Critical Resilient Interdependent Infrastructure Systems and Processes

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Research and Teaching

• Professor: Department of Informatics and Networked Systems, School of Computing and Information

• Teach courses in graduate Telecommunications and Networking Program and grad/undergrad classes in Information Science Program
  – Network Performance
  – Network Design
  – Wireless Networks
  – Infrastructure Protection
  – Computer Networks

• Educational/Curriculum funding
  – NSF, AT&T Foundation, Commonwealth of PA

• Research Funding
  – NSF, NSA, ARO,NIST, DARPA, Bechtel Bettis
1. Resilient Networks
   - Wired/Wireless resilient network design
     • Spectrum pooling/virtualization
     • Quality of Resilience Classes
     • Risk Based Design
   - Cross Critical Infrastructure Resilience

2. Performance Evaluation Techniques
   - Modeling Dynamic Network Behavior:
     • Queueing and Simulation
     • Co-Simulation of cyberphysical systems
   - Recent work: V2V nets, MicroGrid power systems

3. Information Assurance
   - Network Security
     • DDOS – distributed detection, Key Management in Smart Grid Communications
     • Microgrid Security Architecture
   - Insider Attacks
   • Papers on Google Scholar page!
What is Critical Infrastructure?

- **Critical Infrastructures (CI)** are the systems, assets and services upon which society and the economy depend, such as:
  - Energy and utilities
  - Information Technology and Telecommunications
  - Critical Services (food, health care, financial)
  - Transportation
  - Government and Emergency Services
  - Etc.

- DHS formalized government view of CIs into sectors
List of CI in Nat’l Strategy for The Physical Protection of CI and Key Assets, Feb 2003 → 17 later expanded to 18

**Critical Infrastructures (CI)**
- Agriculture & Food
- Water
- Public Health
- Emergency Services
- Defense Industrial Base
- Information Technology
- Telecommunications
- Energy
- Transportation
- Banking & Finance
- Chemicals & Hazardous Materials
- Postal & Shipping
- Critical Manufacturing

**Key Assets:**
- Nat’l Monuments & Icons
- Nuclear Power Plants
- Dams
- Government Facilities
- Key Commercial Assets

Now called Key Resources (KR)
Characteristics of CIs

- Scale of many CIs are immense
  - Consider Power Grid in USA
    - More than 9,200 power plants/generating units
    - More than 300,000 miles of transmission lines
    - More than 1,000,000 miles of distribution lines
    - More than 170 power companies
- Too expensive to protect everything
- Can cross national boundaries/privately owned
There are three layers in most CIs: Cyber-Physical Systems!

- **Organizational Infrastructure**
- **IT/Cyber-Infrastructure**
- **Physical Infrastructure**

Each layer has a degree of dependency on the other layers.

- **People**
- **e.g. Supervisor Control and Data Acquisition (SCADA) systems.**
- **Hardware: e.g., pipelines, transmission lines, etc.**
Characteristics of CIs

Interconnected CIs have a degree of interdependency between similar or other layers in other CIs.

Interdependency leads to a hierarchy of CIs.

- Physical Infrastructure
- Cyber-Infrastructure
- Organizational Infrastructure

Intra-dependency

Inter-dependency
Interdependence and Resilience

- **Research Focus on power grid + ICT**
  - Joint reliability models
    - Failures in communications ➔ Power Delivery
    - Failures in Power ➔ Communications
    - Metrics mapping – downtime/week ➔ SAIDI etc.

- **Designing reliable WANs for Smart Grid**


- **California ISO power grid**
  - 3329 Substations, 75 utilities, 32,000 miles transmission line
  - Distance between substations
    - Min 1.2 miles, Max 1074 miles
Interdependence and Resilience

- Microgrids: localized power grids with a clearly defined boundary
- Operate connected to the main grid in an supplemental fashion or operate in island mode disconnected from the main grid for extended time periods.
- Microgrid work
  - Reliable communication network design
  - Interaction of cybersecurity on power control algorithms

Link economics/investment to reliability in Smart Community context
Comments

- Cross Infrastructure Resilience on Campus Level
  - Microgrids, Smart X, etc. ➔ Hidden ICT
  - Different vendors/protocols (IEC 61850, DNP3, Modbus, etc.)
  - Management (Facilities vs. IT)
  - Security often an afterthought

- NSF Wireless Innovation for Networked Society (WINS)
  
  https://wirelesschallenge.mozilla.org/

- Smart Community Networks Challenge Challenge
  
  Provide wireless Internet Connectivity to underserved communities
  
  Working with local nonprofit METAMESH on submission