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Economics of Dependability

- an open issue in the information society -

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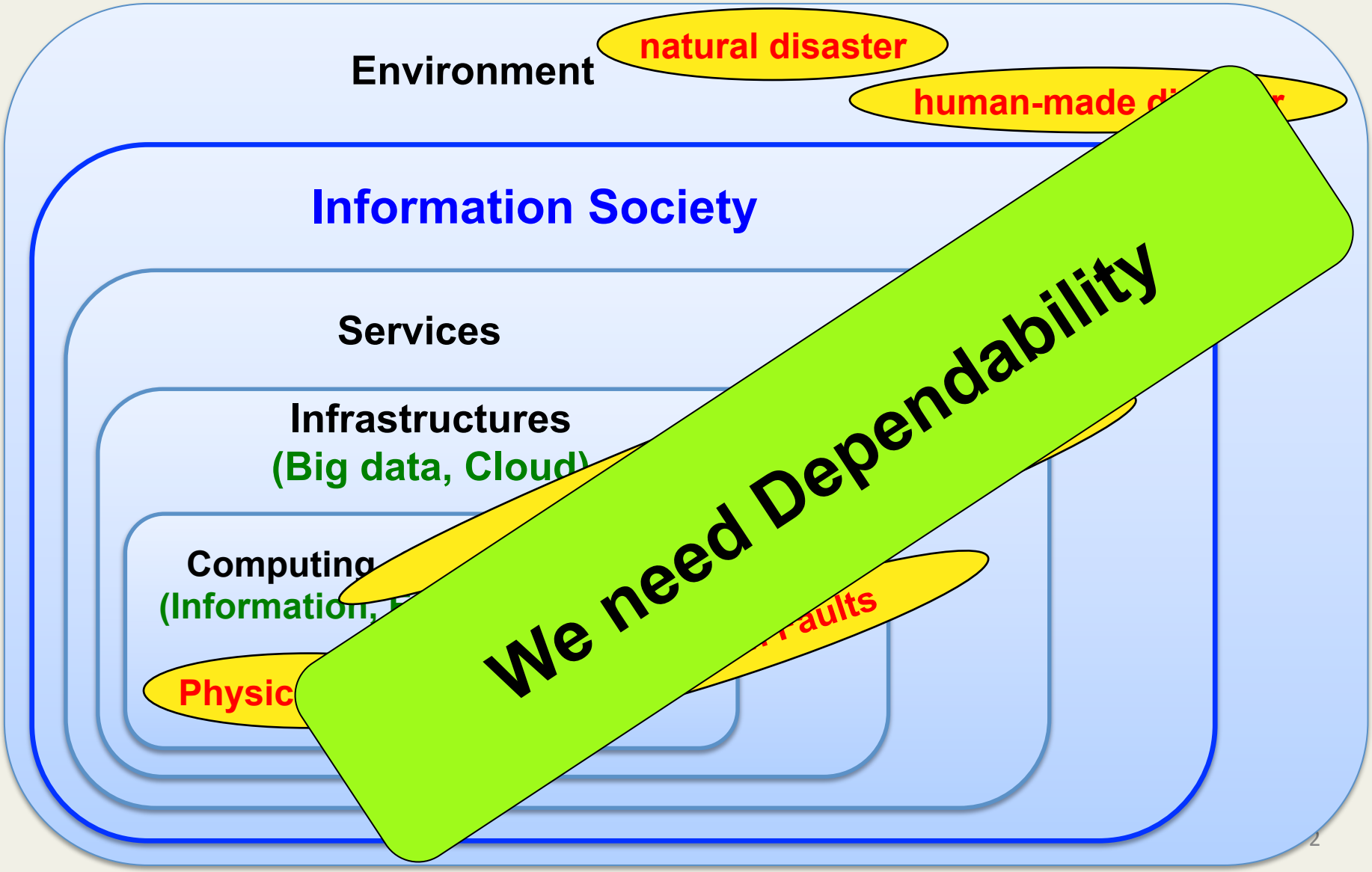
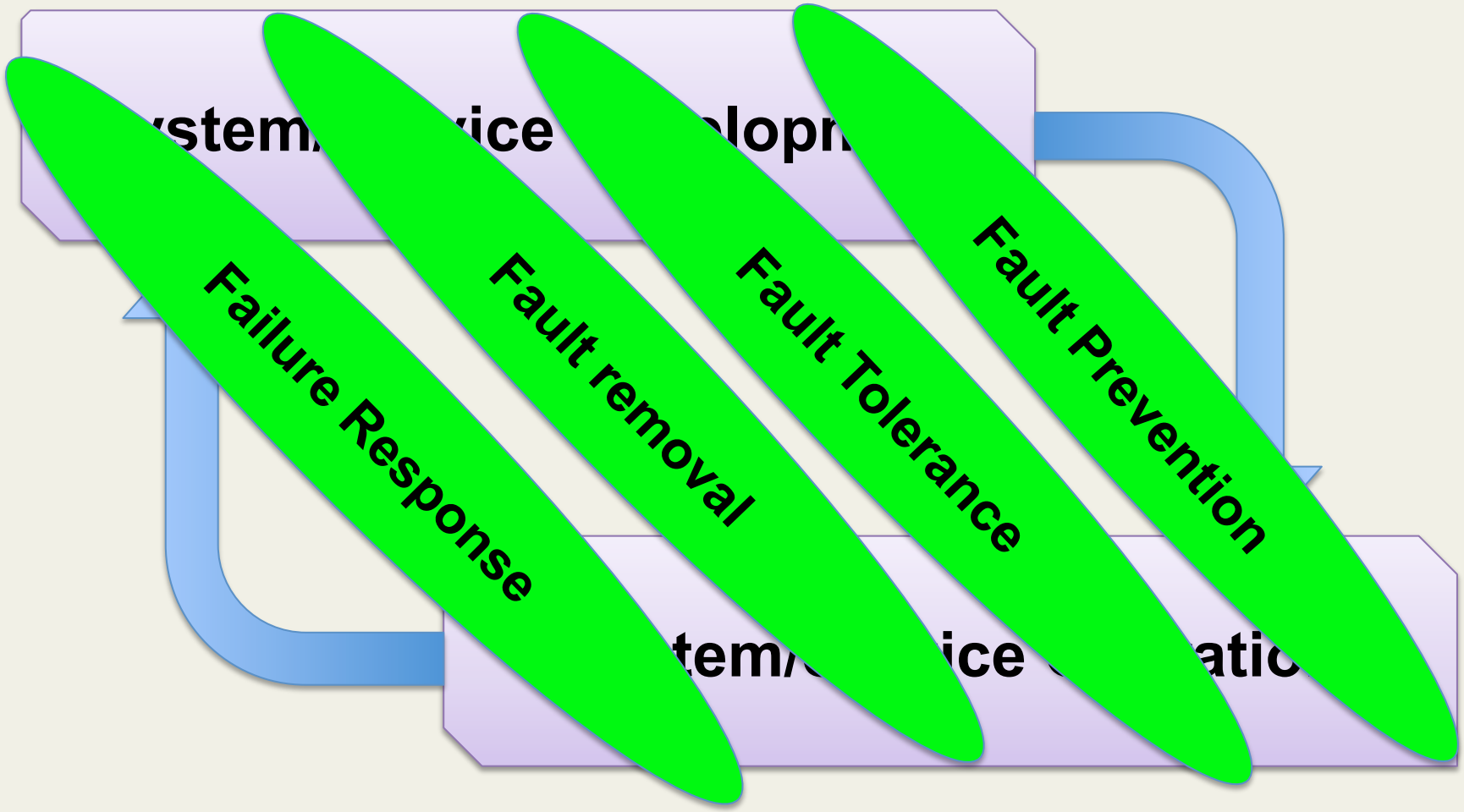
Structure of Information Society



Dependability Efforts



Many methodologies/technologies have been implemented!


Unit 1
Unit 4
We need dependability
How much should we pay for the dependability?
Aerial photo taken on March 20, 2011
by Air Photo Service, Co., Ltd., Japan

Frequently asked questions (1)

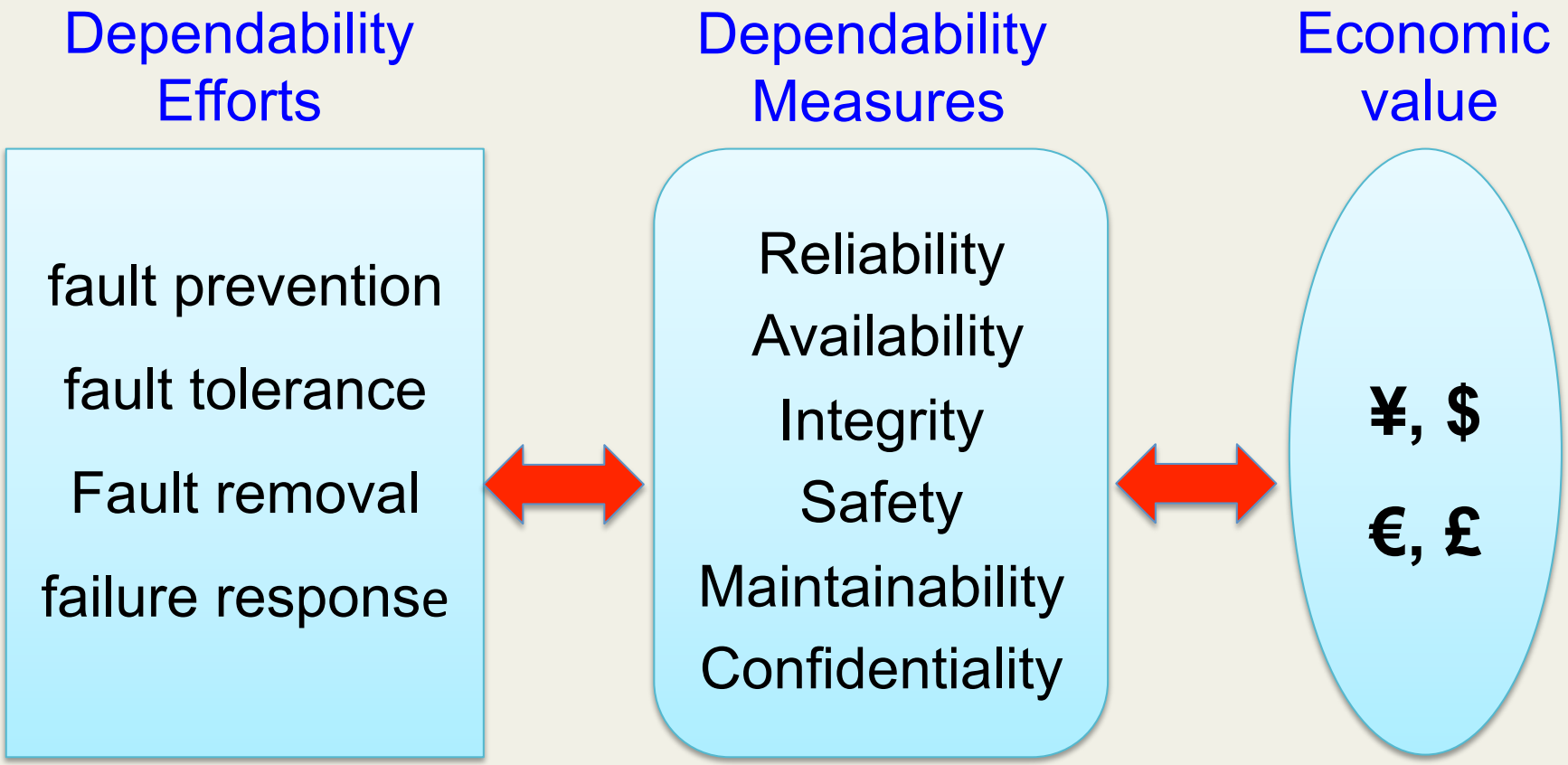
- Customers : “Dependability is my first priority. How can I tell the high dependability from the low in advance? How much more should I pay for it? ”
- We don’t know. No convincing way exists to tell the high from the low in advance, and therefore, no way for pricing.
- CTO/CIOs : “I know we need dependability. How much should we invest in it? and how much return can we get ? ”
- We don’t know. Economics of dependability has not been developed at all, and needs extensive studies.

Frequently asked questions (2)

- Project Managers : “We definitely need dependability. What should we do to achieve high dependability within a given budget and delivery time ?”
- Hard to answer. Dependability engineering is not matured at all, and needs to develop furthermore.
- Engineers : “I know existing dependability methodologies and technologies. What I don’t know is how much higher dependability is achieved by their deployment ”
- Unfortunately, the quantitative effect of dependability efforts on system dependability is not well known or developed.

What we need

Quantifying relations between:



Where we are

- A long history of research on dependability efforts
- Little work on how much effect each effort has on system dependability.
- A long history of research on dependability evaluation
- Little work on mapping of dependability measures to economic value.
- Thus, lack of dependability economics

Value of dependability (1)

- V: Value of service users are willing to pay for
- C_S: Cost of service for providers to deliver
- C_F: Cost of failures that may arise from failures during lifetime

$$C_F = \sum_f \{P(f) \times L(f)\}$$

- P(f) : Probability of failure f L(f): Loss from failure f
- D: Profit on service

$$D = V - (C_S + C_F)$$

Providing service makes sense economically as long as $D \geq 0$

Value of dependability (2)

- Dependability efforts decrease C_F by ΔC_F , but increase C_S by ΔC_S
- Dependability efforts make sense economically as long as
  - $\Delta C_F \geq \Delta C_S$
- Dependability efforts most likely increase V by ΔV, thanks to a good reputation
- ΔD: Economic value of dependability (increment in profit D through dependability efforts)

$$\Delta D = \Delta V - (\Delta C_S + \Delta C_F)$$

Return on Investment

- Return on Investment (ROI) is the actual measure of financial performance
- ROI = (ER - CI) / CI
  - Expected Returns (ER) = Value of Services (V) – Cost of Failures (C_F)
  - Cost of Investment (CI) = Cost of Services (C_S)
- ROI = $\{(V-C_F) – C_S\}/C_S = D/C_S$
- ROI for dependability = $\Delta D / \Delta C_S$

Goal of dependability efforts

- Dependability efforts
  - Fault Prevention, Fault Tolerance, Fault Removal, Failure response
- Maximizing $\Delta D = \Delta V - \{\Delta C_S + \Delta C_F)$
  - ΔD: Increment in profit D on service
  - ΔV: Increment in value V of service
  - ΔC_S: Increment in cost C_S of service
  - ΔC_F: Decrement in cost C_F of failures $C_F = \Sigma \{P(f) \times L(f)\}$

    P(f) : Probability of failure f L(f): Loss from failure f
- *Establish relations among dependability efforts, dependability measures, and economic value for dependability!*

Estimating ΔV, ΔC_S, ΔC_F

- ΔV (Increment in value of service):
  - Open to the public
  - Easy to estimate from past data
- ΔC_S: Increment in cost of service
  - Hardly disclosed
  - Possible to estimate based on existing implementation
- ΔC_F: Decrement in the cost of failures
  - Hardly disclosed
  - Difficult to estimate

What do we begin with?

- Revisiting dependability efforts
- Revisiting dependability measures and evaluation
- Cost analysis for life-time failures
- Modeling for design/operation/interaction faults
- Modeling dependability process

An inconvenient truth

- Most users cannot tell high dependability from low
  - Providers are not rewarded for dependability efforts
  - Even the providers don’t know how dependable
  - Users have no reason to pay more for dependability
  - Thus, providers are disinclined to invest in it

Market for “lemons”?

George A. Akerlof, “The Market for “Lemons”: Quality Uncertainty and the Market Mechanism”, The Quarterly Journal of Economics (Aug. 1970)

- Lemons: a euphemism for a low-quality car
- Plums: a euphemism for a high-quality car
- When dependability is indistinguishable by buyers, sellers will lower dependability.
- Buyers will suspect sellers to make light of dependability, and they lower their willingness to pay.
- Then, prices will go down.

Market for “lemons”?

- In turn, sellers will be compelled to lower dependability even further to make profits at the lower prices.
- Thus, dependability will decline until nothing but the lowest dependability (lemons) are left in the market.
- The market fails.
- Sellers cannot sell high dependability (plums) at high prices even though buyers would be willing to pay the high prices for plums

Summary

We need quantitative mappings between: