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Economics of Dependability
- Research Proposal -

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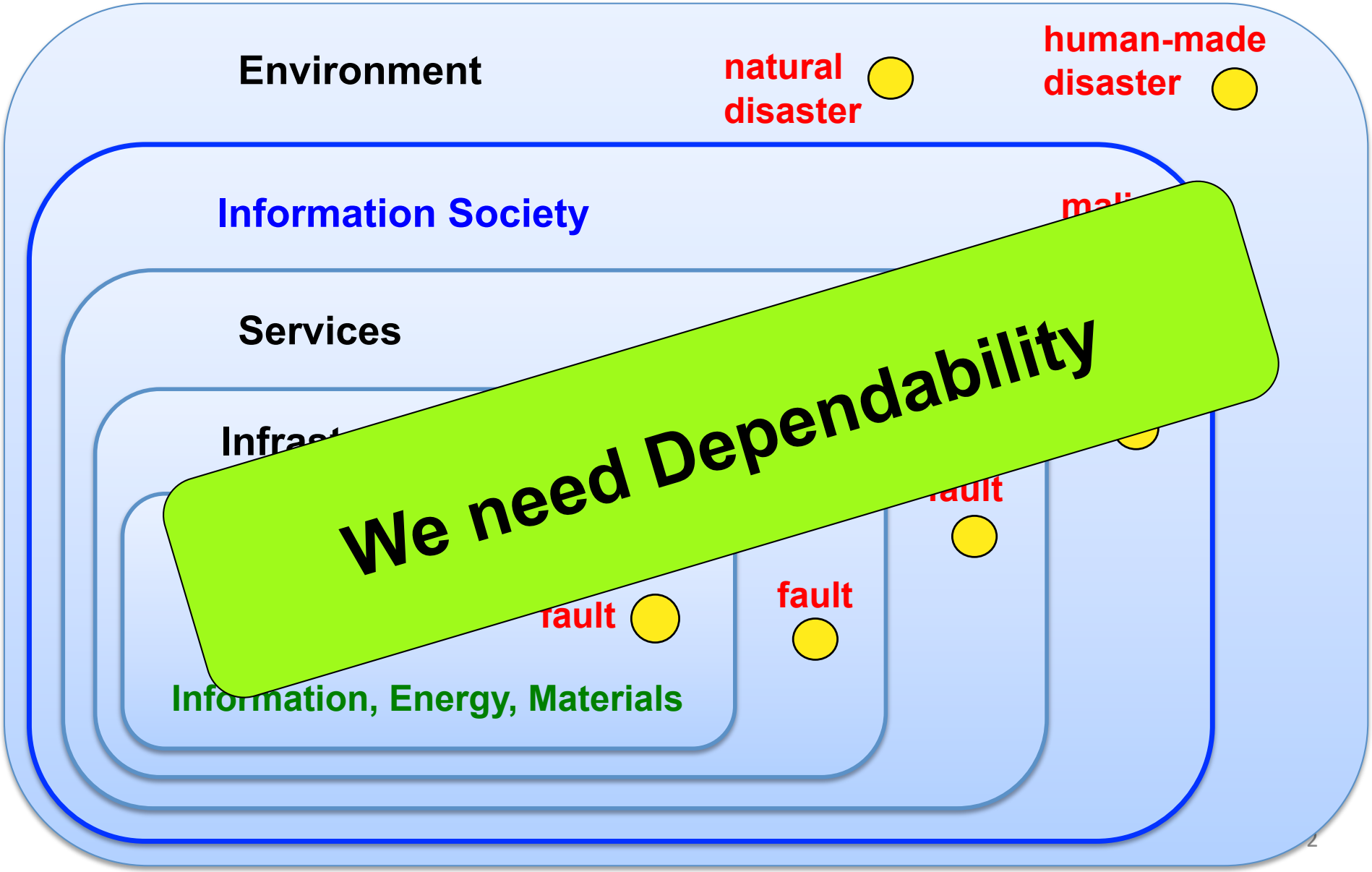
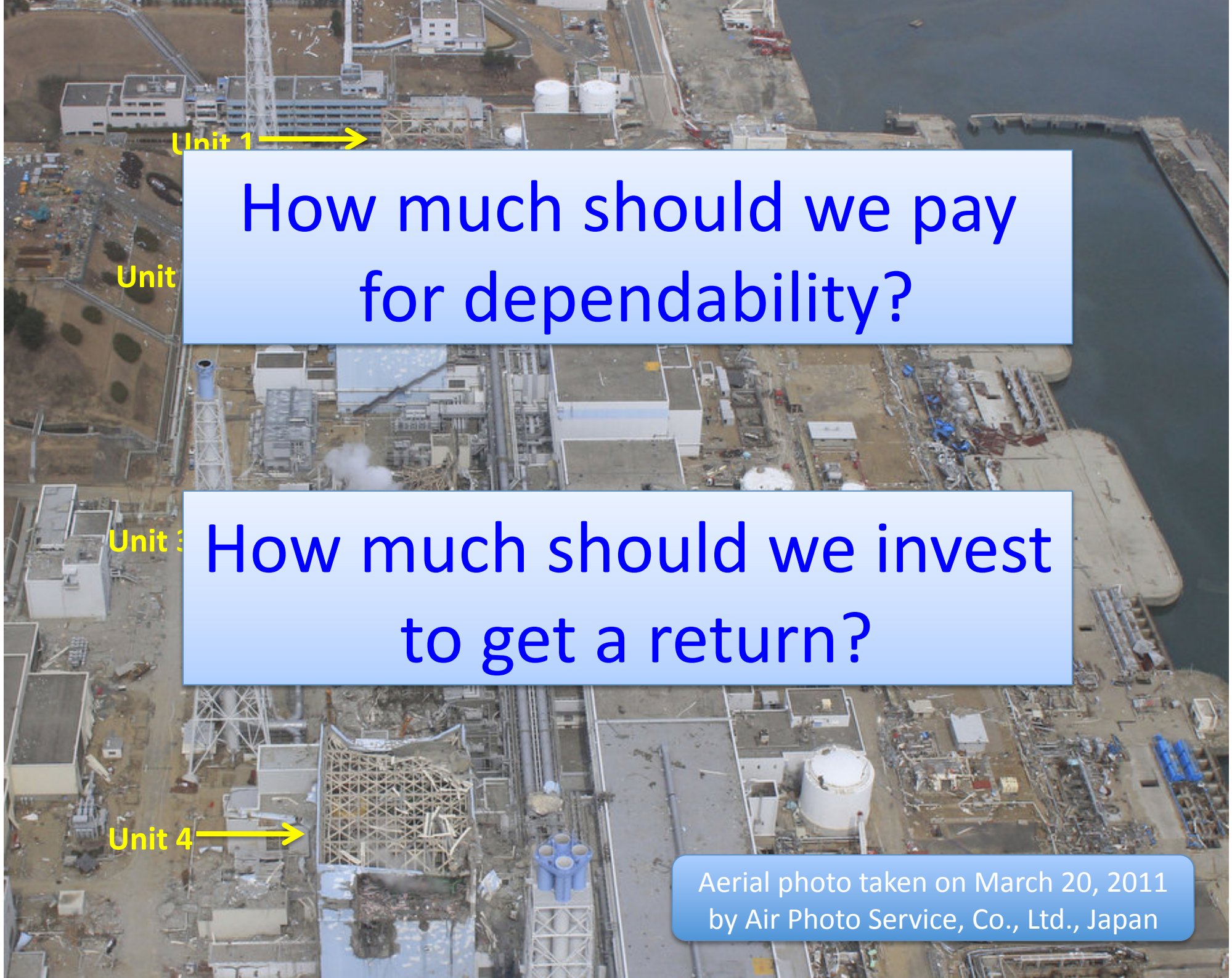
Information Society




Unit 1
Unit
Unit 3
Unit 4
How much should we pay for dependability?
How much should we invest to get a return?
Aerial photo taken on March 20, 2011
by Air Photo Service, Co., Ltd., Japan

Frequently asked questions

- By CTO/CIOs : “I know we need dependability. How much should we invest in it? and how much return can we get ? ”
- By PMs : “We need dependability. What dependability efforts should we exert to make our system dependable within a given cost and delivery time ?”
- By engineers : “I know existing dependability technologies. What I don’t know is how much more dependability is attained by their deployment from user’s point of view. ”
- By customers : “I eager for dependability. How can I know beforehand this service is more dependable than that ? How much more should I pay for this presumable enhancement ? ”

Observations

- It is not known how much better dependability measures are attained by the deployment of known efforts for dependability within a given cost and delivery time
- Further, it is not known how much more economic value is added by enhancement in dependability measures.
- Then, it is not known how much we should invest in service dependability to get an economic return that make sense.
- As a result, users don't know which service gives more dependability benefit than others, how much more, and how much they should pay on it.

What we need

- Relationship between dependability efforts (fault prevention/ removal, fault tolerance, failure response) and dependability measures (reliability, availability, integrity, etc…)
- Relationship between dependability measures and economic value ($, €, ¥, …)
- Relationship between lower-level dependability efforts and economic value in information society from public point of view

Motives

- While research on dependability evaluation has a long history, it lacks a mapping of evaluation results to economic value which is essential to the dependability practice in industry and society

- As we have many global problems concerning dependability of information society, the DSN community should expand to explicitly address not only “dependable computing” but also “dependable information society”

- Then, we should be challenged to address economics of dependability from socio-technological point of view

Value of dependability (1)

- V: Value of service users are willing to pay for at market
- C: Cost of service to deliver dependable service
- E: Cost of failures that may arise from failures during lifetime

$$E = \sum_{f} \{P(f) \times L(f)\}$$

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

$$D = V - (C + E)$$

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

Value of dependability (2)

- Dependability efforts decrease E by ΔE , but increase C by ΔC

  where *ΔC is an incremental cost for dependability*

- Dependability efforts make sense economically as long as

  – $\Delta E \geq \Delta C$

  that is, the decrement in the cost of failures should not be less than the incremental cost for dependability

- 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)

  $\Delta D = \Delta V - (\Delta C + \Delta E)$

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 (E)
  - Cost of Investment (CI) = Cost of Services (C)
- ROI = {(V-E) – C}/C = D/C = Profit / Cost
- ROI for dependability = ΔD / ΔC

Goal of dependability efforts

- Dependability efforts
  - Fault Prevention, Fault Tolerance, Fault Removal, Failure response
- Maximizing $\Delta D = \Delta V - \{\Delta C + \Delta E\}$
  - ΔD: Increment in profit D from service
  - ΔV: Increment in value V of service
  - ΔC: Increment in cost C of dependable service
  - ΔE: Decrement in cost E of failures $E = \sum \{P(f) \times L(f)\}$

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

Dependability insurance

- Insurance is a means of recovering the financial losses of policyholders after the occurrence of service failures, based on the failure rate and the loss amount.
- For a large contemporary system with interactive complexity and tight coupling, quantifying the failure rate and loss amount is challenging for some reasons:
  - Risks of failures are closely coupled and interdependent of each other
  - Efforts for an entity may be undermined by failures elsewhere
  - Historical information may not be accurate for new technologies
  - Mechanisms of interaction faults and design faults are unknown
- The dependability-insurance markets look underdeveloped, or even don't exist.

Revisiting known for looking ahead

- Dependability process modeling
- Validation and verification of dependability efforts
- Dependability measurement and evaluation
- Failure analysis
- Fault modeling, especially, for design/operation/interaction faults
- Benefit/cost analysis

Some economical insights

The insights on the following slides were inspired in part by R. Anderson & T. Moore "Information security economics - and beyond", CRYPTO '07, pp. 68-91 (2007)

- Since most users cannot tell high dependability from low, developers are not compensated for efforts to enhance it.

- Even the developers don't know how dependable their services are. So users have no reason to pay more for dependability, and developers are disinclined to invest in it.

Externalities

- Dependability creates many externalities, i.e. side-effects of economic transactions that may have positive or negative effects on third parties.
- Network vulnerability shows a negative externality like air pollution, someone who connects an insecure PC to the Internet does not face the full economic costs of that.
- An individual taking protective measures for dependability creates positive externalities for others that in turn may discourage them from investment.
- As a network effect, benefit of deploying dependability technology may depend on the number of users who adopt it. The cost may exceed the benefit until a minimum number adopts. Therefore everyone might wait for others to go first, and the technology never gets deployed.

Free riding

- Dependability often depends on the effort of many individuals. How much effort each individual exerts depends on his own benefits and costs, and the efforts exerted by the other individuals
- In the total-effort case where dependability depends on the sum of the efforts exerted by the individuals, dependability is determined by the individual with the highest benefit-cost ratio. All other individuals free ride on this individual.
- In the weakest-link case where dependability depends on the minimum effort, dependability is determined by the individual with the lowest benefit-cost ratio.
- Then, as more individuals are added, systems become more dependable in the total-effort case, but less dependable in the weakest-link case.

Large project failures

- Large software project failures can cost billions and threaten the survival of organizations.
- Perhaps 30% of large development projects fail, and this figure seems impervious to technological progress: better tools help engineers make larger systems, the same proportion of which still fail as before.
- This suggests that project failure is not technical but down to socio-economic factors such as the way decisions are taken in firms.
- Large software project failures are mostly due to overambitious, vague or changing specifications, coupled with poor communications and an inability to acknowledge the signs of failure early enough to take corrective action.

Dependability markets

- The attitude of “ship it Tuesday and get it right by version 3” is perfectly rational behavior at market.
- Many software markets have dominant firms thanks to the combination of high fixed and low marginal costs, network externalities and client lock-in, so winning market races is all-important.
- In such races, competitors must appeal to complementers, such as application developers, for whom dependability gets in the way; and dependability tends to be a “market for lemons” anyway.

Conclusions: Research proposal

- For the dependability practice to be promoted in industry and society, establish
  - relationships between dependability efforts and dependability measures
  - relationships between dependability measures and economic value for dependability
  - dependability measures for higher-level services in information society
  - relationships between lower-level efforts and higher-level economic value for dependability