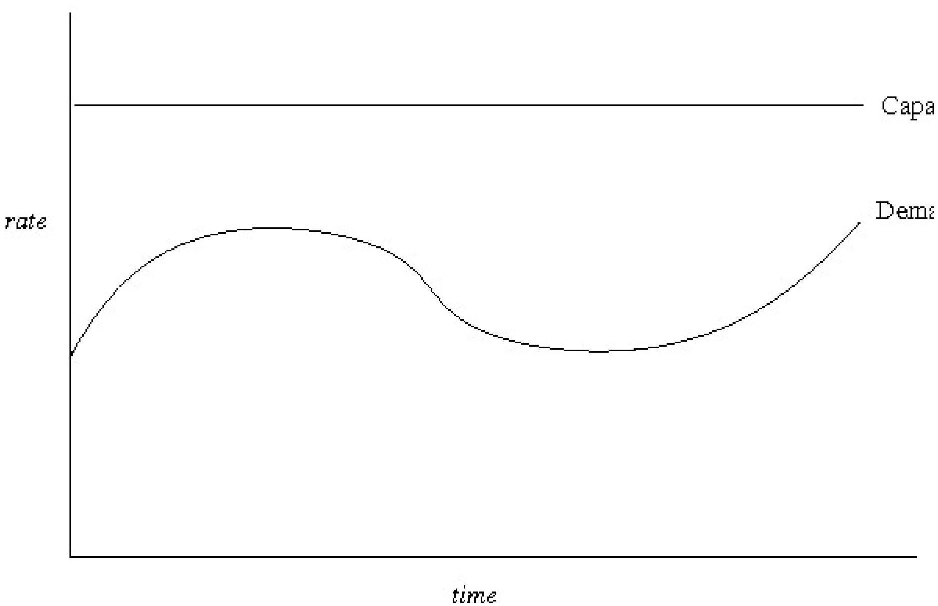
Operating region

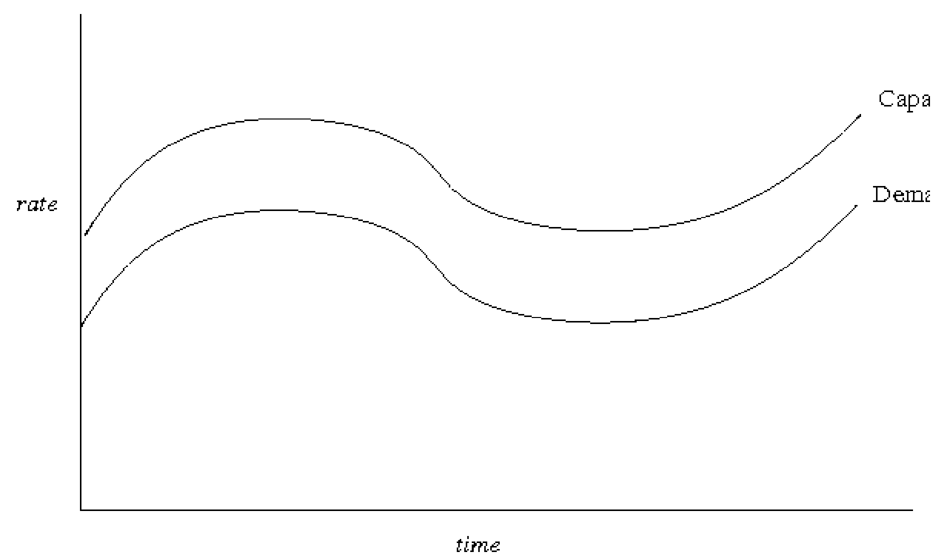
- What are the limits in which we can operate our system or business, before they `crash'?



Providing / “provisioning”

- What are the limits in which we can operate our system or business, before they `crash'?
  - Excess capacity (“over-provisioning”)
  - Optimally adapting
  - Inventory methods



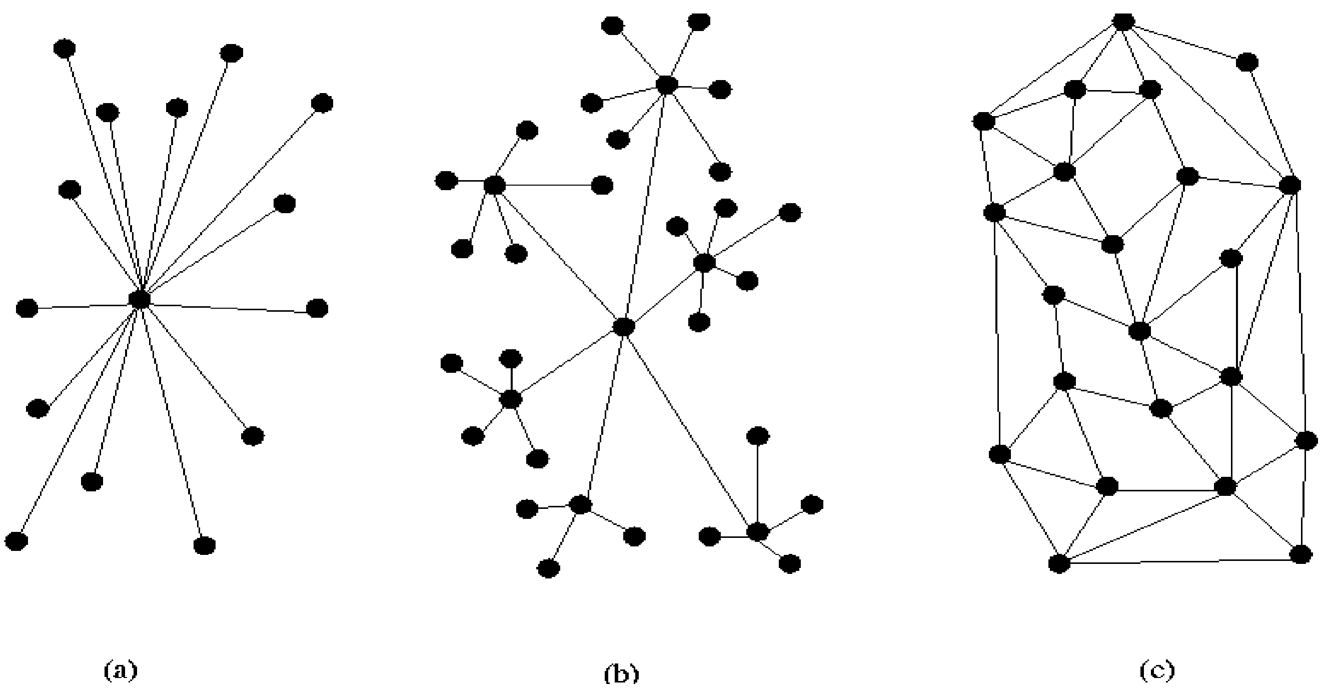


Quantities and States

- What are our *quantity* and *quality* variables *q*?
- Continuous
  - Time series – demand, response from dependencies (outsourcing)
  - Inventory storage, service levels
- Discrete
  - State transitions -- customer interactions (*ordered, waiting.., graph relationships*)
  - Object types – Windows, Unix,...

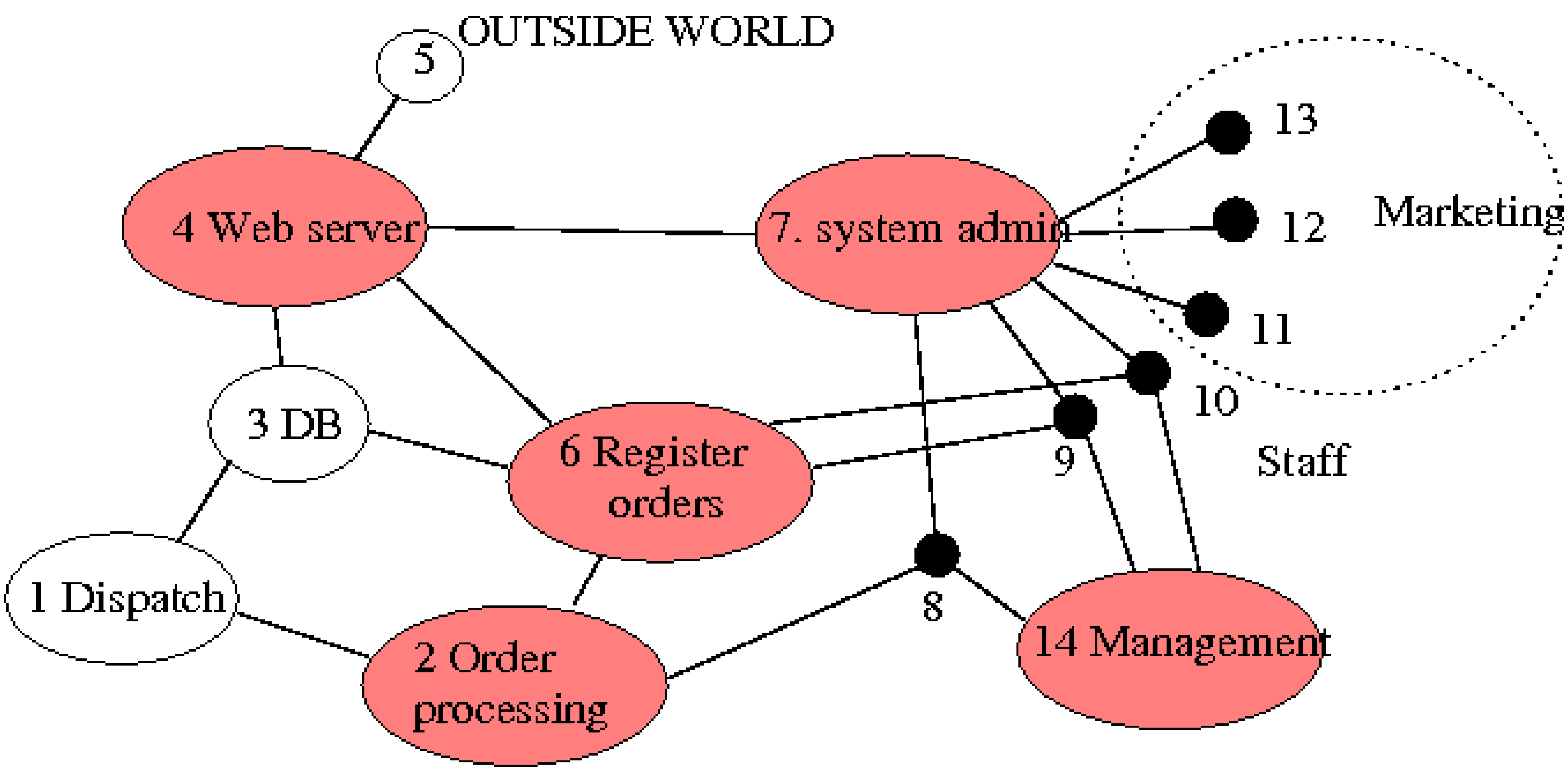
Workflow/interaction models

- Scalability and capacity from workflow:
  - Control flow (hierarchy or service oriented?)
  - Workflow model (bottleneck analysis)
  - Queueing and communication models

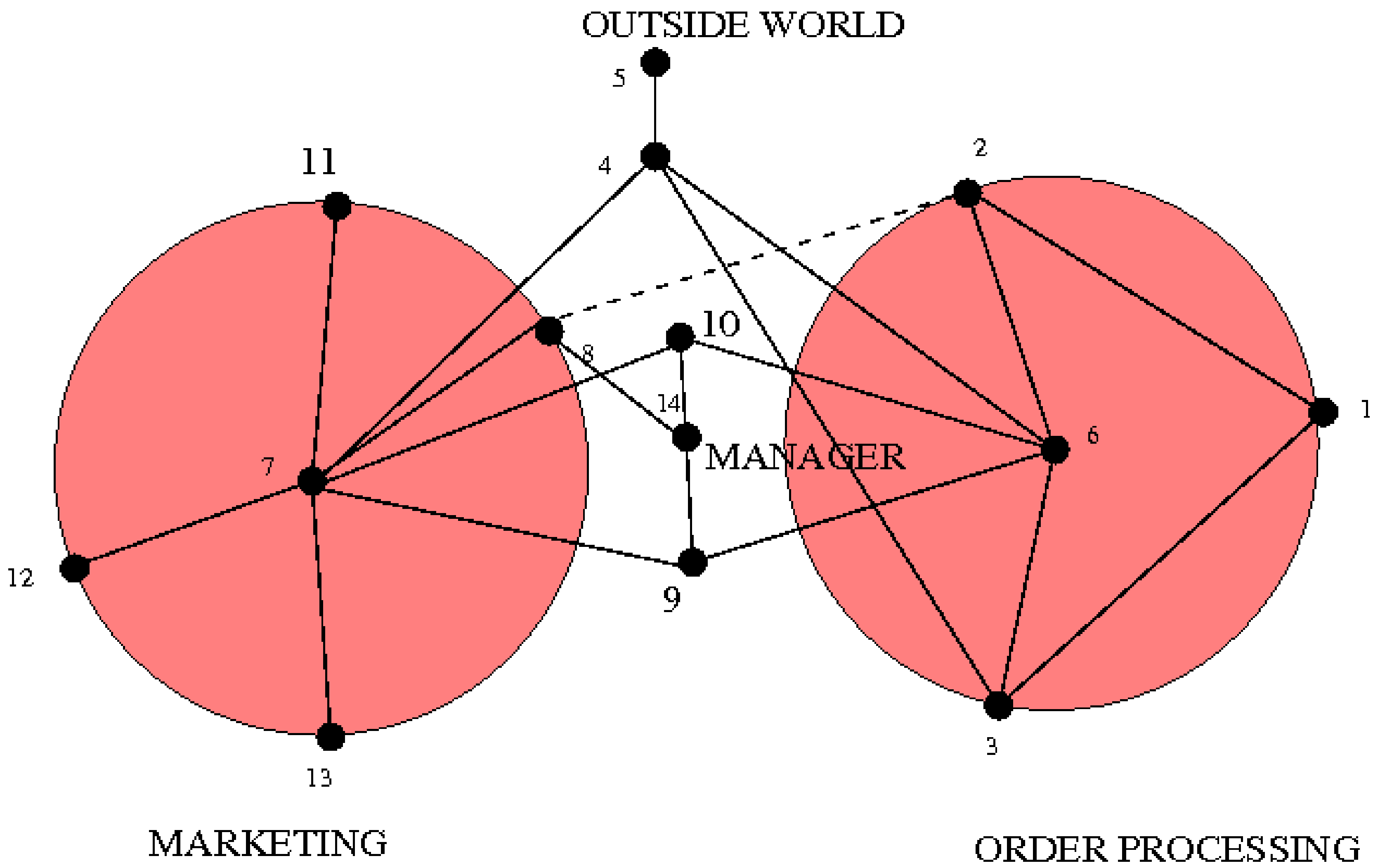


Detecting poor organization

- Designs based on *a priori* guesses or subjective evaluation are not always correct



Centrality-scope

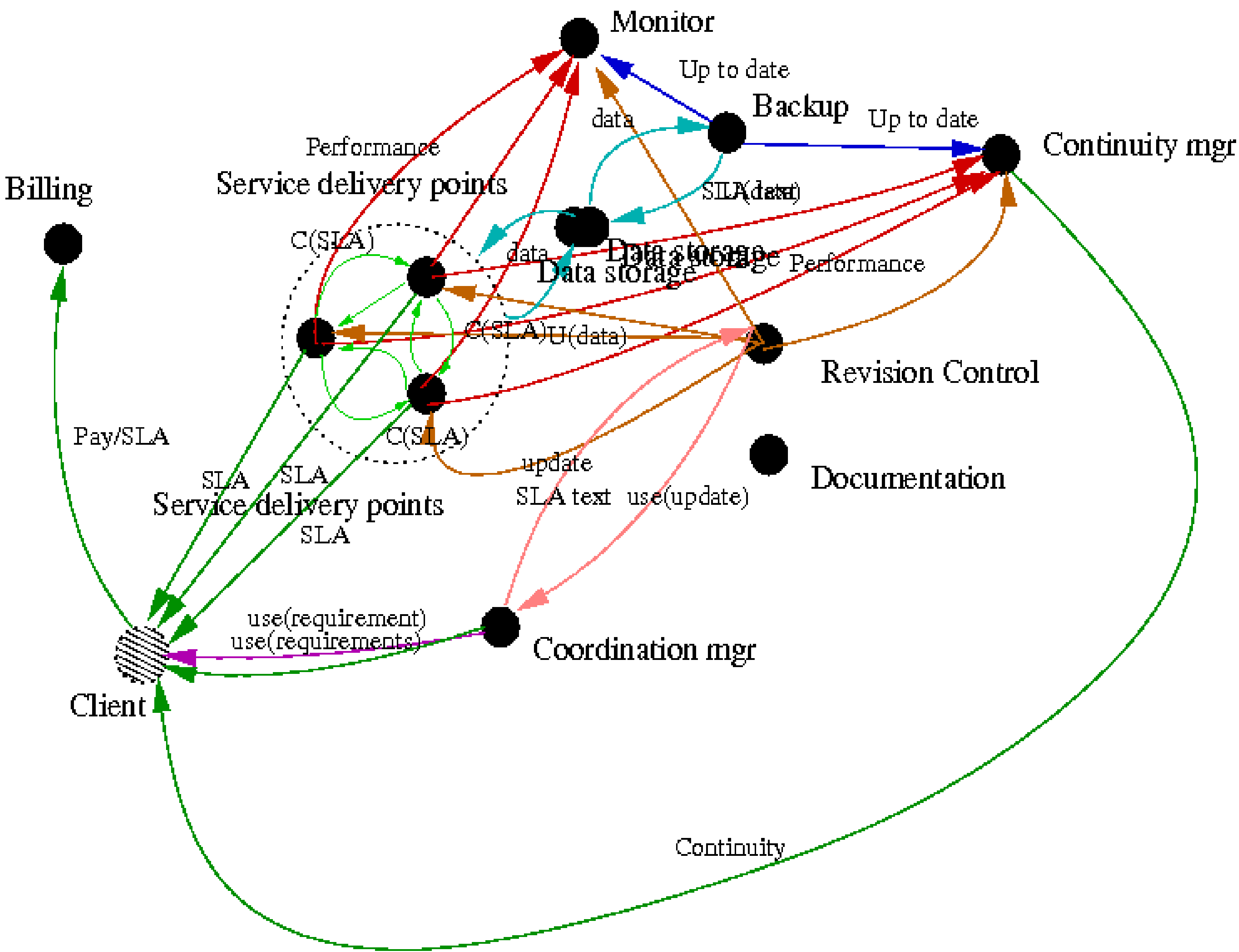


ITIL – IT Infrastructure library

- **Service support**
  - Incident management
  - Problem management
  - Configuration management
  - Change management
  - Release management
- **Service delivery**
  - Service Level Management
  - Problem management
  - Configuration management
  - Change management
  - Release management

"Best practices"

ITIL and promises

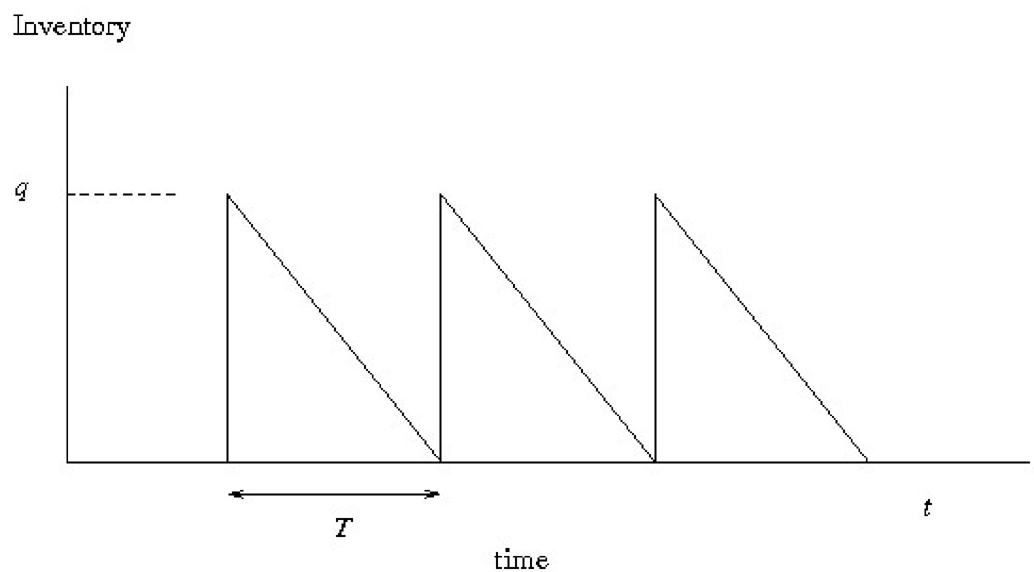


Inventory models

- How to optimize buying and storing supplies.
- Huge topic – many levels of approximation
- Demand (need) is a stochastic process
  - Replace PCs, screens
  - New disks when they become full
  - Extra servers, increased business capacity
  - Can also apply to services with new interpretation
- Try to minimize the overheads associated with administrating an order, assuming we can afford to buy.

Simple inventory model

- Think only in terms of averages and make a pseudo-deterministic, (regular) ordering process.
- Order suddenly and use gradually until exhausted



q = stock,system change,DNS lookups – any processing item

Cost per order/period

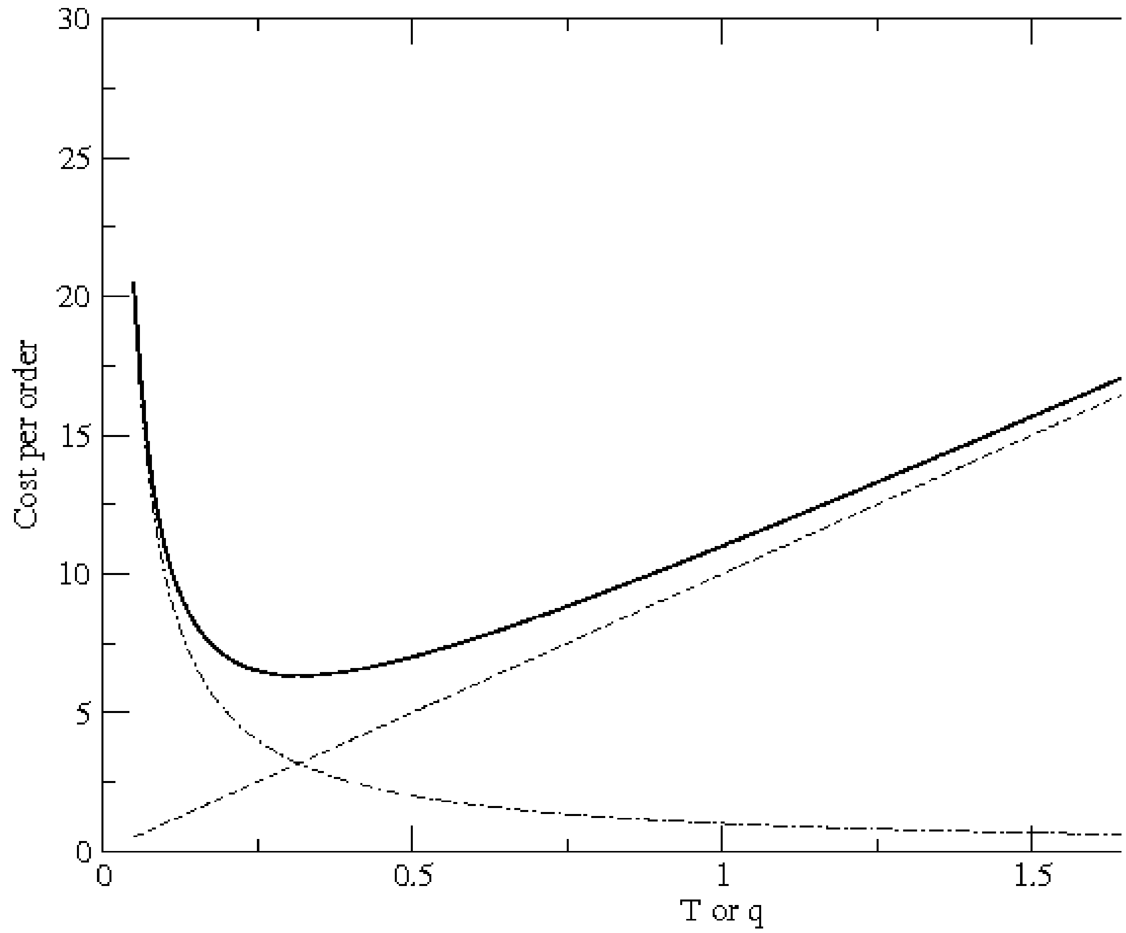
- k – overhead cost of ordering
- h – holding cost (storage)
- λ demand rate (or service rate)
- I(t) – inventory level at time t

$$C(T) = \frac{1}{T}\left(k + h\int_0^T I(t)dt\right)$$

$$I(t) = q - \lambda t, \quad (0 \le t \le T).$$

Cost per order/period

- Cost function has a minimum, and therefore an order size/frequency that minimizes overheads



Randomness: queueing theory

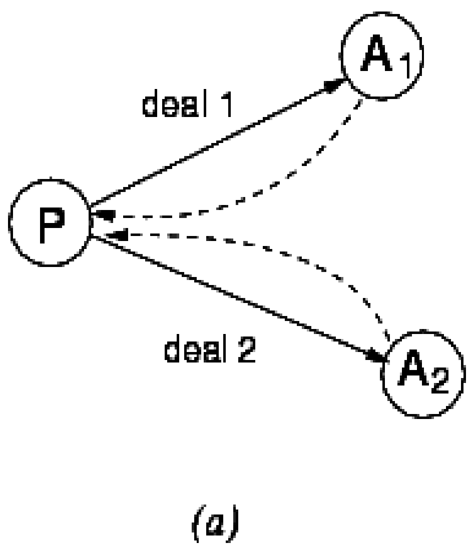
- A generalization of the idea of inventory, in which we try to supply materials or work “just in time”.
- Take explicit account of the stochastic nature of the “arrival process” (demand)
- Many important results about optimization
- *Poisson* vs *Power law* discussion (rare events)
- How predictable is demand and our ability to respond to it?

Contracts and Outsourcing

- Principal-agent theory (economic subroutines!)
  - A principal wants to outsource a service
  - Agents provide services at different prices
    - Cheap agents (Asia)
    - Expensive agents (West)
- How does the principal design a contract to get the best deal?
  - Don't pay enough, no one will take it
  - Pay too much, lose money
- Solve for selfish agents – promise/game theory

Promises and information

- Who promises first?
  - Strategic advantage when dealing with selfish agents



$$P \xrightarrow{w_i/e_i} A_i$$
$$A \xrightarrow{e_i/w_i} P.$$

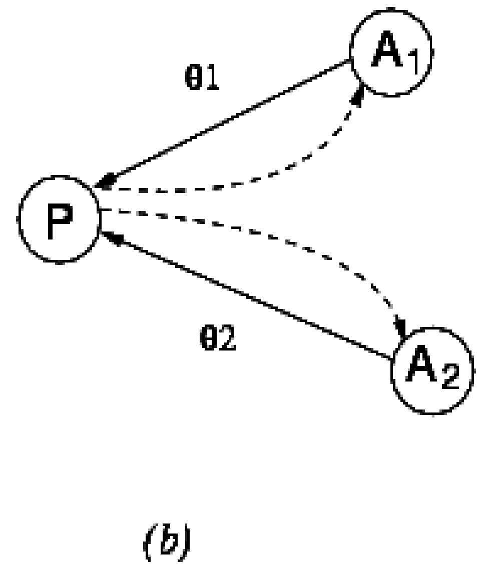


Figure 3: The principal agent model's bilateral promises.

Value of promises

$$
\begin{aligned}
v_P\left(P \xrightarrow{w_i/e_i} A_i\right) &\mapsto -w_i && \text{if } e_i \\
v_A\left(P \xrightarrow{w_i/e_i} A_i\right) &\mapsto +w_i && \text{if } e_i \\
v_P\left(A \xrightarrow{e_i/w_i} P\right) &\mapsto +e_i && \text{if } w_i \\
v_A\left(A \xrightarrow{e_i/w_i} P\right) &\mapsto -C(e_i).
\end{aligned}
$$

Each agent wants to maximize its own perceived value - competition

Incomplete information

- Maximize $\langle \pi_{\text{principal}} \rangle = \sum_i p_i(e_i - w_i),$
- Subject to constraints:

$$\begin{aligned}
w_1 &\geq \frac{1}{2}\theta_1 e_1^2 \\
w_1 - \frac{1}{2}\theta_1 e_1^2 &\geq w_2 - \frac{1}{2}\theta_1 e_2^2 \\
w_2 &\geq \frac{1}{2}\theta_2 e_2^2 \\
w_2 - \frac{1}{2}\theta_2 e_2^2 &\geq w_1 - \frac{1}{2}\theta_2 e_1^1 \\
\theta_2 &> \theta_1 \\
p_1 + p_2 &= 1
\end{aligned}$$

Solution

Thus we may maximize the Lagrangian:

$$L = p_1(e_1 - w_1) + p_2(e_2 - w_2) + \alpha\left(w_1 - \frac{1}{2}\theta_1(e_1^2 - e_2^2) - w_2\right) \\ + \beta\left(w_2 - \frac{1}{2}\theta_2 e_2^2\right).$$

The new equations are therefore:

$$\begin{aligned} \frac{\partial L}{\partial w_1} &= -p_1 + \alpha = 0 \\ \frac{\partial L}{\partial w_2} &= -p_2 - \alpha + \beta = 0 \\ \frac{\partial L}{\partial e_1} &= p_1 - \alpha\theta_1 e_1 = 0 \\ \frac{\partial L}{\partial e_2} &= p_2 - \alpha\theta_1 e_2 - \beta\theta_2 e_2 = 0 \end{aligned}$$

Substituting eqn. (21) into (23) gives the optimum effort

$$e_1 = e_1^* = \frac{1}{\theta_1}.$$

and ubstituting eqn. (22) into (24) gives

$$e_2 = e_2^* = \frac{1}{\theta_2 + \frac{p_1}{p_2}(\theta_2 - \theta_1)} < \frac{1}{\theta_2}.$$

Budgets - scales/numbers

Policy

- We summarize all our decisions as policy
  - Some questions can be answered by optimization (rationally)
  - Remainder must be solved ad-hoc (irrationally)
- Policy determines actions
  - Classification implies alphabet of “symptoms”
  - Map “symptoms” to maintenance operations
- Policy is only every satisfied on average, just as inventory is only available on average
  - (Maintenance theorem)
  - Applies to “not enough money” too!

This course

- Demonstrate how to reason rationally
- Illustrate how to model systems creatively but formally
- Show how we can put numbers into decision-making
- Ask you to be critical of your assumptions
- Prepare you for your thesis…
  - What do I think might happen?
  - How can I predict what will happen?
  - How can I show whether or not I was right