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Availability

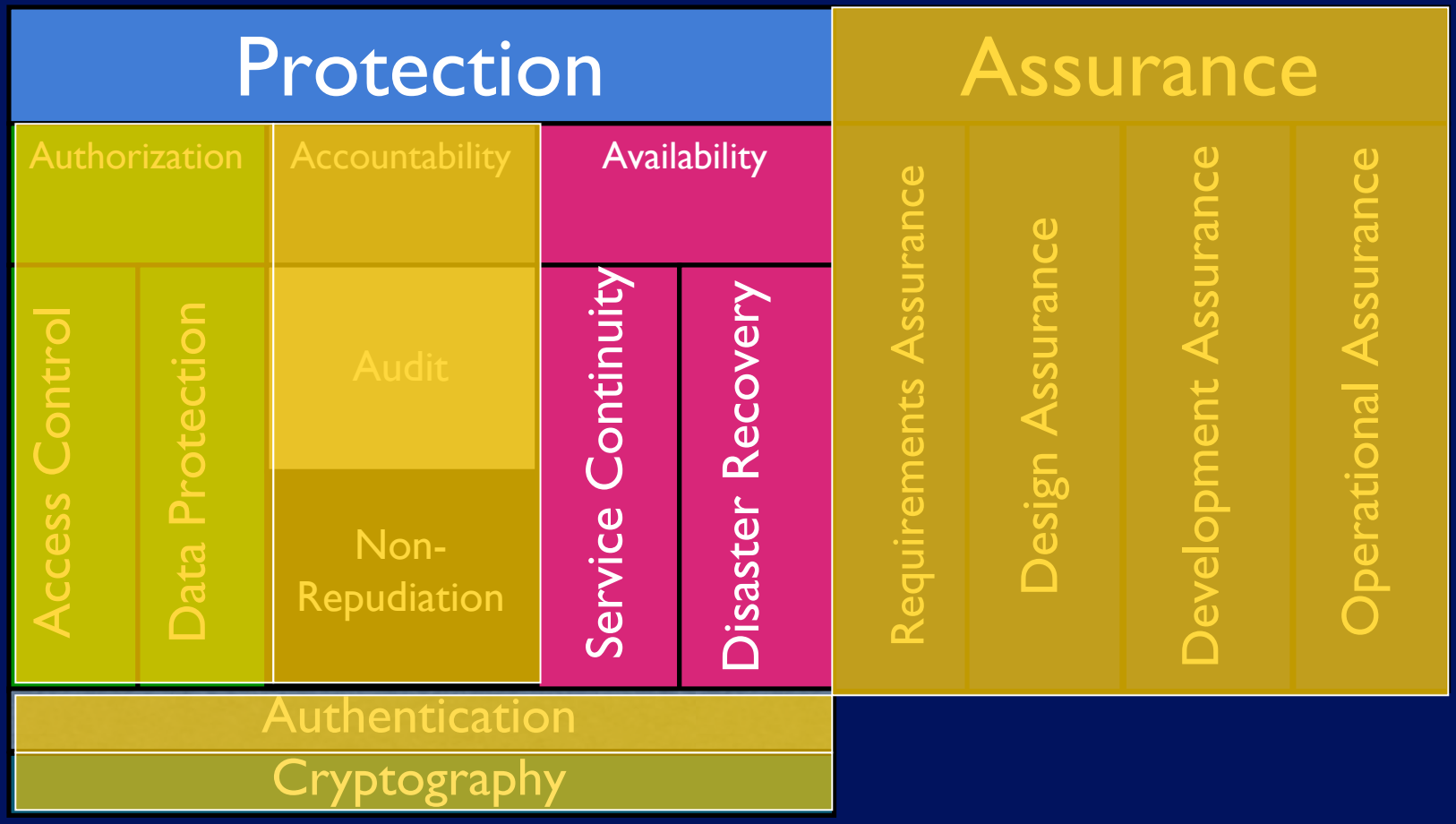
EECE 412

Session 18

Last Session Recap

- Types of malicious logic
- Theory of detecting malware
- Protection and detection techniques

Where We Are


Protection
Assurance
Authorization
Accountability
Availability
Access Control
Data Protection
Audit
Non-Repudiation
Service Continuity
Disaster Recovery
Requirements Assurance
Design Assurance
Development Assurance
Operational Assurance
Authentication
Cryptography

Outline

- Availability in the presence of failures
  - FT terminology
  - k fault tolerance
  - two army problem
  - Byzantine Generals problem
  - Services continuity and disaster recovery
- Availability in the presence of attacks
  - Failures vs. attacks
  - Random vs. scale-free networks
  - Internet tolerance to attacks and failures
  - Services continuity and disaster recovery

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Availability in the Presence of Failures

Failures, Errors, and Faults

- A system is said to fail when it cannot meet its promises
- Error may lead to a failure
- Fault -- a cause of an error

Fault Types

- Transient: occur once and then disappear
- Intermittent: occurs, then vanishes, then reappears
- Permanent: continues to exist

Availability and Reliability

- **Availability**: Probability that a system operates correctly at any given moment and is available to perform its functions

- **Reliability**: time period during which a system continues to be available to perform its functions

- Problem: calculate system availability and reliability if it's unavailable for 1 second every hour.

Fault Tolerance

A fault tolerant system can provide its services even in the presence of faults

Classification of Failure Modes

Type of failure	Description
Crash failure	A server halts, but is working correctly until it halts
Omission failure Receive omission Send omission	A server fails to respond to incoming requests A server fails to receive incoming messages A server fails to send messages
Timing failure	A server's response lies outside the specified time interval
Response failure Value failure State transition failure	The server's response is incorrect The value of the response is wrong The server deviates from the correct flow of control
Arbitrary (a.k.a. Byzantine) failure	A server may produce arbitrary responses at arbitrary times

Achieving k fault tolerance

A system is k fault tolerant if it can survive faults in k components

- silent failure vs. Byzantine failure

  k+1 2k+1

Agreement among honest players with unreliable communications: Two-army Problem

Even with nonfaulty processes, agreement even between two processes is not possible in the face of unreliable communications

Agreement among dishonest players with perfect communications: Byzantine Generals Problem

Results:

1. In a system with *m* faulty processes, agreement can be achieved only if *2m+1* correctly functioning processes are present (total 3m+1). (Lamport et al., 1982)

2. If messages cannot be guaranteed to be delivered within a known, finite time, no agreement is possible even with one faulty process. (Fischer et al., 1985)

Ways to Deal with Failures

- Service continuity
  - Masking failures via
    - Redundancy of
      - information
      - time
      - physical
- Disaster recovery
  - Backward recovery
    - check pointing
  - Forward recovery
    - bringing system into a correct new state
  - Don’t underestimate backups!

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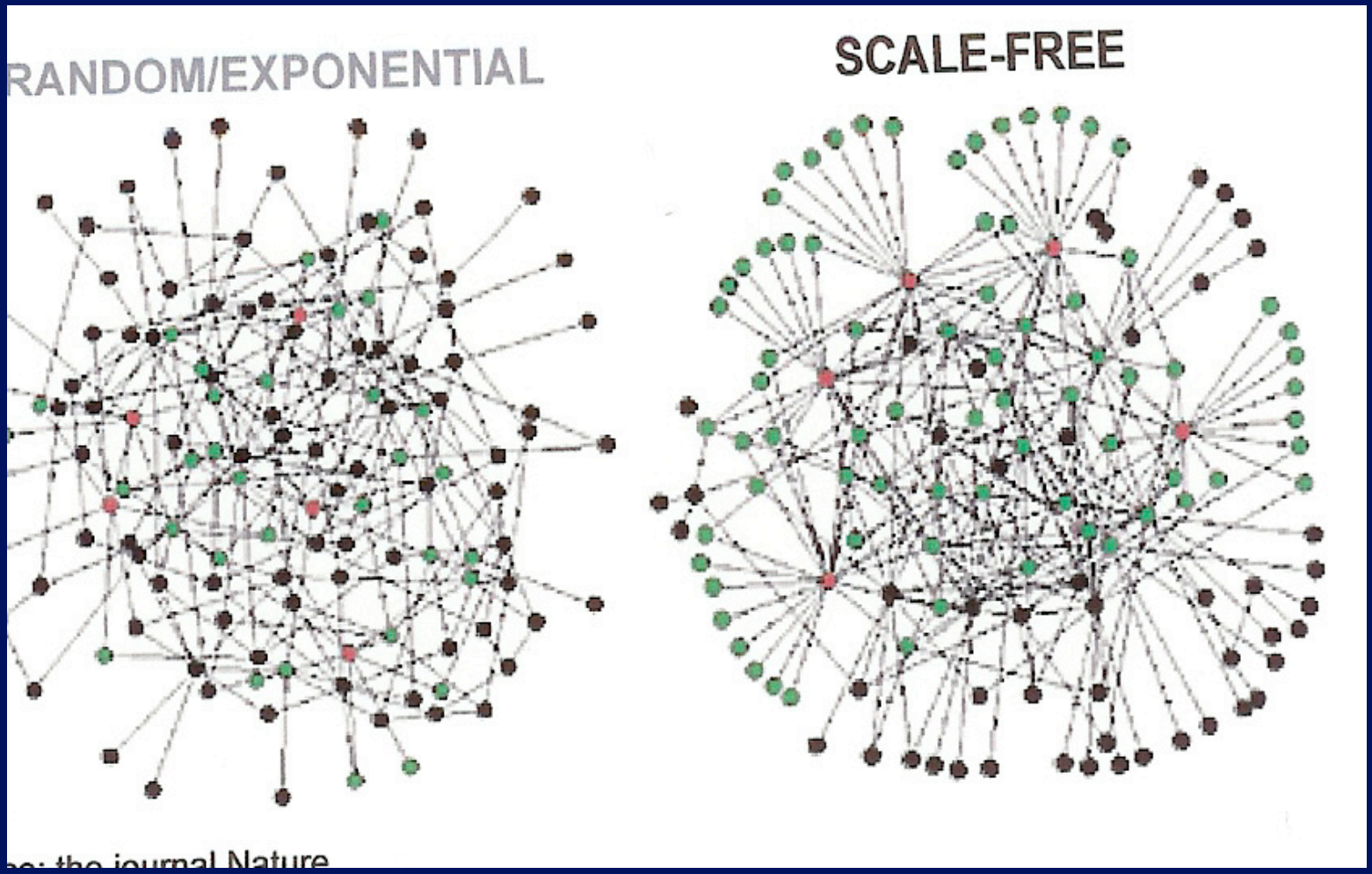
Availability in the Presence of Attacks

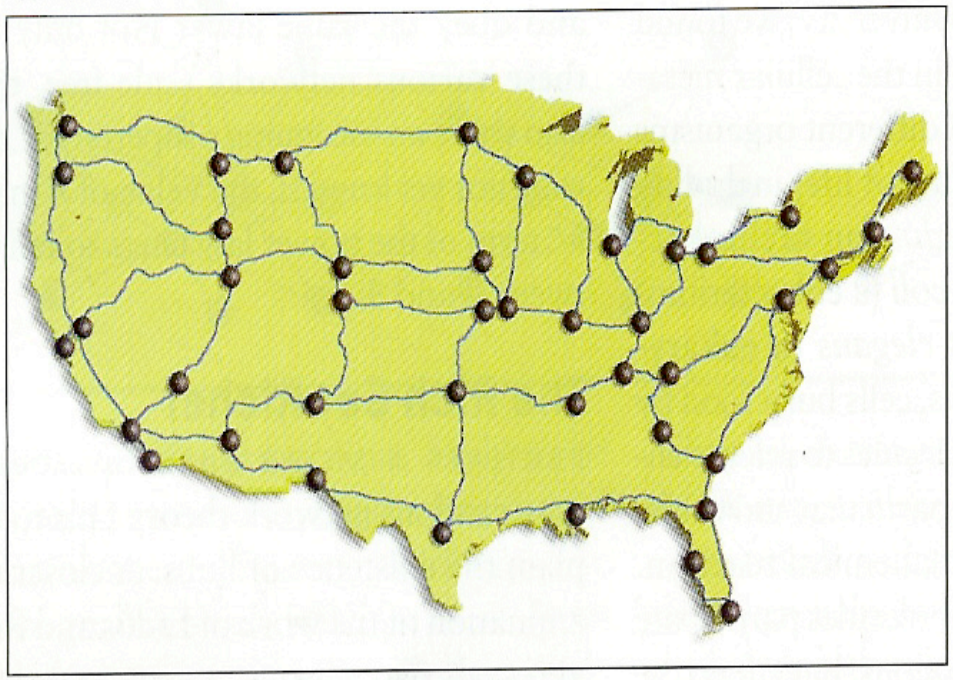
Failures vs. Attacks

- **Failure**
  - Random unavailability of participants and/or infrastructure elements
- **Attack**
  - Systematic unavailability of participants and/or infrastructure elements

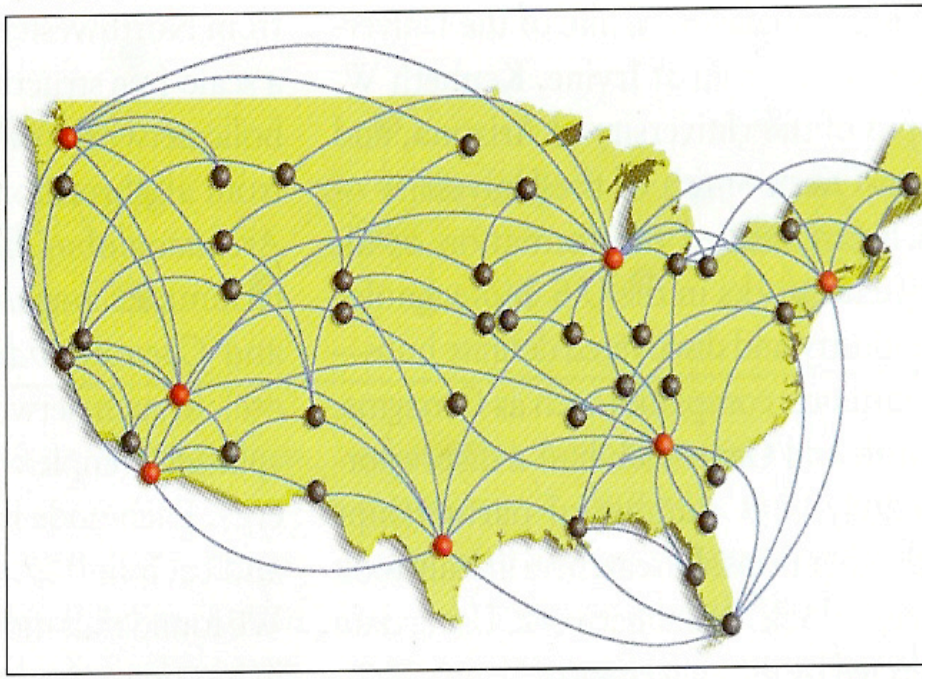
Random vs. Scale-free Networks



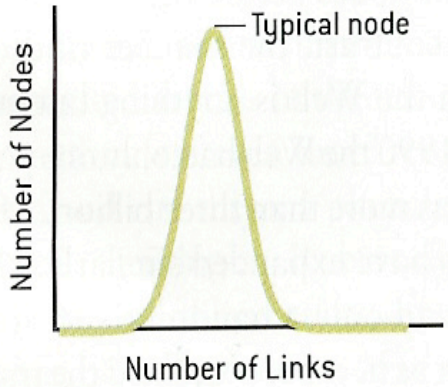
Random Network



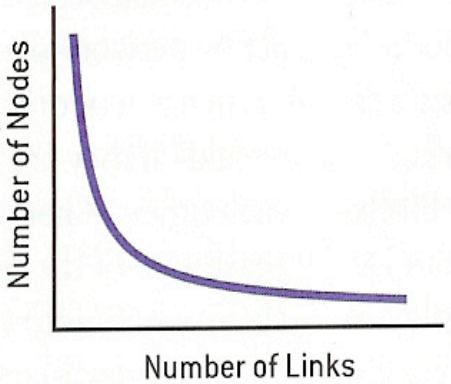
Scale-Free Network

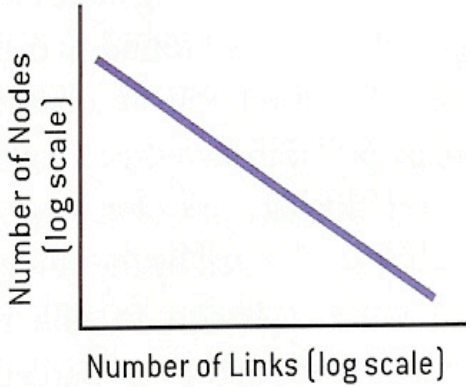


Bell Curve Distribution of Node Linkages



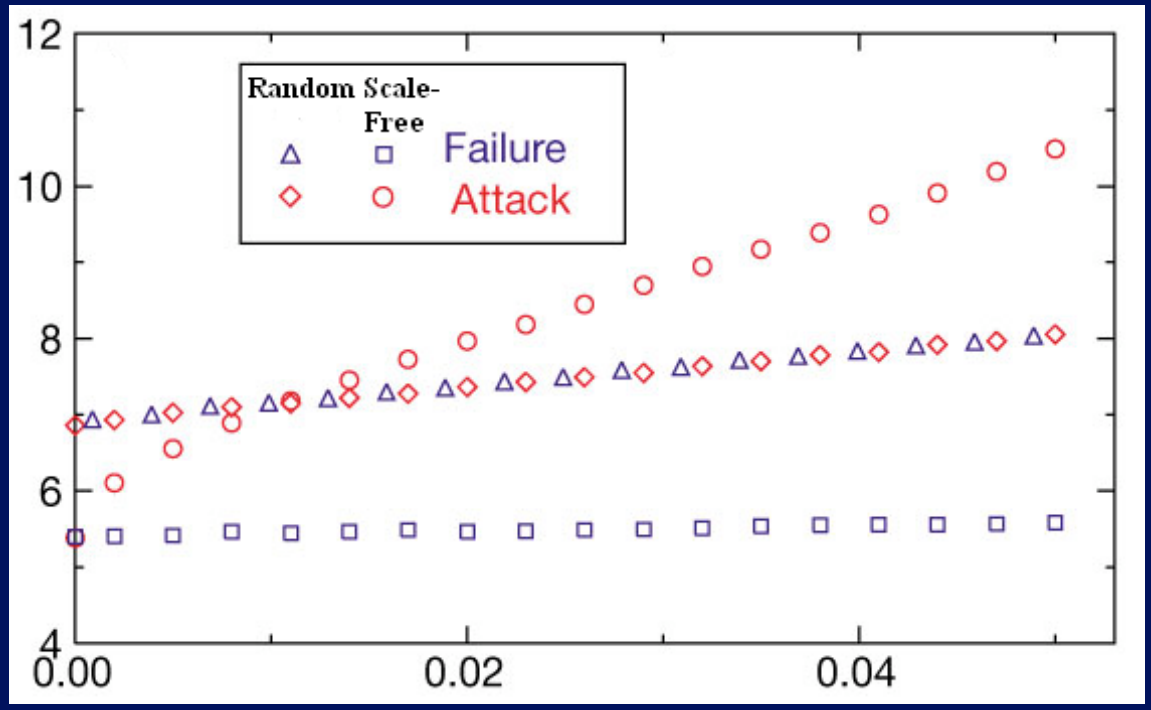
Power Law Distribution of Node Linkages





Internet Tolerance to Attacks and Failures

- Scale-free networks are failure-tolerant
- Random networks are attack-tolerant



Source: R. Albert, H. Jeong, and A.-L. Barabasi, "Error and attack tolerance of complex networks," Nature, vol. 406, no. 6794, 2000, pp. 378-82.

Ways to Deal with Attacks

- Service continuity
  - Same as for FT, plus
  - Heterogeneity
    - Diversification
      - Avoid monocultures
    - Randomization
      - Avoid "hubs"
- Disaster recovery
  - Same as for FT