

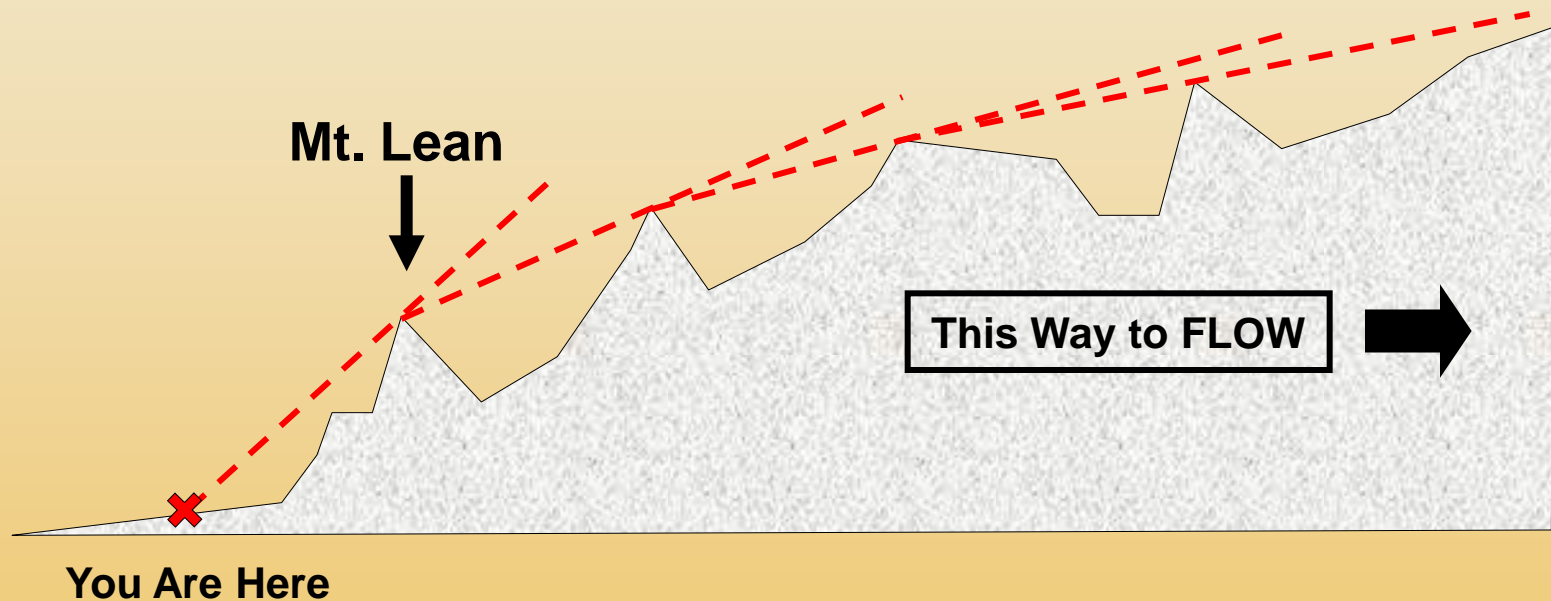
# **The Easy Road to FLOW Goes through a Town Named LEAN**

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***Lean is not the destination, it is a  
waypoint on the journey to Flow.***



**Just because it's the tallest mountain you can see, doesn't mean it's the tallest mountain.**

# Today's Discussion

- **Lean has brought some powerful and useful ideas for product developers.**
- **It has also brought us ideas that are that are oversimplified, faith-based, and potentially toxic to product developers.**
- **Where must we refine these ideas?**
- **Where must we extend them?**
- **Where can we find more advanced thinking?**

# Many Heuristics, Some Useful

- **Eliminate waste.**
- **Eliminate variability.**
- **Prevent defects instead of correcting them.**
- **Use the customer as the ultimate judge of value.**
- **Reduce batch size and seek one piece flow.**
- **Use FIFO processing.**
- **Block arrivals when you reach WIP limits.**
- **Stop the line when you find a problem.**

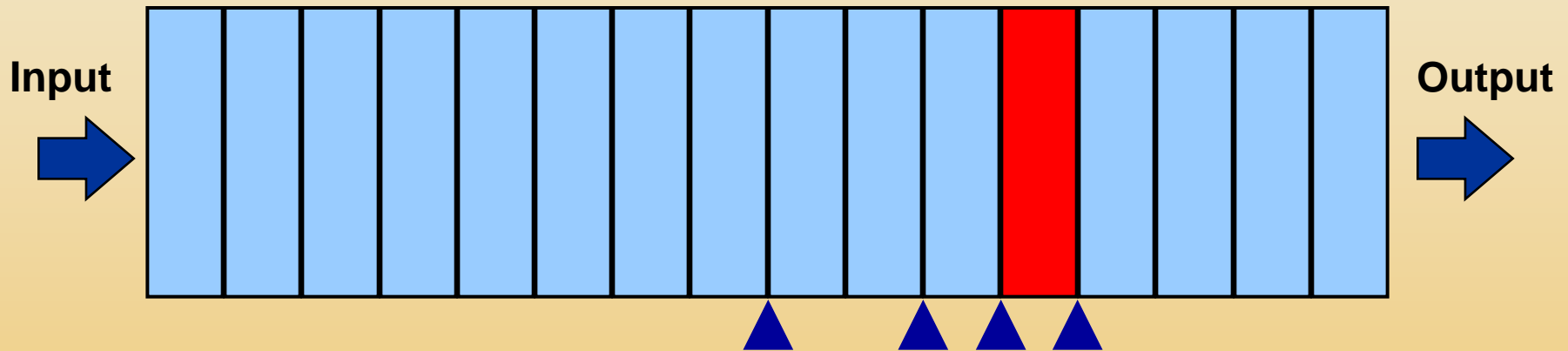
# Eliminate Waste

- **Waste is bad; eliminate it.**
- **Eliminate non-value-added activity.**
- **Let's test the utility of these concepts.**
- **Which choice is better?**
  - **Operate the test area at 80 percent utilization with a 48 hour queue.**
  - **Operate the test area at 90 percent utilization with a 96 hour queue.**

# Eliminate Variability

- **This is potentially the single most toxic idea for product developers.**
- **Product development creates economic value by doing something new.**
- **To do this, we must take rational economic risks, accepting uncertainty in outcomes.**
- **We cannot eliminate all variability without eliminating all value-added.**
- **Moreover, to maximize the efficiency with which we generate information we need a surprisingly high failure rate.**

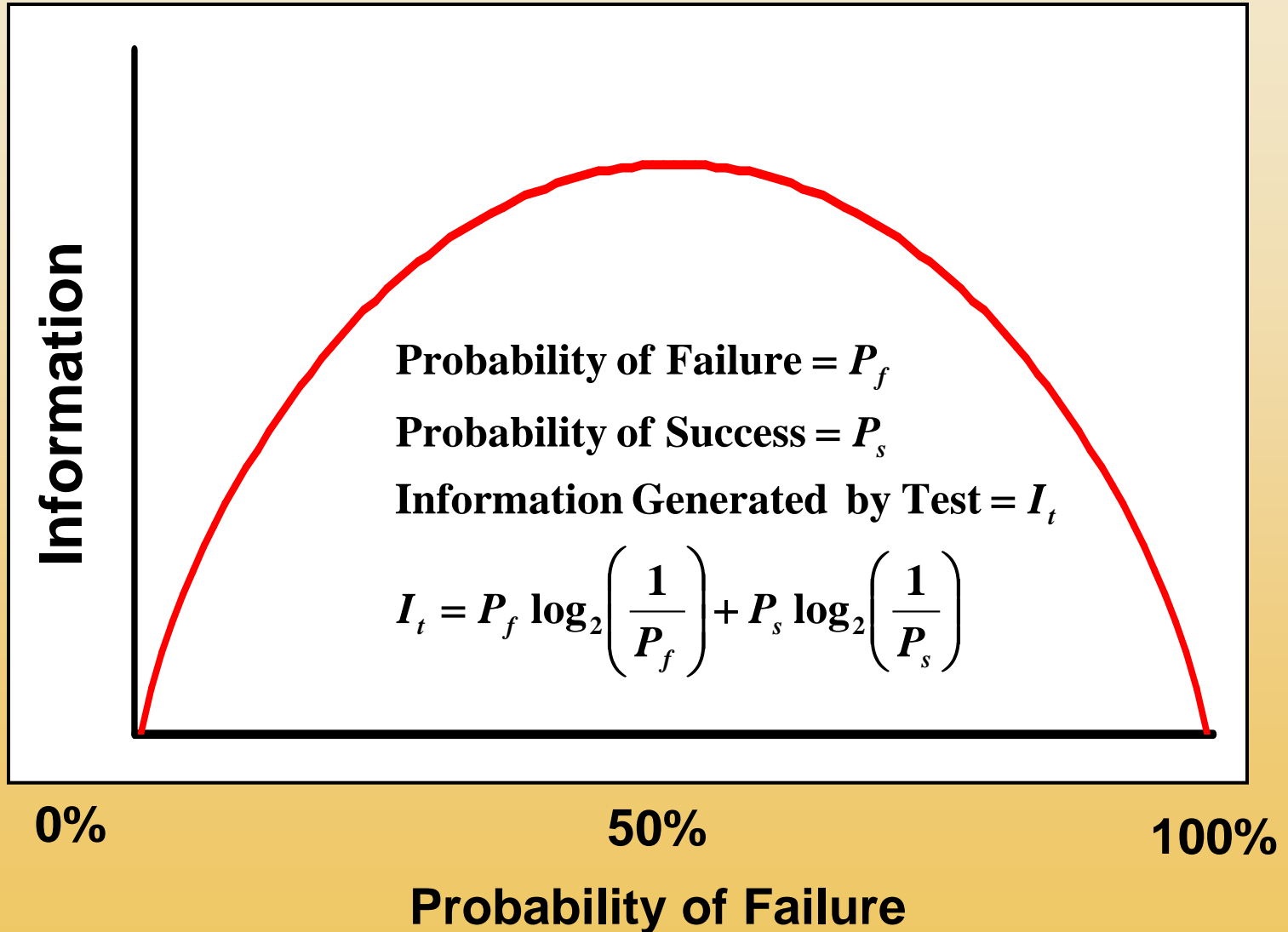
# Learning Efficiently



16 Modules with 1 defective

How many probes does it take to find the defective module?

# Information and Testing





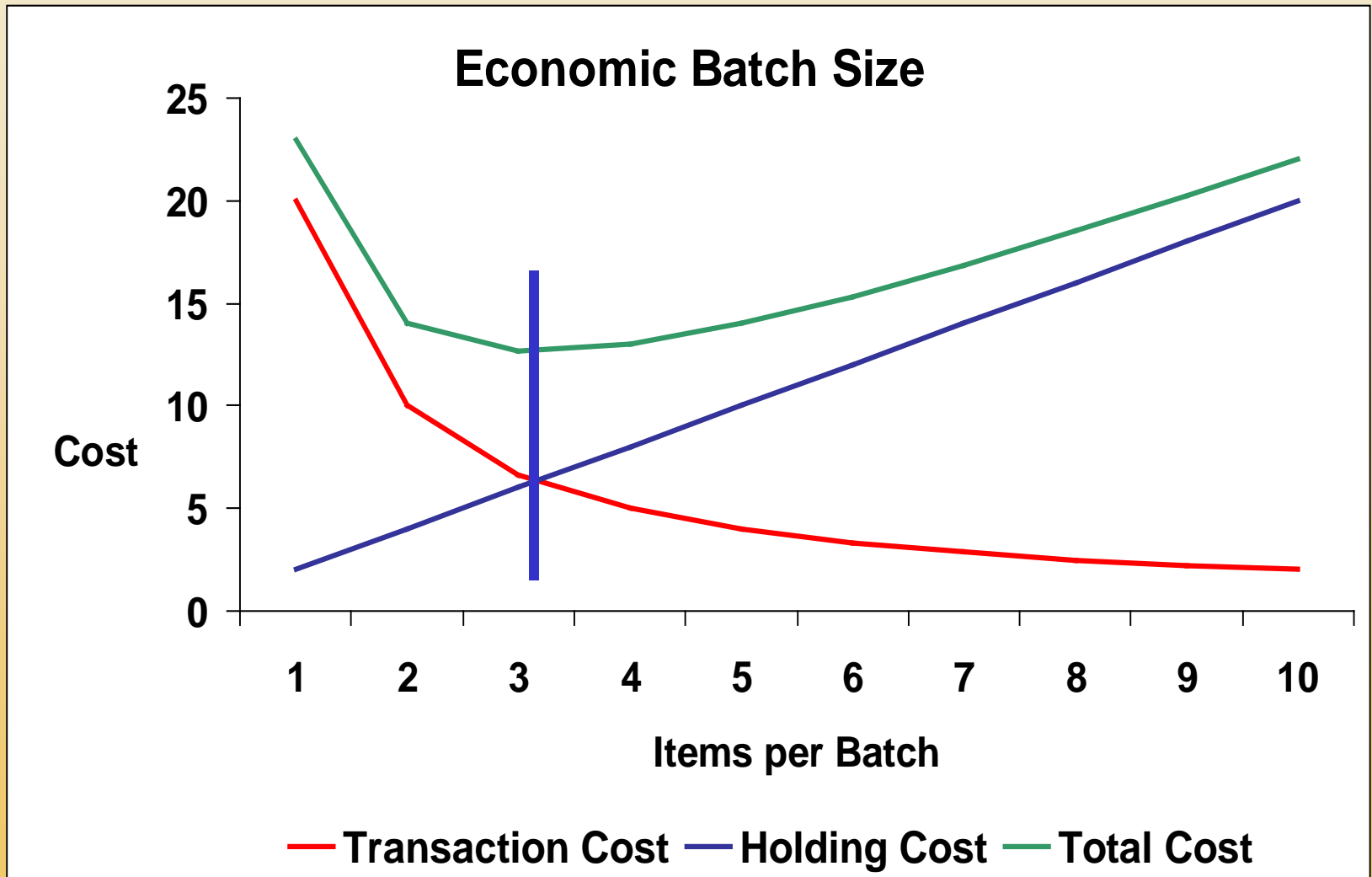
# Prevent Defects

- Preventing defects has a cost.
- Finding and correcting defects has a cost.
- To optimize the overall system we should minimize the combination of these two costs.
- To minimize either cost, in isolation, is local optimization not system thinking.
- For example, why do we use spellcheckers on word processors?

# The Customer Is Sole Judge of Value

- In economics the concept of value-added is well established.
- If you would pay more for a work product after an operation than before, that difference is value added.
- For example, lean manufacturing views testing as necessary waste.
- This is a dangerous view for product developers.

# Seek One-Piece Flow



# The TPS Emergency Room

- We desire to rigorously imitate the practices of Toyota.
- All arriving patients will be processed on a FIFO basis.
- We will set strict limits on WIP.
- We will stop the line if a quality problem occurs.
- Routings will be standardized.
- Routing decisions will be front-loaded.



# Why Doesn't This Work

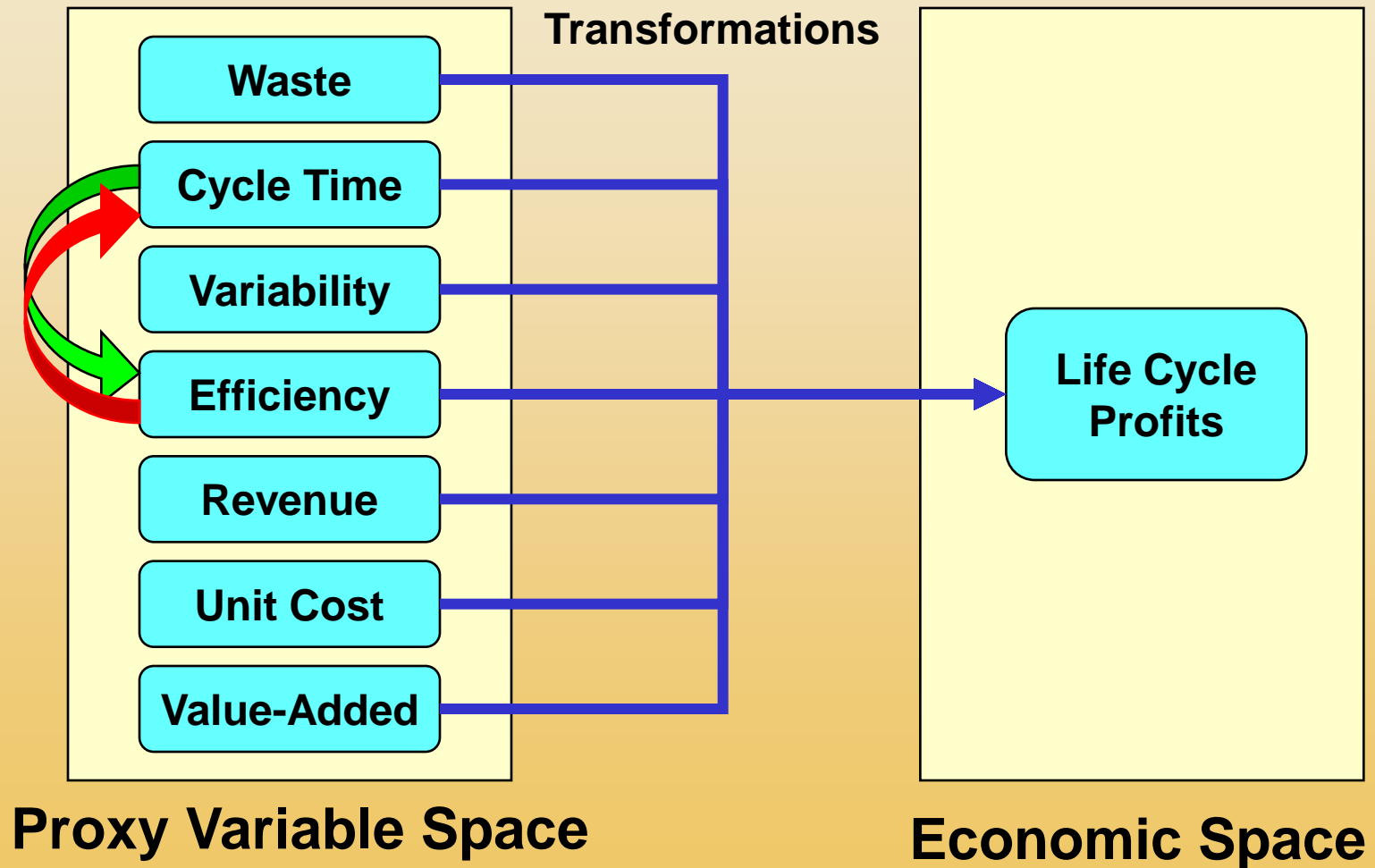
- **Delay costs are not homogeneous.**
- **Task durations are not homogeneous.**
- **“Shut the Door” WIP control can be expensive.**
- **A defect on one patient may not predict an identical defect on the next.**
  - **Stopping the line has a cost for other patients.**
- **Least-common-denominator routings are almost always sub-optimal.**
- **Better information emerges continuously.**
  - **Feedback alters optimal economic choices.**

# Where Should We Extend Lean Manufacturing?

- **Adopt approaches that work for non-homogeneous flows.**
- **Recognize the different role of variability.**
- **Develop protocols for tasks of unpredictable or possibly infinite duration.**
- **Drive decisions with economics.**
- **Recognize different economic leverage points.**

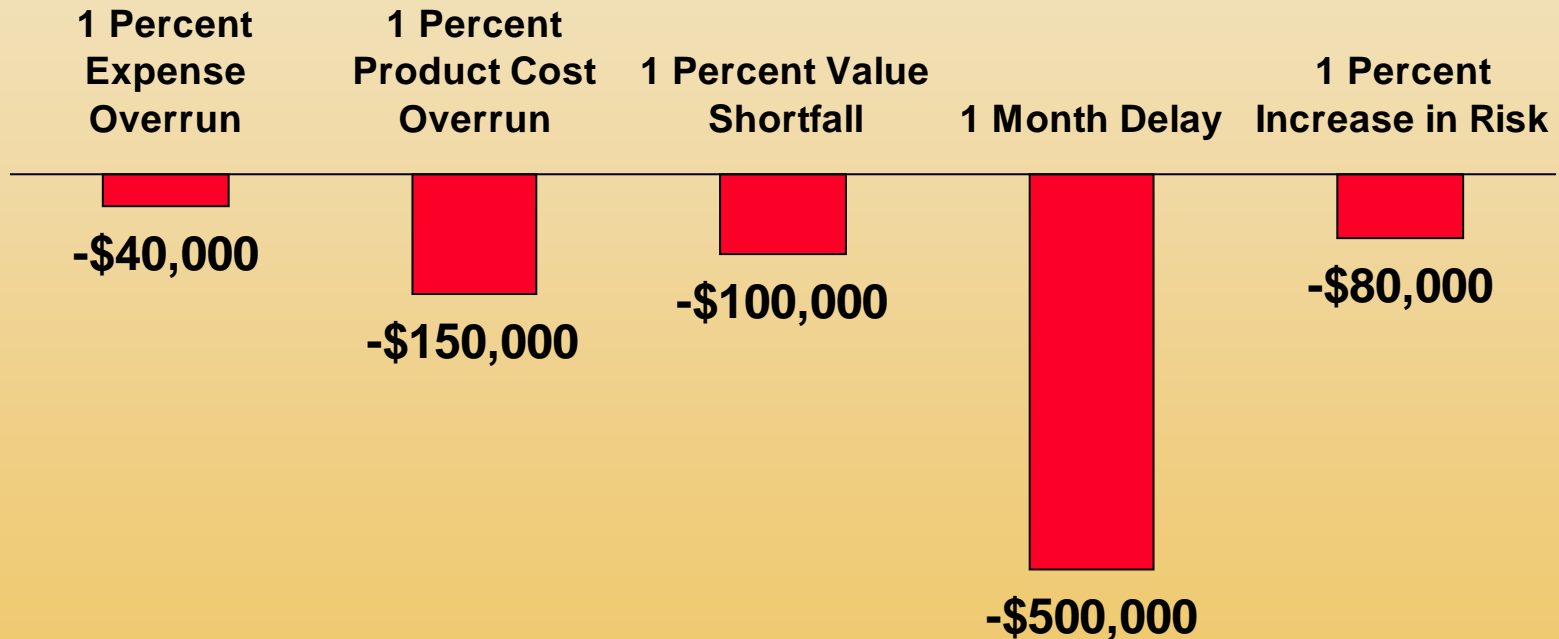
**When we fail to frame decisions economically they become slower, less correct, and more opaque. Even worse, we cripple management's capacity to give us quick and enthusiastic support.**

# Making Economic Decisions



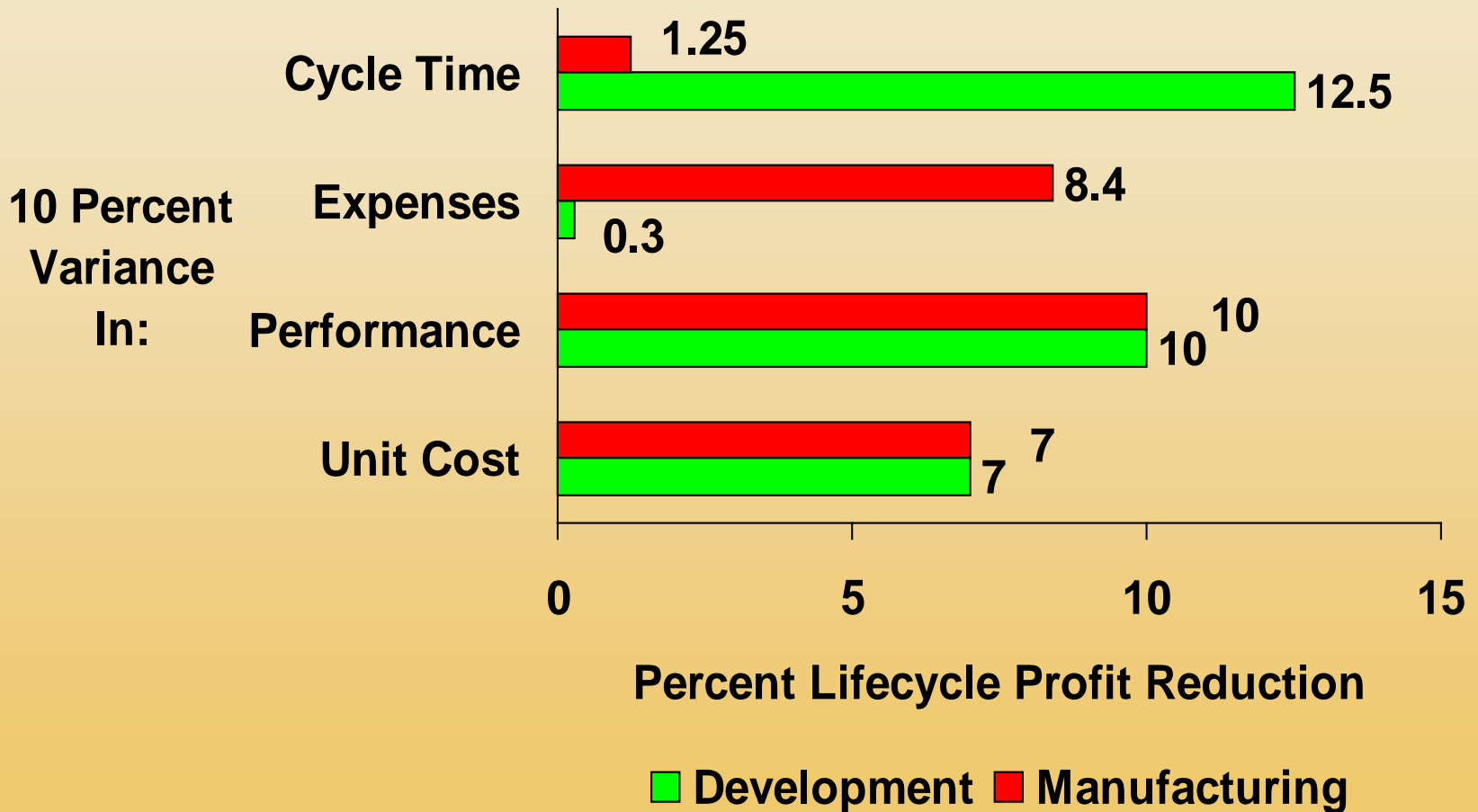
# Understand Sensitivity Factors

## Life-Cycle Profit Impact





# Development has Different Economic Leverage Points



Note: These percentages vary by business.

# If Not the TPS, Then What?

- **Consider the Internet.**
- **The mathematical foundations were laid in 1909.**
- **It is product of 40 years of evolution.**
- **It is designed to work in the presence of inherent variability in load and capacity.**
- **It achieves quality levels far in excess of  $6\sigma$ .**
- **It has scaled by many orders of magnitude without affecting its operation.**
- **New approaches are embraced and quickly, and reversibly, tested.**

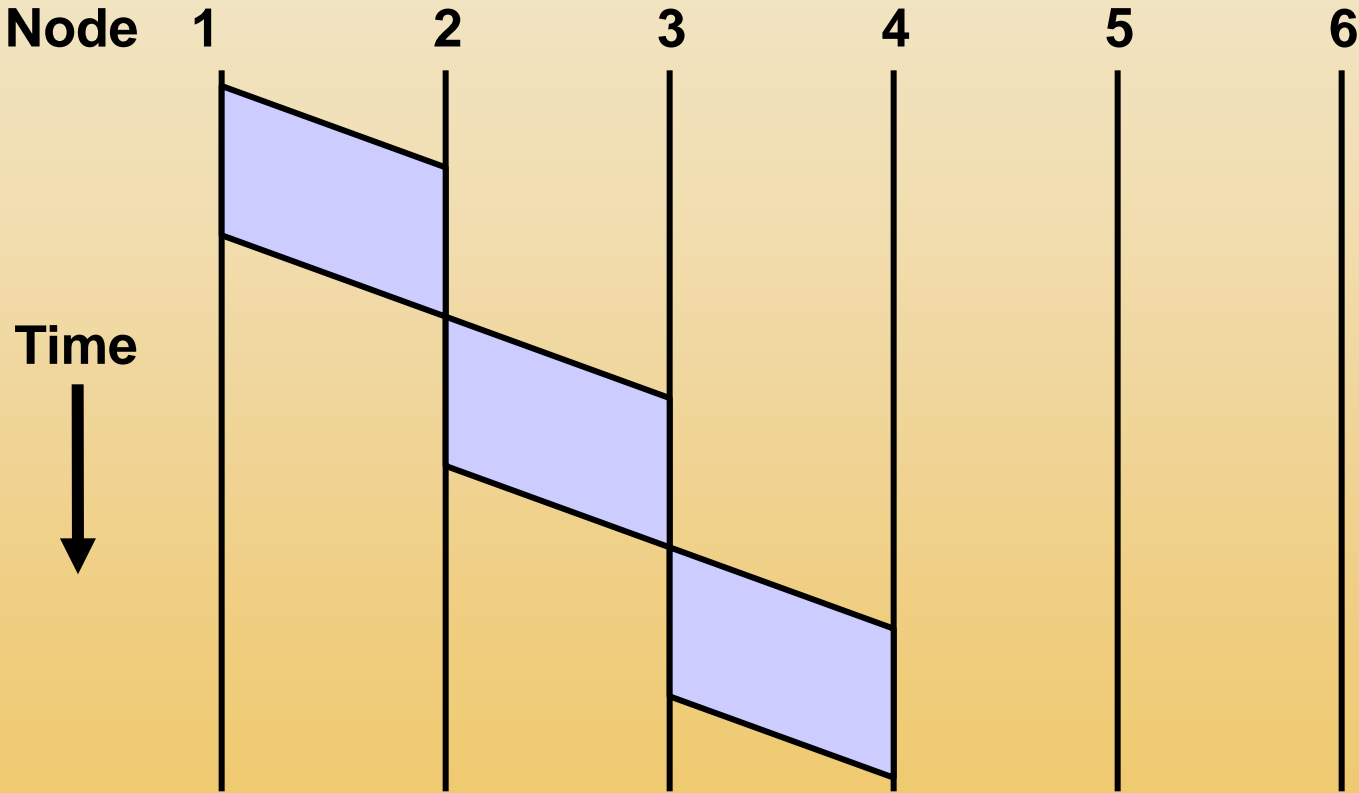
# **Seven Lessons from the Internet**

- 1. Use small batch sizes to simultaneously raise speed, efficiency, and quality.**
- 2. Use dynamic WIP constraints.**
- 3. Create quality by iteration, not by defect prevention.**
- 4. Make dynamic routing decisions based on observed congestion.**
- 5. Bind resources at short time horizons.**
- 6. Avoid congestion, don't just control it.**
- 7. Provide different quality of service to different work streams.**

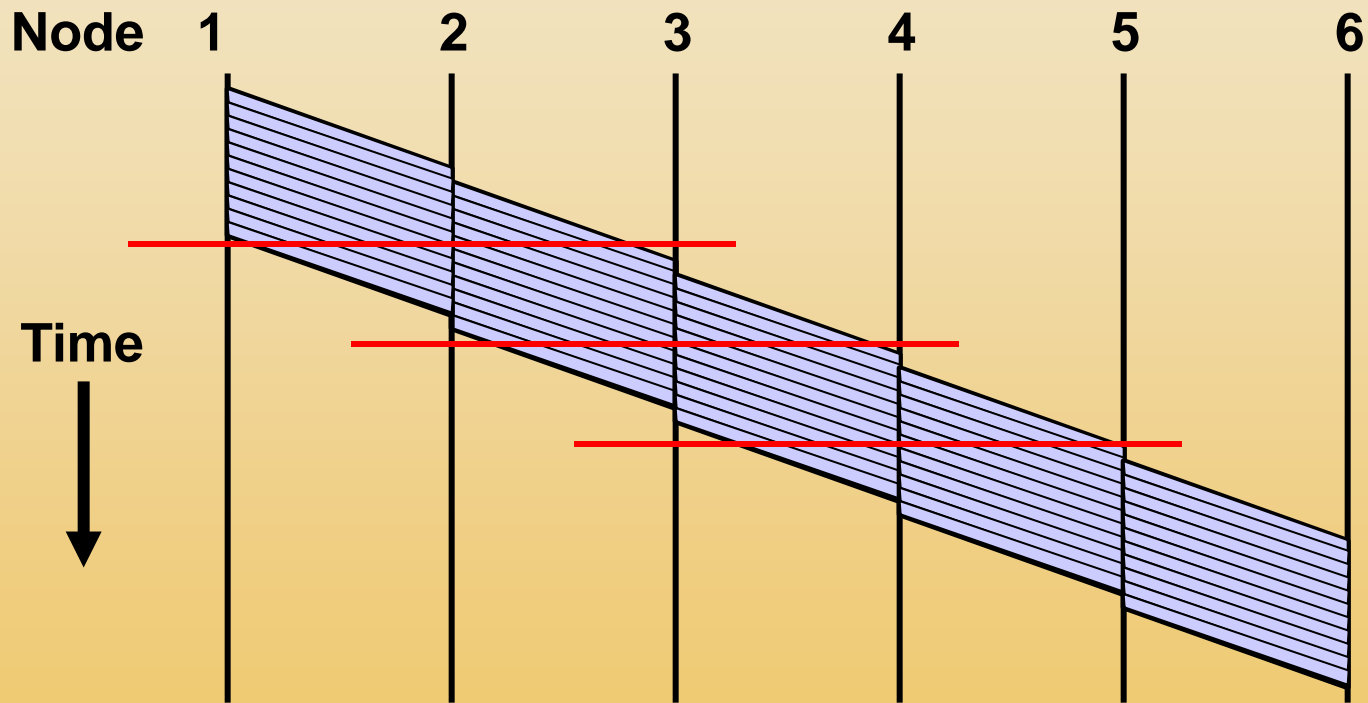
# 1. Small Batches

- **Packet switching networks decompose messages in many small, standardized, packets.**
- **These packets are transmitted independently, often along different routes.**
- **Lost or corrupted packets are retransmitted.**
- **The receiver reassembles these packets into a complete message.**

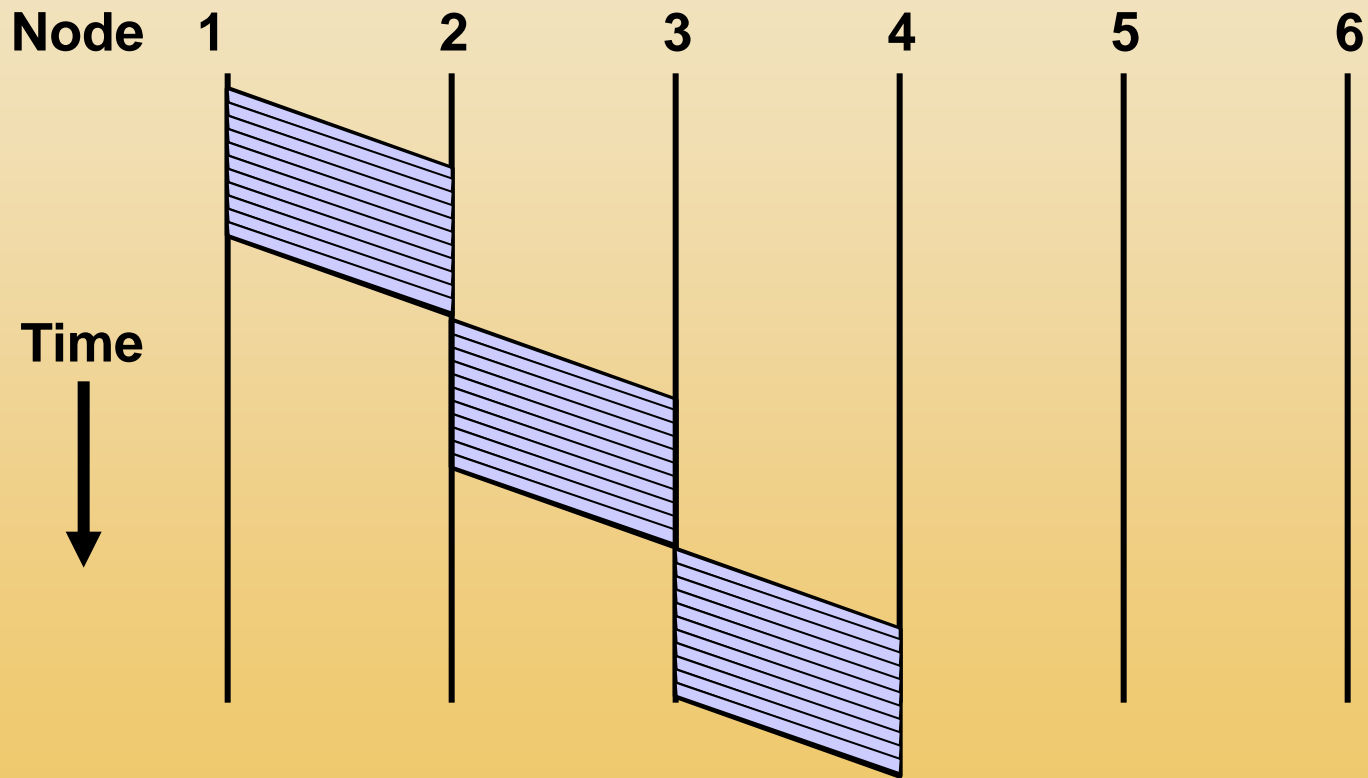
# Transmission without Packets



# Transmission with Packets



# Packets Alone Are Insufficient



# Why Packet Switch?

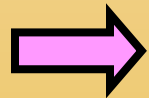
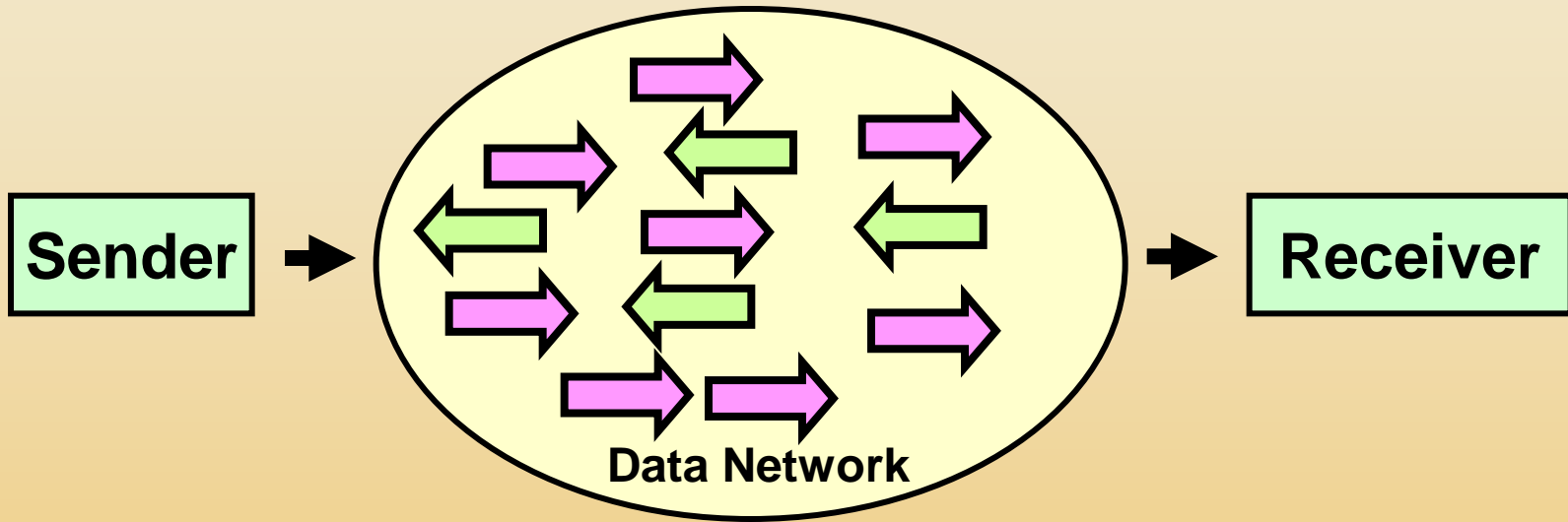
- **Advantages**
  - **Faster end-to-end cycle time.**
  - **Better resource utilization.**
  - **Less retransmission for errors.**
- **Disadvantages**
  - **Some reassembly required.**
  - **More overhead per packet.**
    - **Thus, one piece flow is not optimal.**



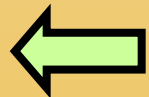
## 2. Dynamic WIP Constraints

- **By controlling packets in flight we can match rates of sender and receiver.**
- **We can also adjust for changing link availability and throughput.**
- **Since link capacity changes, we dynamically probe link capacity and adjust WIP levels.**
- **We use sophisticated loading and unloading strategies to prevent system instability. (e.g. AIMD)**

# Controlling Internet Flows



**Packet from Sender**



**Acknowledgement (ACK) from Receiver**

**Packets + ACKs < Window Size**  
**Window Size Limits Number**  
**of Unacknowledged Packets**

# 3. Quality by Iteration

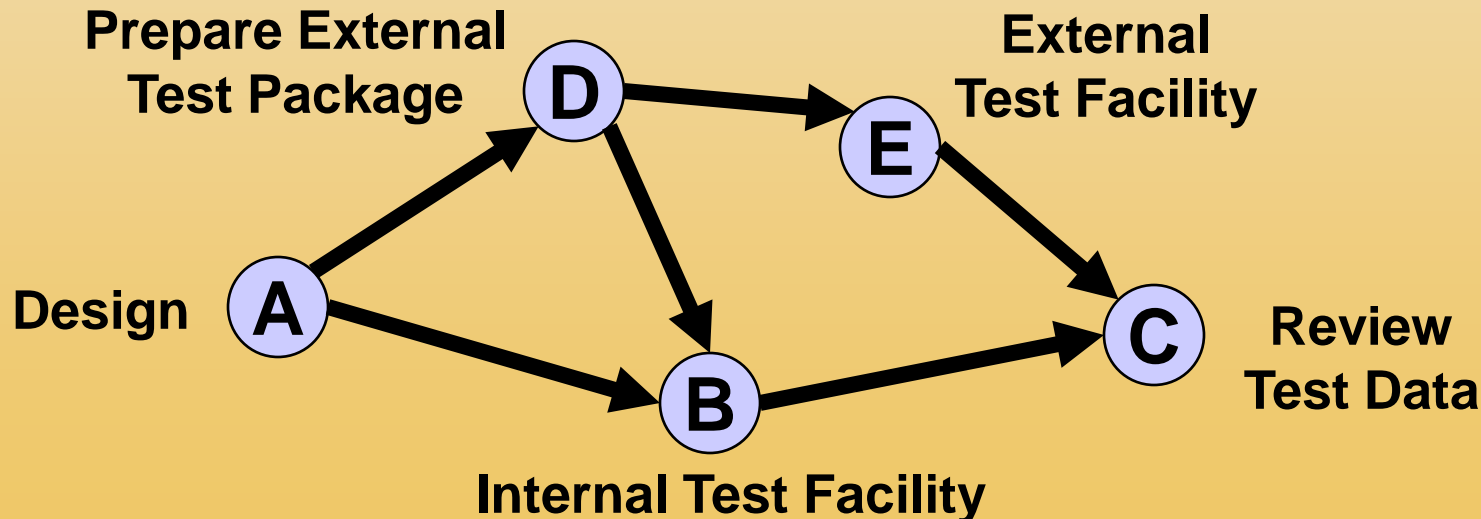
- **The Internet does not guarantee delivery - it is a “best efforts” network.**
- **Although node-to-node communication is reliable, errors will still occur.**
- **The responsibility for achieving quality lies with the sender and receiver, not the network.**
- **This allows messages to be forwarded quickly with minimal processing at each node.**
- **Thus, quality is achieved through finding and correcting errors, not by preventing defects.**

# 4. Dynamic Routing

- On the Internet, messages are routed to the receiver using the shortest “Path Length”.
- Path Length is not simply physical distance, but a complex function of distance, circuit cost, and congestion.
- Routing tables are updated many times per minute.
  - This route status information need not be global, just enough to route to the next node.
- Thus, routing becomes a near real-time decision based on the current state of the nearby section of the system.

# Dynamic Routing

- Route based on current system conditions.
- Use preplanned paths.
- Make downstream system states visible with feedback.



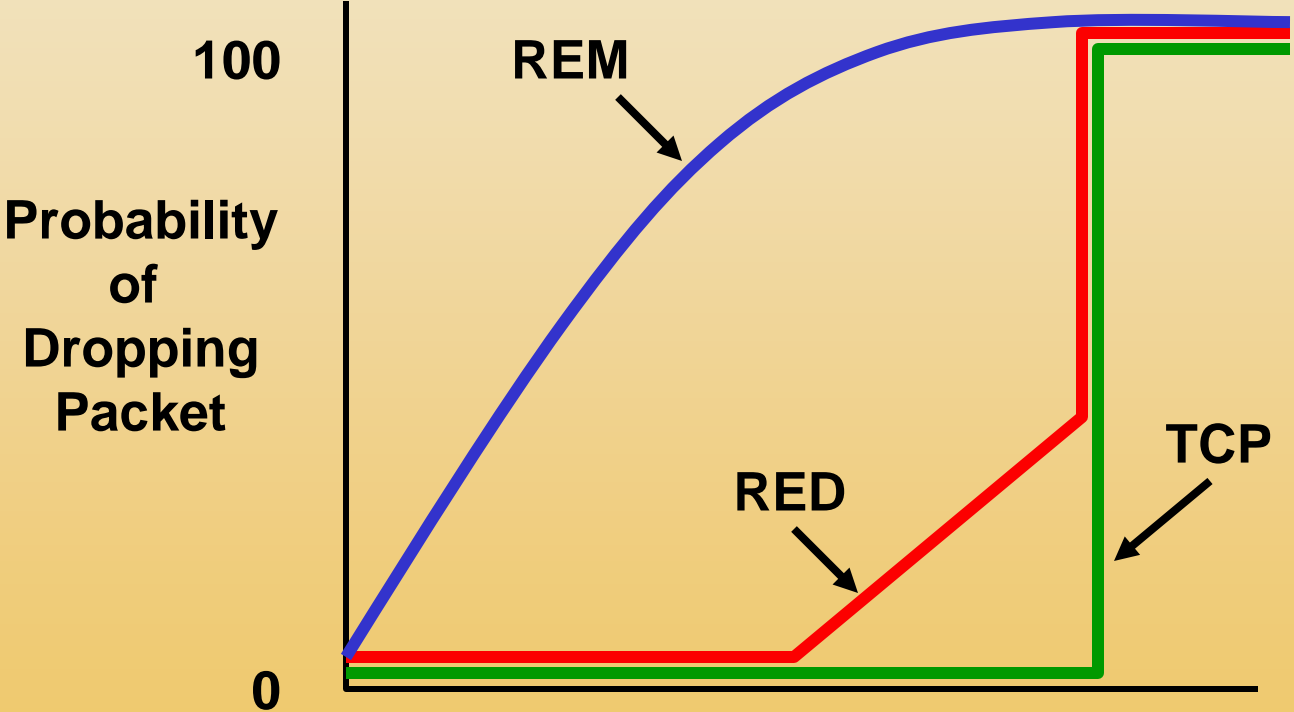
# 5. Late Binding to Resources

- **Telephone systems rely on circuit switching.**
  - **The resource, bandwidth, is committed for the full duration of a call.**
  - **This enables guaranteed delivery.**
  - **But, it wastes bandwidth.**
- **In contrast, packet networks do not reserve bandwidth for individual users.**
- **Instead, they only provide bandwidth when there are packets ready to be transmitted.**
- **Thus, they bind resources to demand at very short time horizons.**

# 6. Avoid Congestion

- **Traditional systems of congestion control would start dropping packets when buffers became full.**
- **This caused the system to operate with little reserve margin most of the time.**
- **Emphasis has shifted to anticipating and avoid congestion rather than reacting to it.**
- **Such systems begin throttling their sources as queues pass a certain level.**

# Congestion Avoidance vs. Control



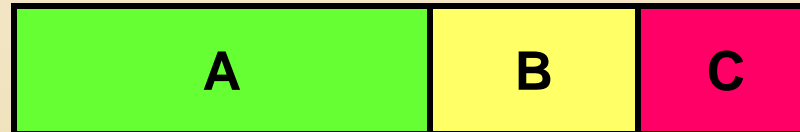
RED = Random Early Detection, REM = Random Early Marking



# 7. Differentiate Quality of Service

- **Different types of messages have different Quality of Service (QoS) requirements.**
  - **For example, control messages should have highest priority.**
- **Overall resources can be allocated among different workstreams.**
- **Then WIP constraints can be used to provide different average response times.**
- **This requires establishing priorities and monitoring service levels.**

# Managing Workstream Priorities



	<b>A</b>	<b>B</b>	<b>C</b>
<b>Weekly Resource Allocation</b>	5 pd	3 pd	2 pd
<b>Work Content Time per Item</b>	1 pd	1 pd	4 pd
<b>Processing Rate Items per Week</b>	5 items	3 items	0.5 item
<b>Service Time Goal</b>	1 week	3 weeks	6 weeks
<b>WIP Constraint</b>	5 items	9 items	3 items

$$W_s = \frac{L_s}{\lambda}$$

pd = person-day

# Contrasting Strategies

## Toyota Production System

- On/Off Flow Control
- Static WIP Limits
- One Service Level
  
- Local Feedback Loops
  
- Static Routing
  
- Constrains Variability

## INTERNET

- Progressive Throttling
- Dynamic WIP Limits
- Multiple Service Levels
  
- Local and Global Feedback Loops
- Dynamic Routing
  
- Tolerates Variability

Which system is a better fit with the needs of product development?

# Beyond the Internet

- **The Internet is structured to make packets transportable over any link. Resources are fungible.**
  - **How do we exploit the economic benefits of work matching when both work and worker is not fungible?**
- **On the Internet packets do not expand to fill available time.**
  - **How do we deal with work that can expand like the perfect gas?**

# Second Generation Idea Sources

Apply the Ideas of  
Lean Manufacturing

+

Add Concepts from  
other Domains

DOMAIN

- Repetitive Tasks
- Low Variability
- Homogenous Flows

- Non-Repetitive Tasks
- High Variability
- Non-Homogenous Flows

LPD1

Lean Manufacturing

Toyota

LPD2

Queueing Theory

Computer OS Design

The Internet

Economics

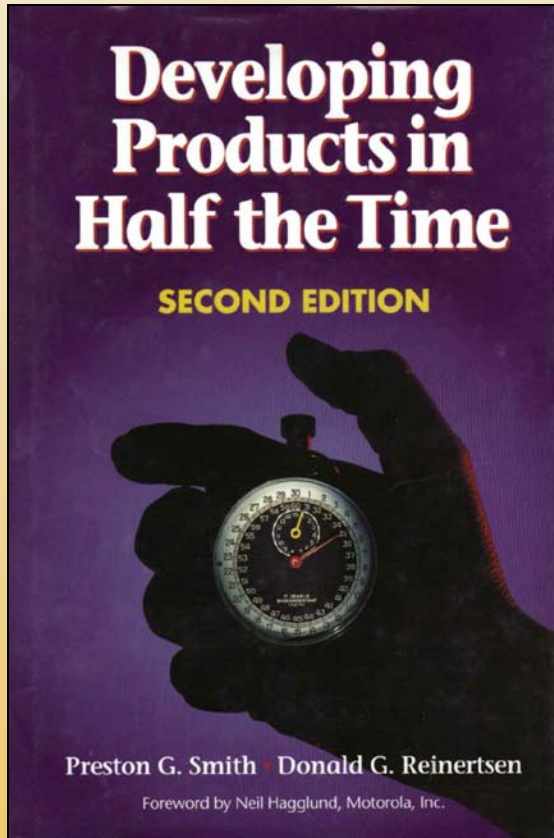
Traffic Flow Theory

Maneuver Warfare

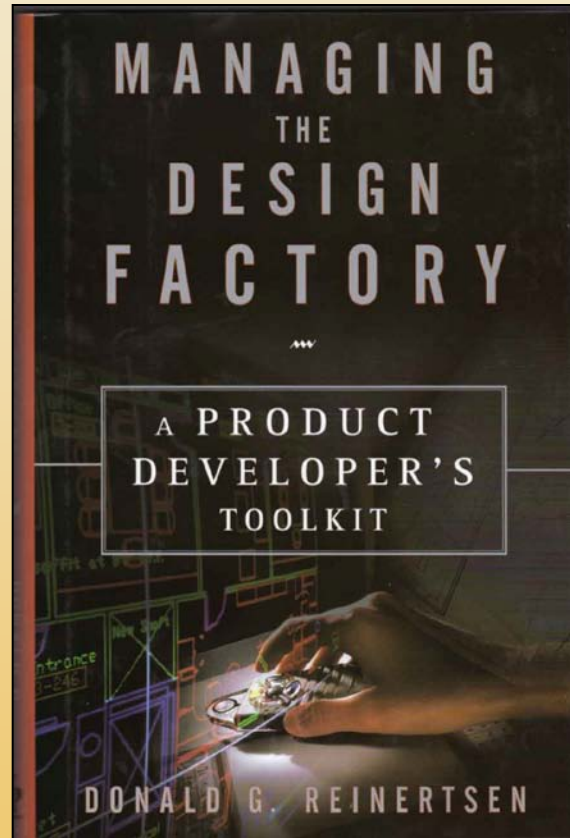
# Some Final Comments

- **Seek isomorphisms with well-understood problems.**
  - **Look broadly in multiple domains.**
  - **Distinguish the instantiation from the principle or pattern.**
  - **Seek to understand and to test mechanisms of action.**
  - **Understand the relation between method and context.**
  - **Focus on synergistic patterns rather than methodologies.**
- **Strive to make your understanding quantitative.**
  - **Seek to quantify input/output relationships.**
  - **Recognize that the most important problems have multiple competing effects which must be measured in the same frame of reference.**
  - **Avoid binary thinking.**

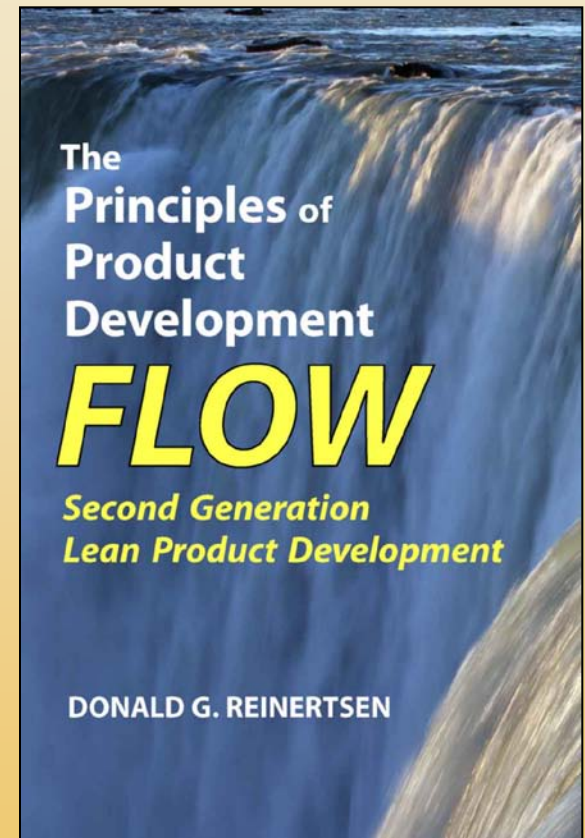
# Going Further



1991 / 1997



1997



2009

