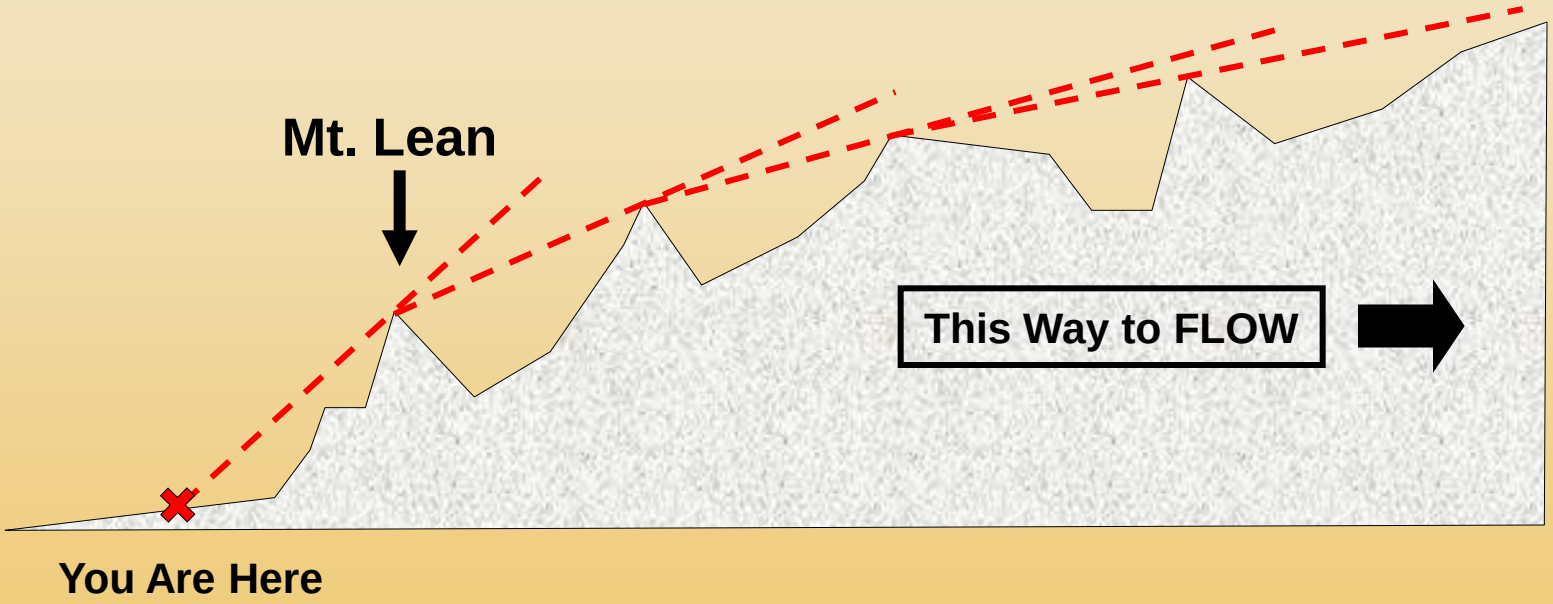
The Easy Road to FLOW Goes through a Town Named LEAN

LSSC Conference
Atlanta, GA
April 16, 2009

Donald G. Reinertsen
Reinertsen & Associates
600 Via Monte D'Oro
Redondo Beach, CA 90277 U.S.A.
(310)-373-5332
Internet: DonReinertsen@gmail.com
www.ReinertsenAssociates.com

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.**

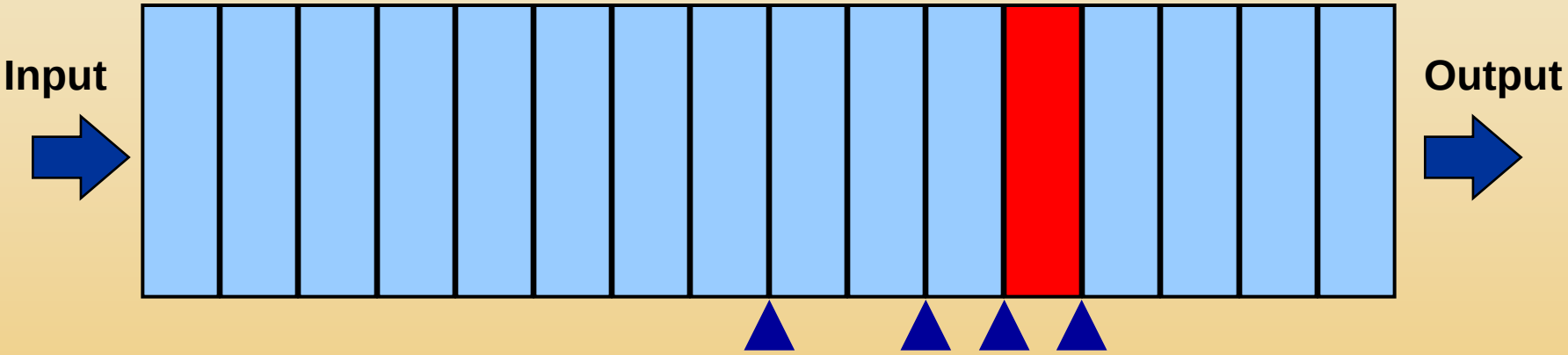
Eliminate Waste

- **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.**

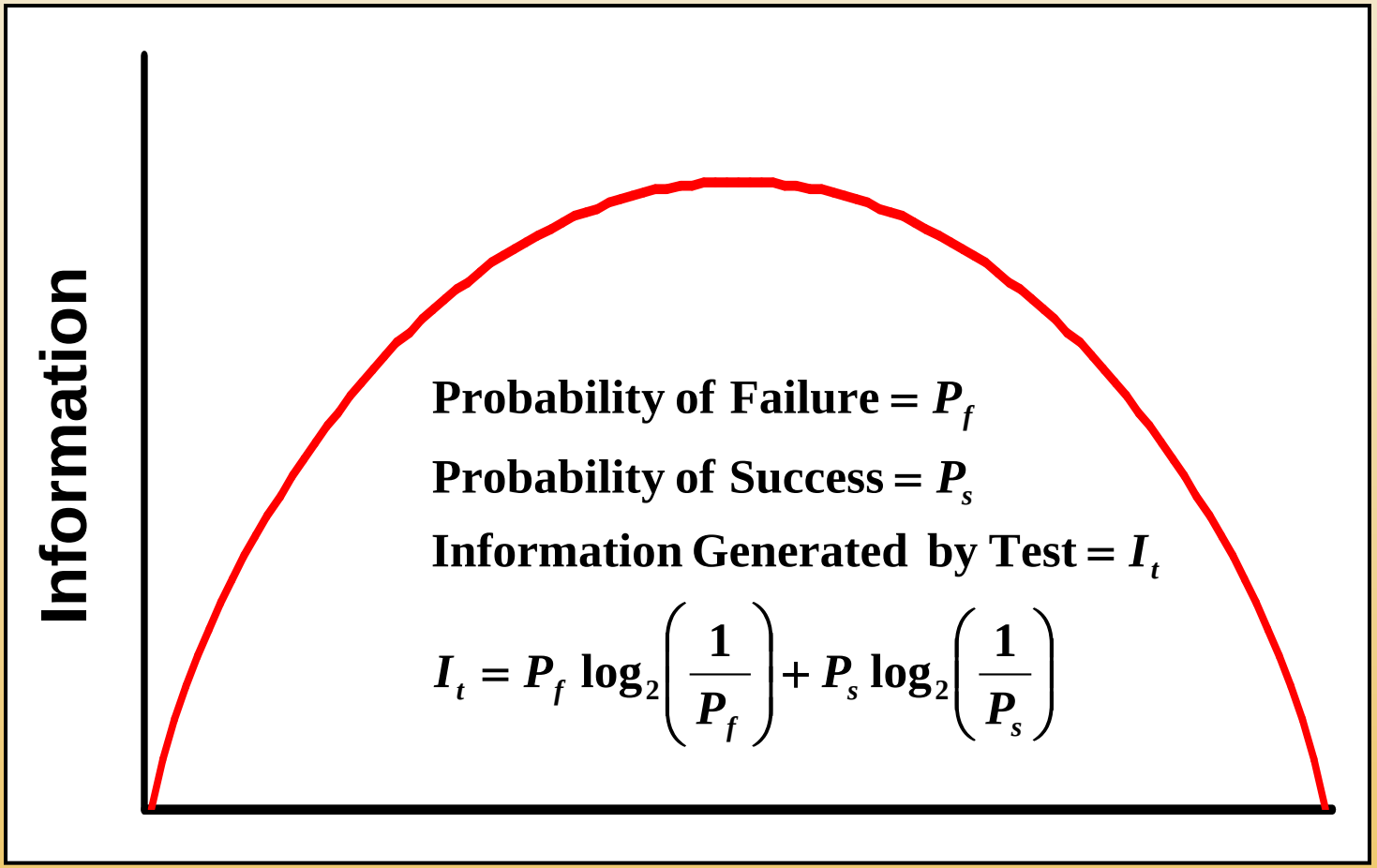
Learning Efficiently



16 Modules with 1 defective

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

Information and Testing



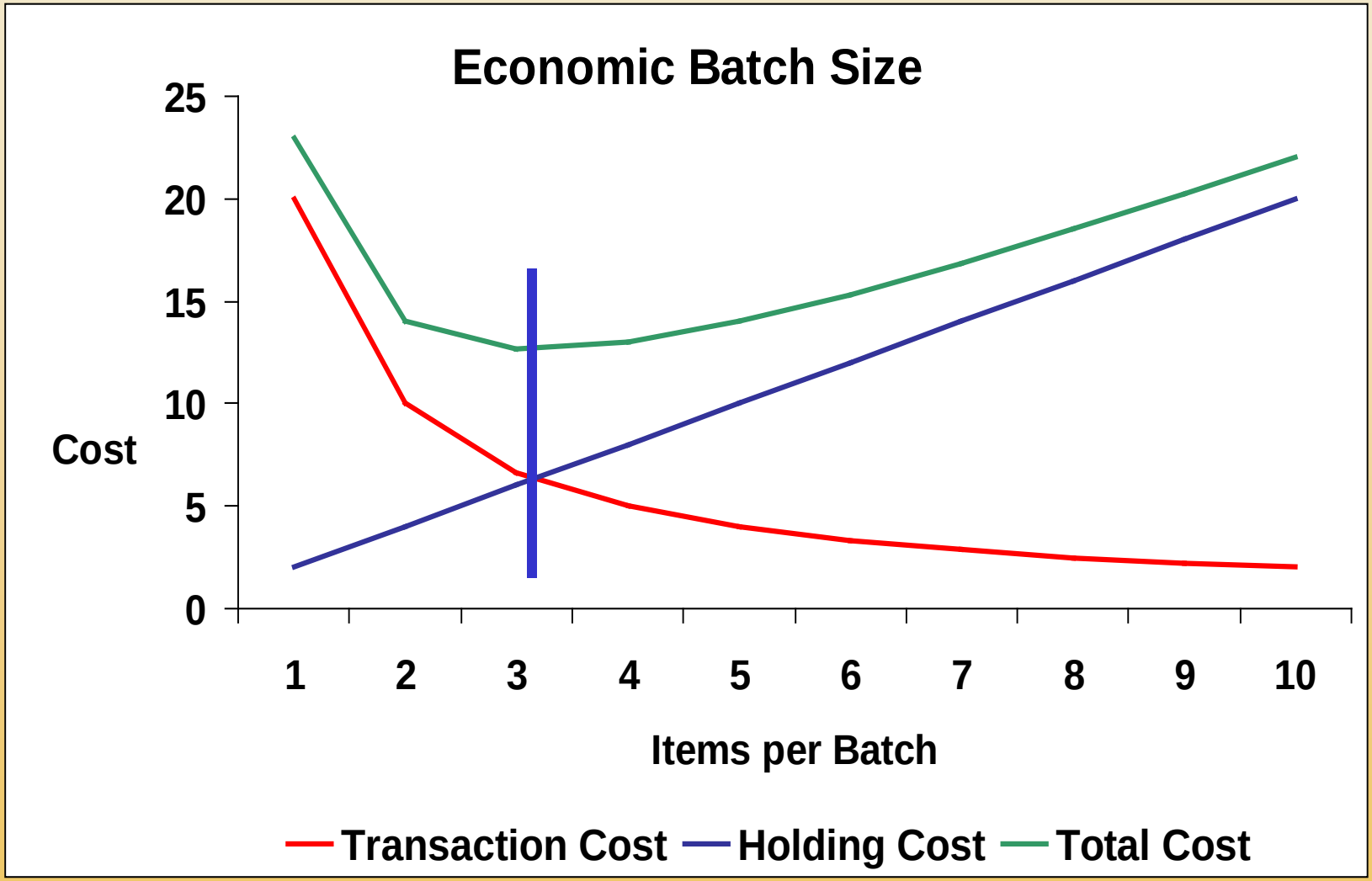
Prevent Defects

- **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

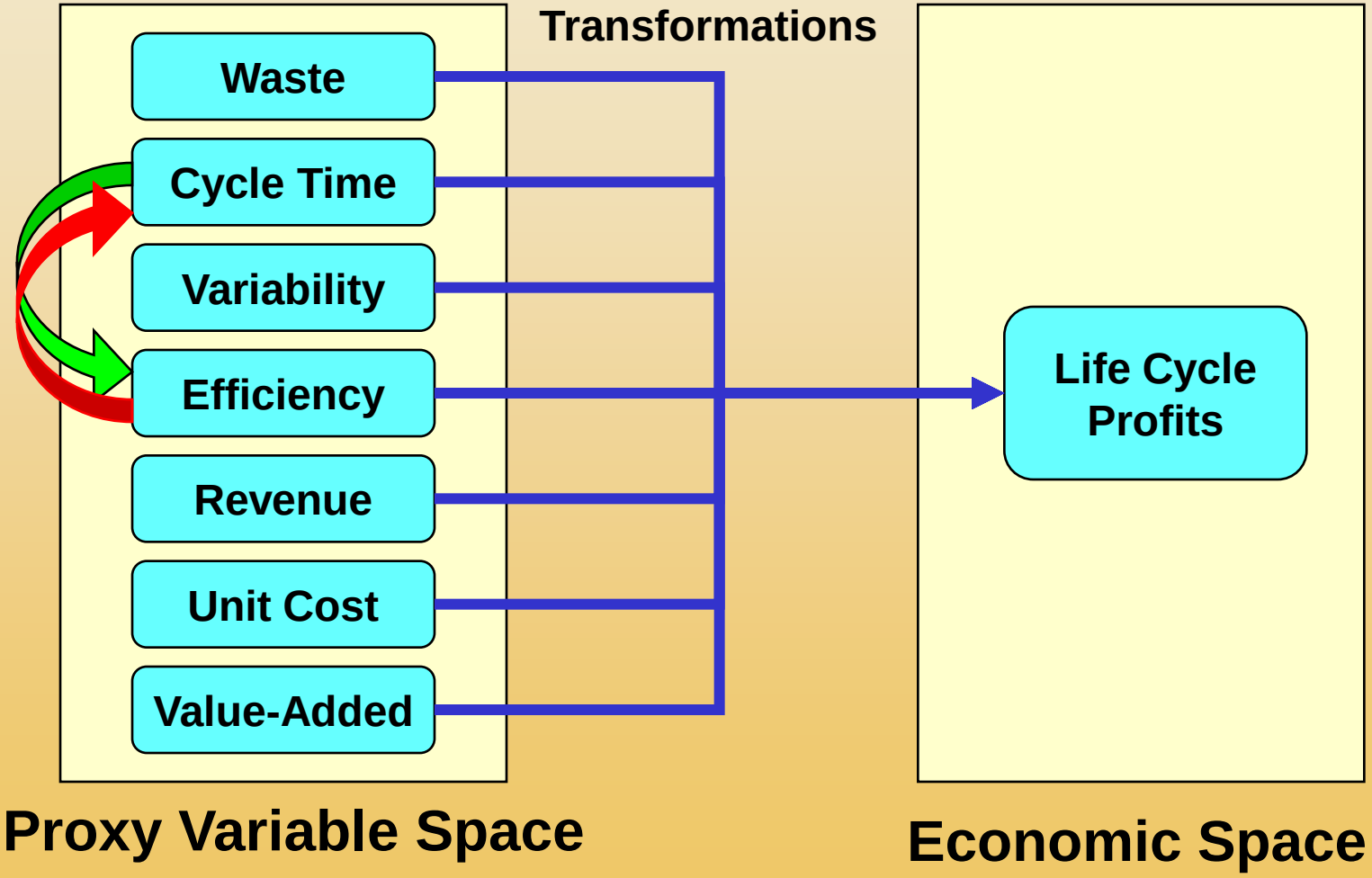
- Delay costs are not homogeneous.
- Task durations are not homogeneous.
- “Shut the Door” WIP control can be expensive.
- A defect on one patient may not predict an identical defect on the next.
  - Stopping the line has a cost for other patients.
- Least-common-denominator routings are almost always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

Where Should We Extend Lean Manufacturing?

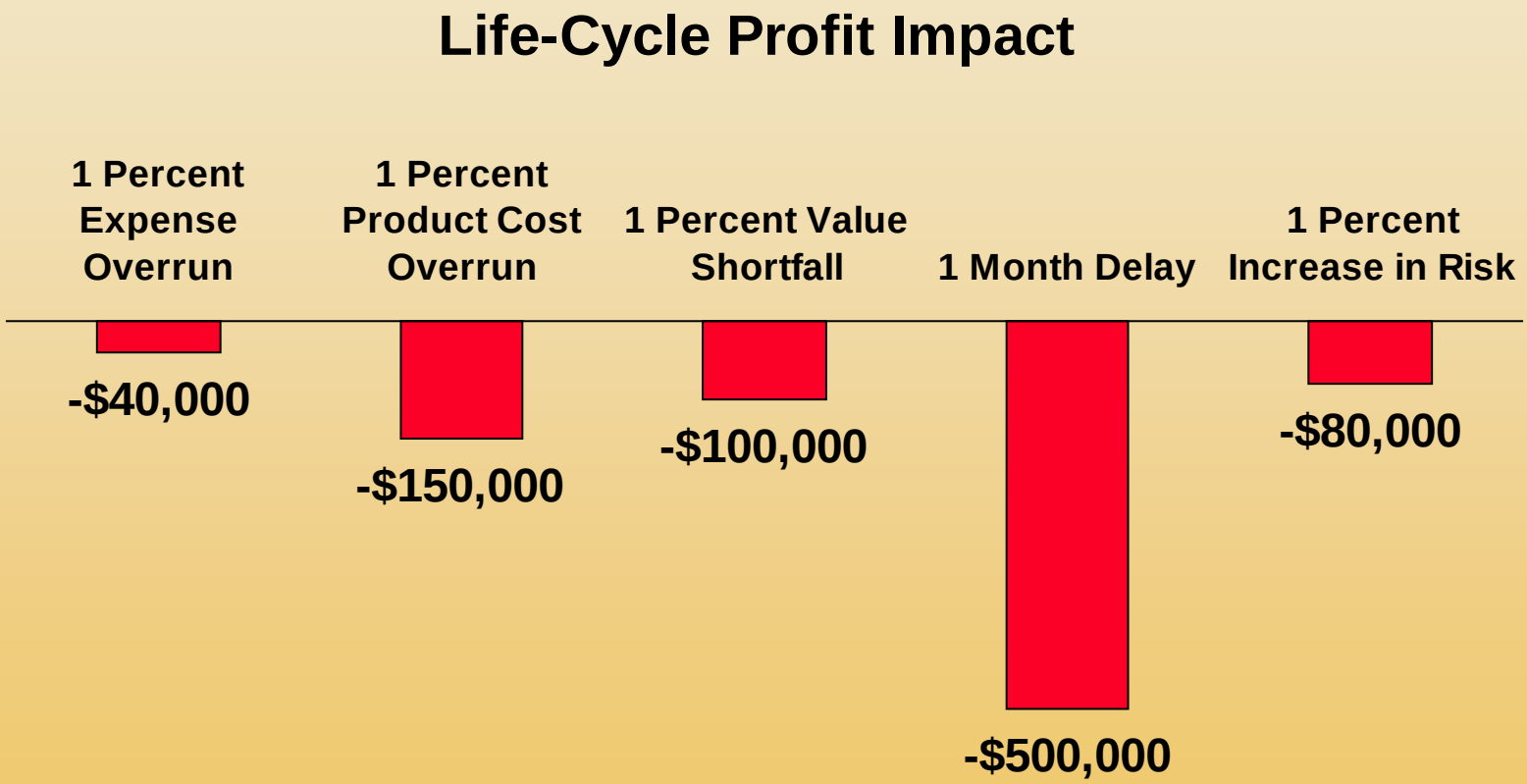
- **Adopt approaches that work for non-homogeneous flows.**
- **Recognize the different role of variability.**
- **Develop protocols for tasks of unpredictable or possibly infinite duration.**
- **Drive decisions with economics.**
- **Recognize different economic leverage points.**

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.

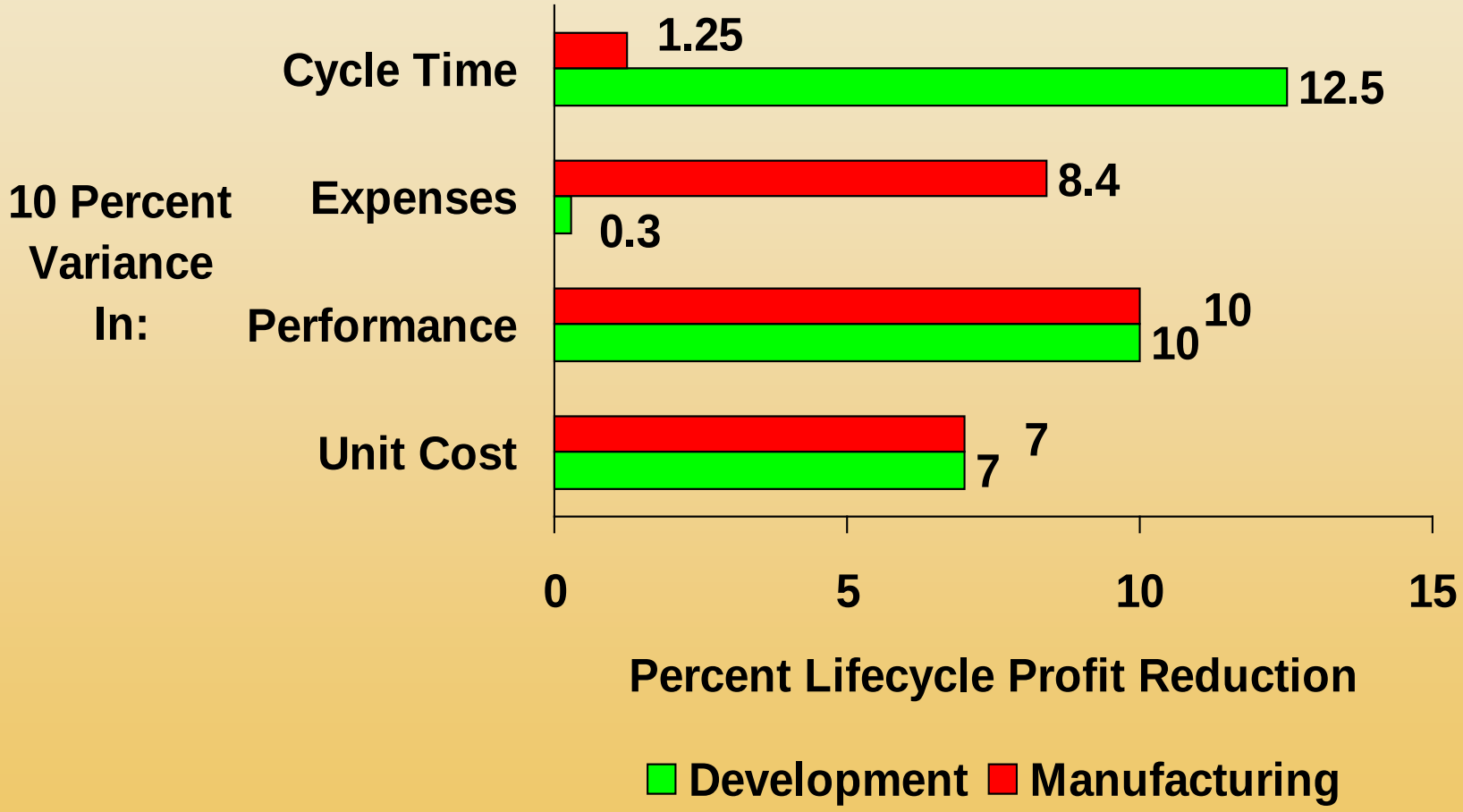
Making Economic Decisions



Understand Sensitivity Factors



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 6σ.**
- **It has scaled by many orders of magnitude without affecting its operation.**
- **New approaches are embraced and quickly, and reversibly, tested.**

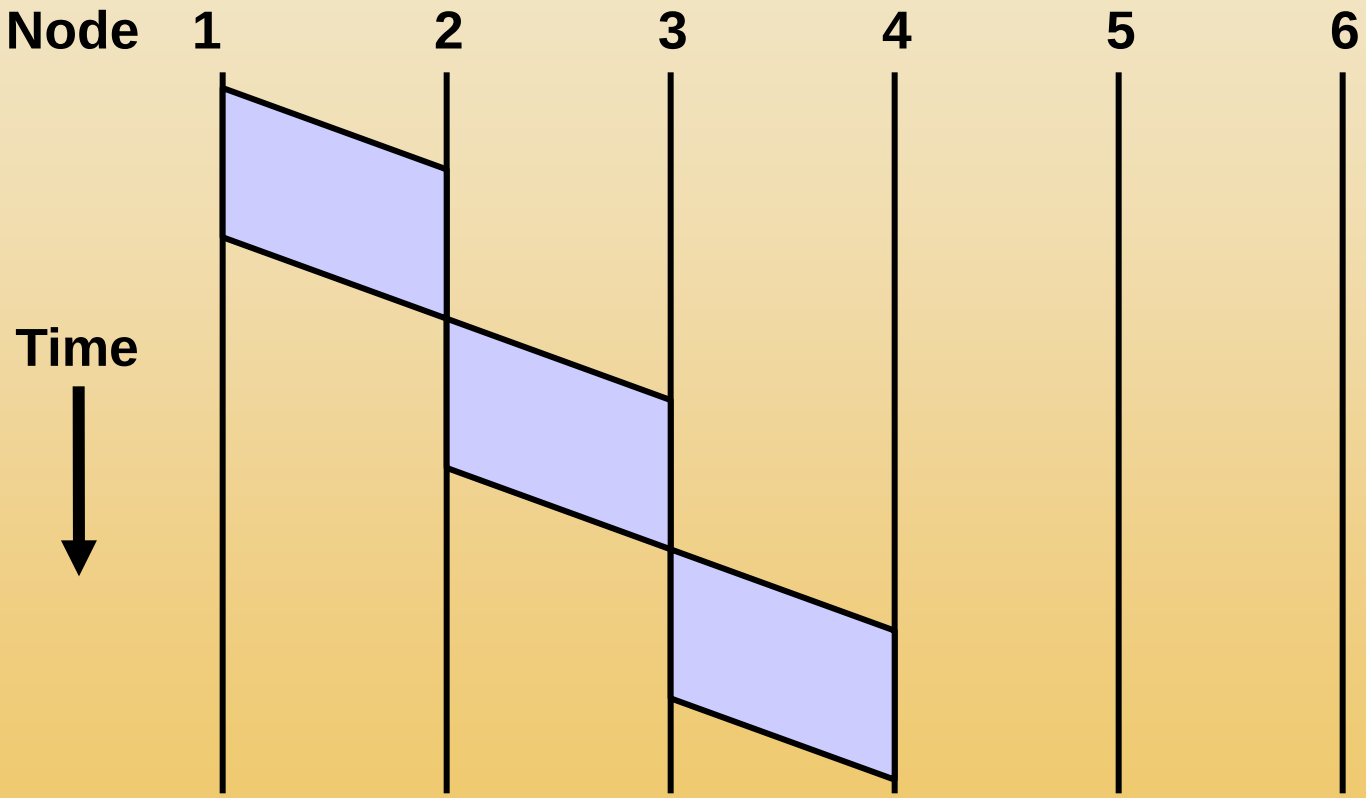
Seven Lessons from the Internet

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.

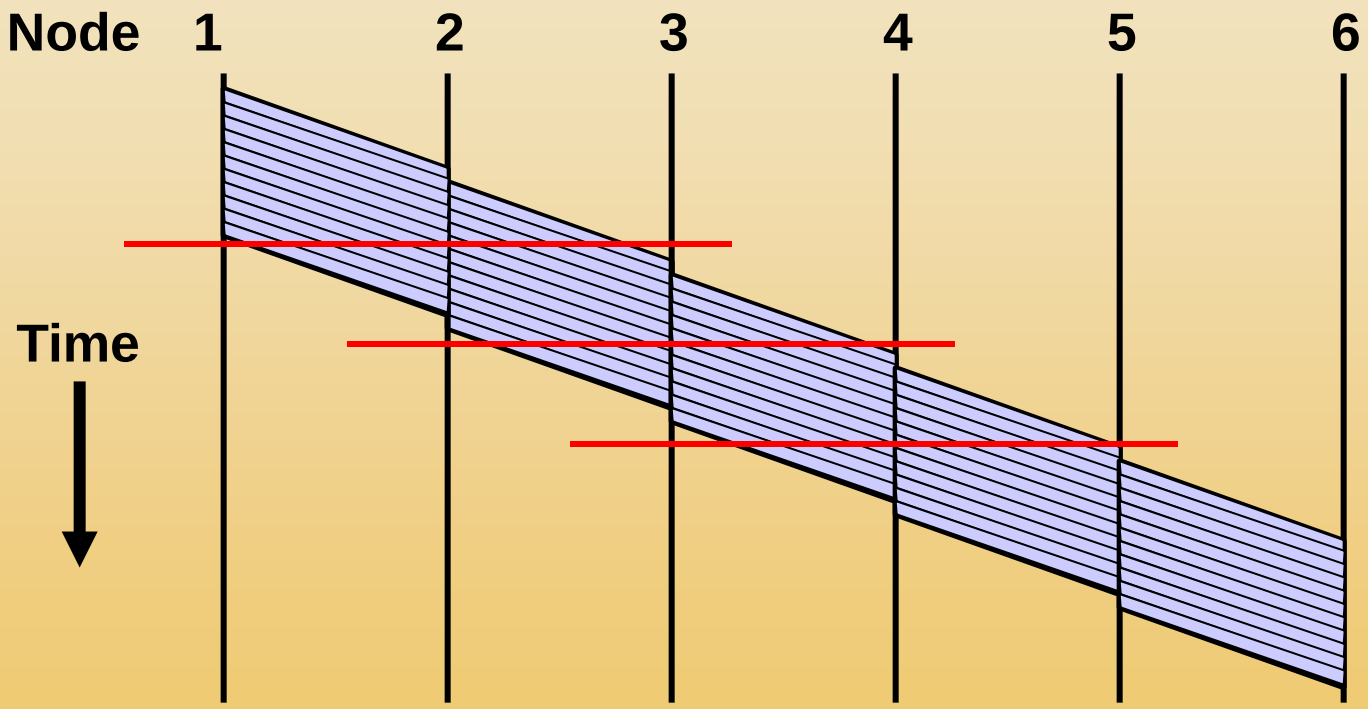
1. Small Batches

- **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.**

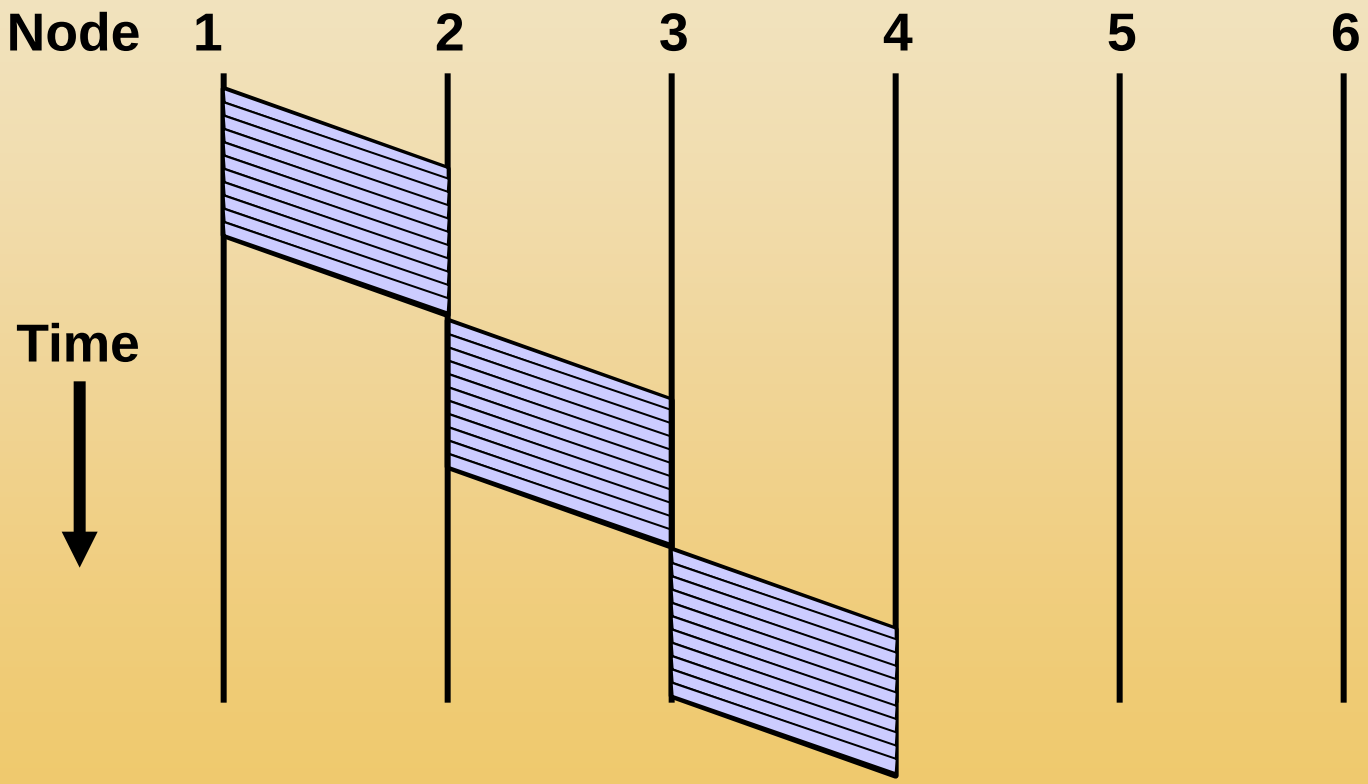
Transmission without Packets



Transmission with Packets



Packets Alone Are Insufficient



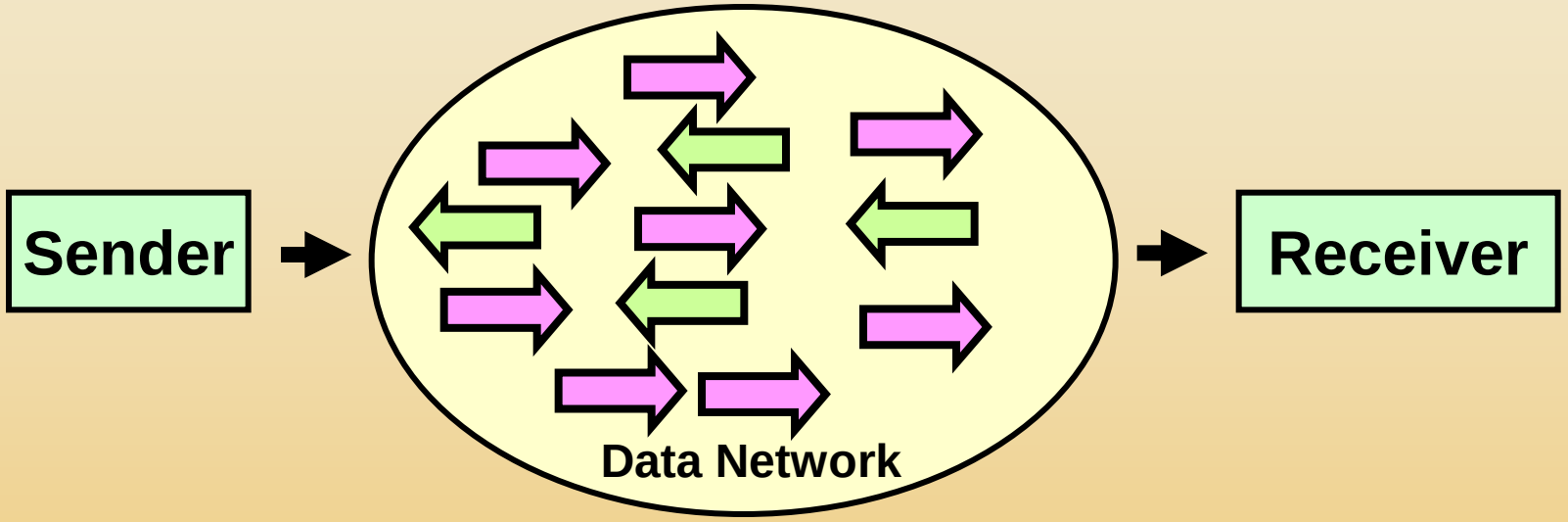
Why Packet Switch?

- 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



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

Packet from Sender

Acknowledgement (ACK) from Receiver

3. Quality by Iteration

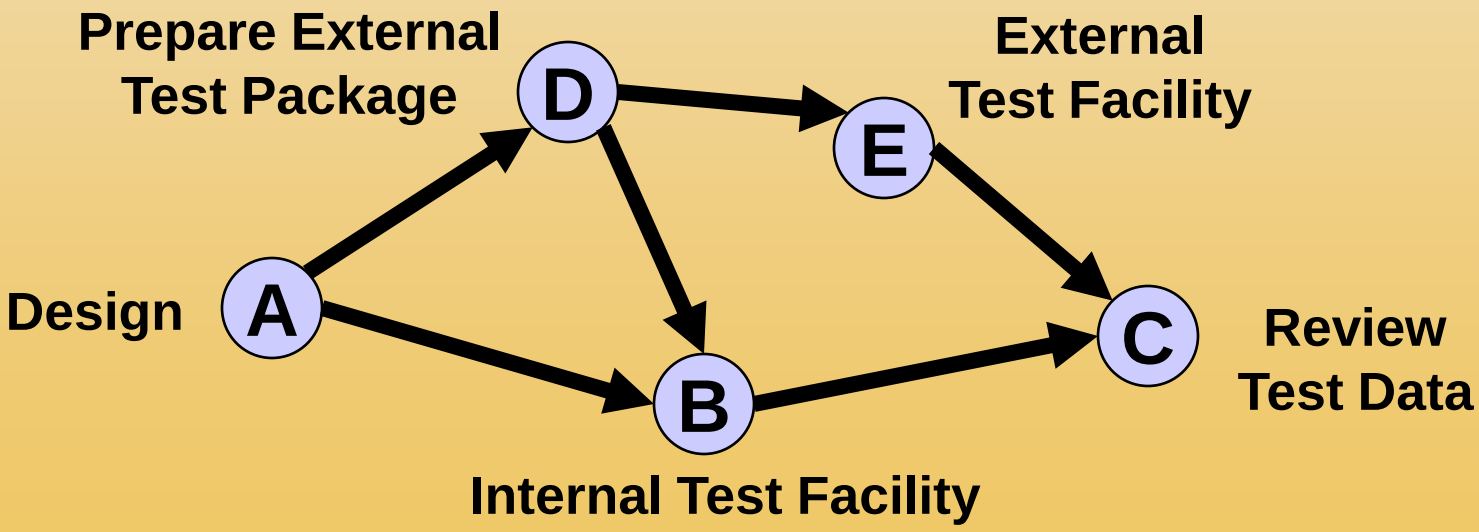
- **The Internet does not guarantee delivery - it is a “best efforts” network.**
- **Although node-to-node communication is reliable, errors will still occur.**
- **The responsibility for achieving quality lies with the sender and receiver, not the network.**
- **This allows messages to be forwarded 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 a 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.**



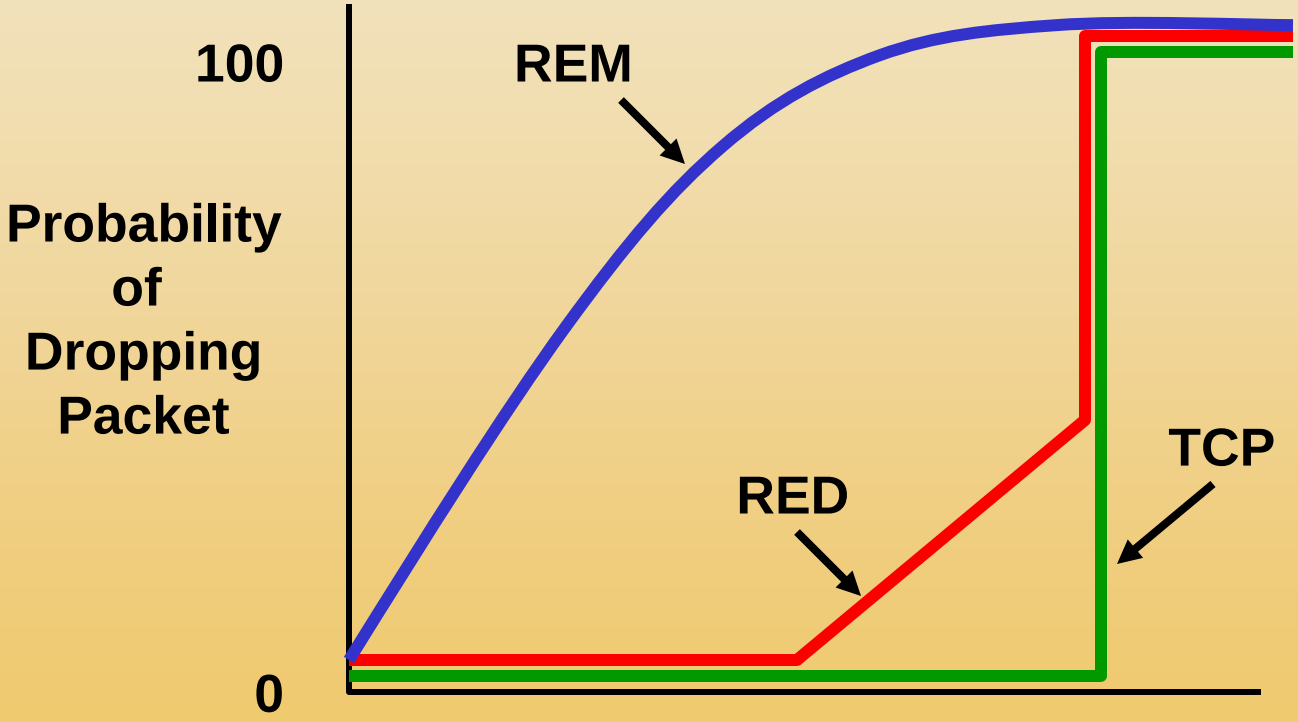
5. Late Binding to Resources

- 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

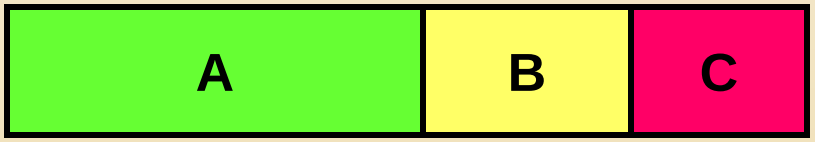


RED = Random Early Detection, REM = Random Early Marking

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



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

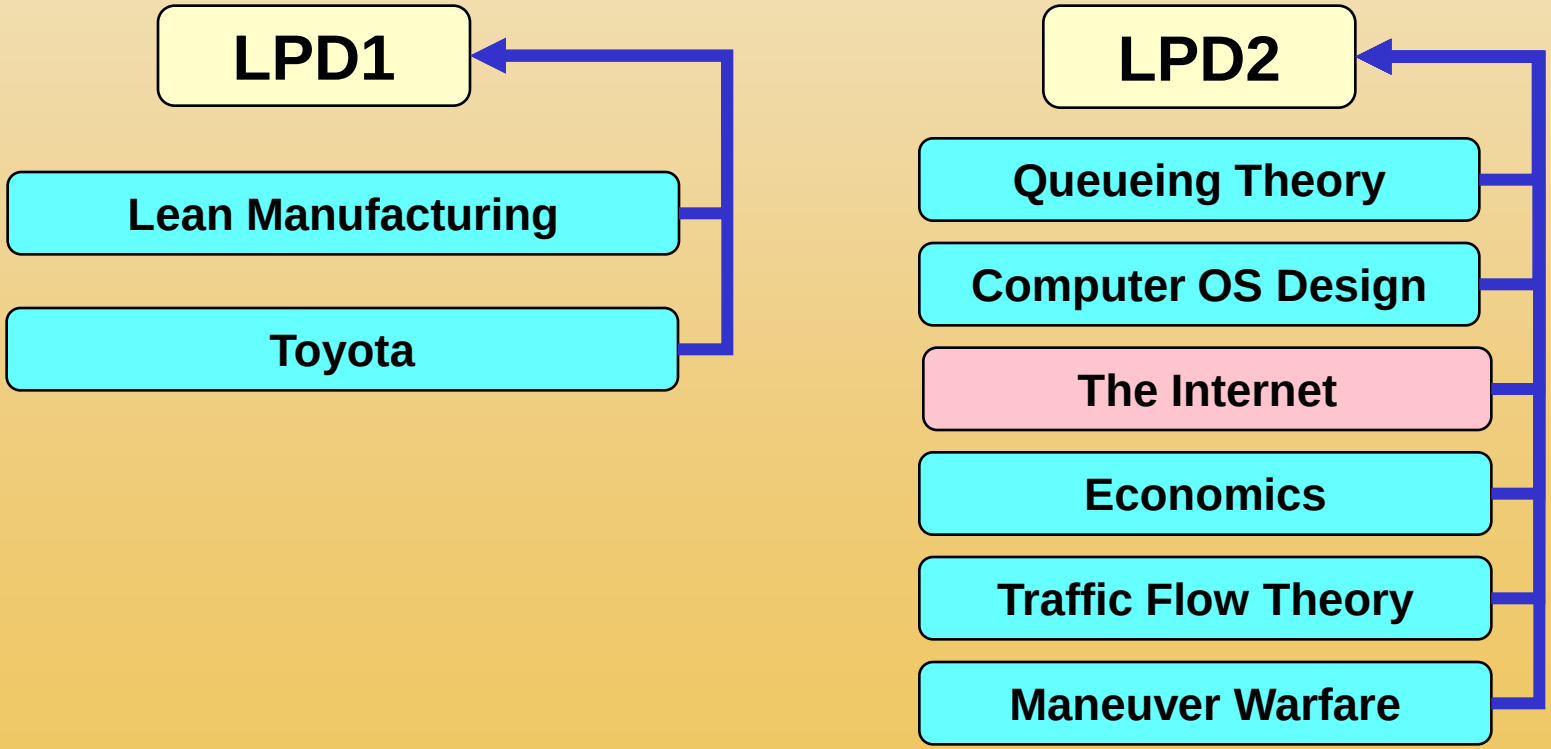
+

Add Concepts from other Domains

DOMAIN

- Repetitive Tasks
- Low Variability
- Homogenous Flows

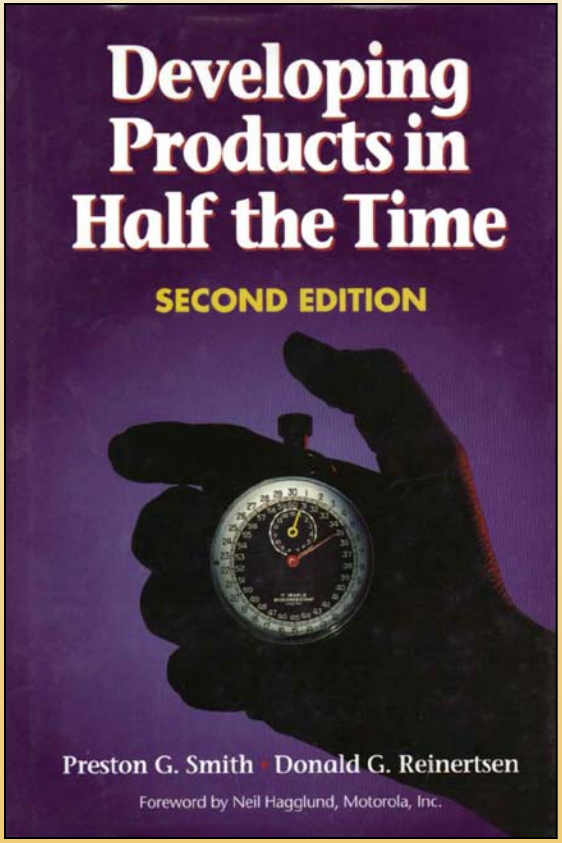
- Non-Repetitive Tasks
- High Variability
- Non-Homogenous Flows



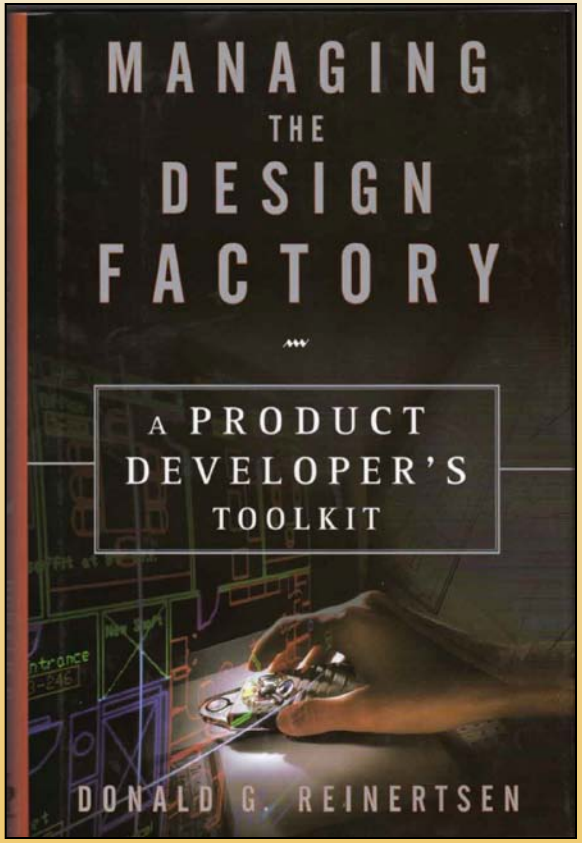
Some Final Comments

- 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.

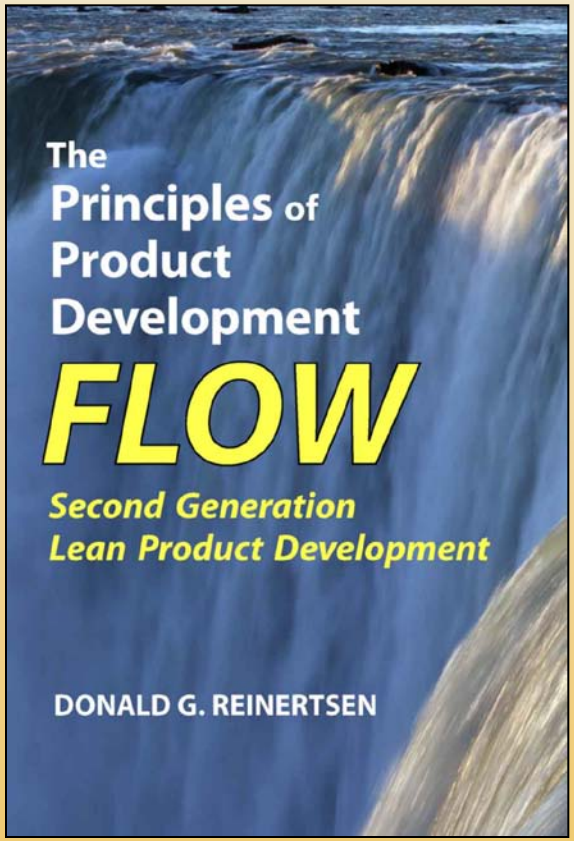
Going Further



1991 / 1997



1997



2009