University of Pittsburgh

Critical Resilient Interdependent Infrastructure Systems and Processes

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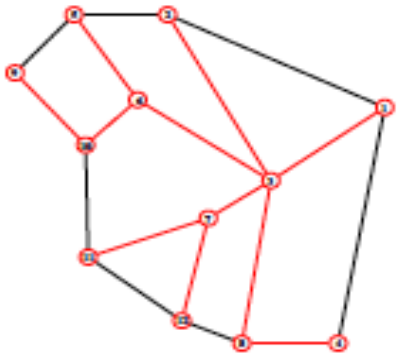
Research and Teaching

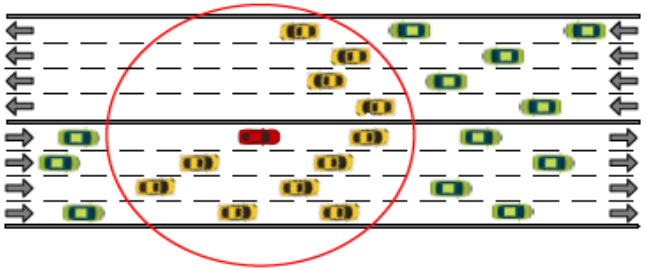
- Professor: Department of Informatics and Networked Systems, School of Computing and Information
- Teach courses in graduate Telecommunications and Networking Program and grad/undergrad classes in Information Science Program
  - Network Performance
  - Network Design
  - Wireless Networks
  - Infrastructure Protection
  - Computer Networks
- Educational/Curriculum funding
  - NSF, AT&T Foundation, Commonwealth of PA
- Research Funding
  - NSF, NSA, ARO,NIST, DARPA, Bechtel Bettis

Research and Teaching

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 in to sectors

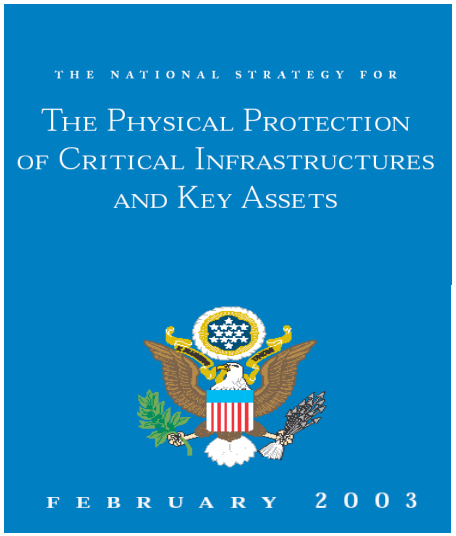
Critical Infrastructure and Key Resources

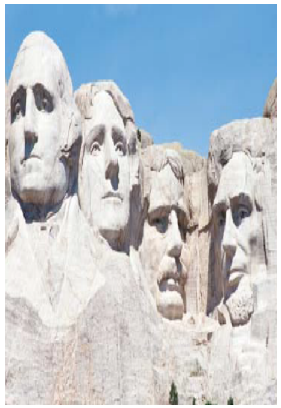
List of CI in Nat'l Strategy for The Physical Protection of CI and Key Assets, Feb 2003

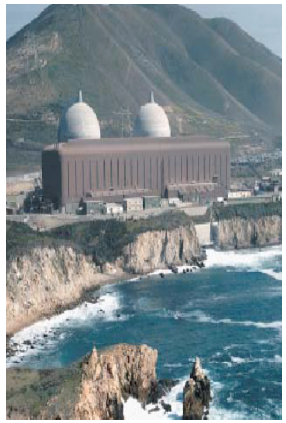
→ 17 later expanded to 18

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

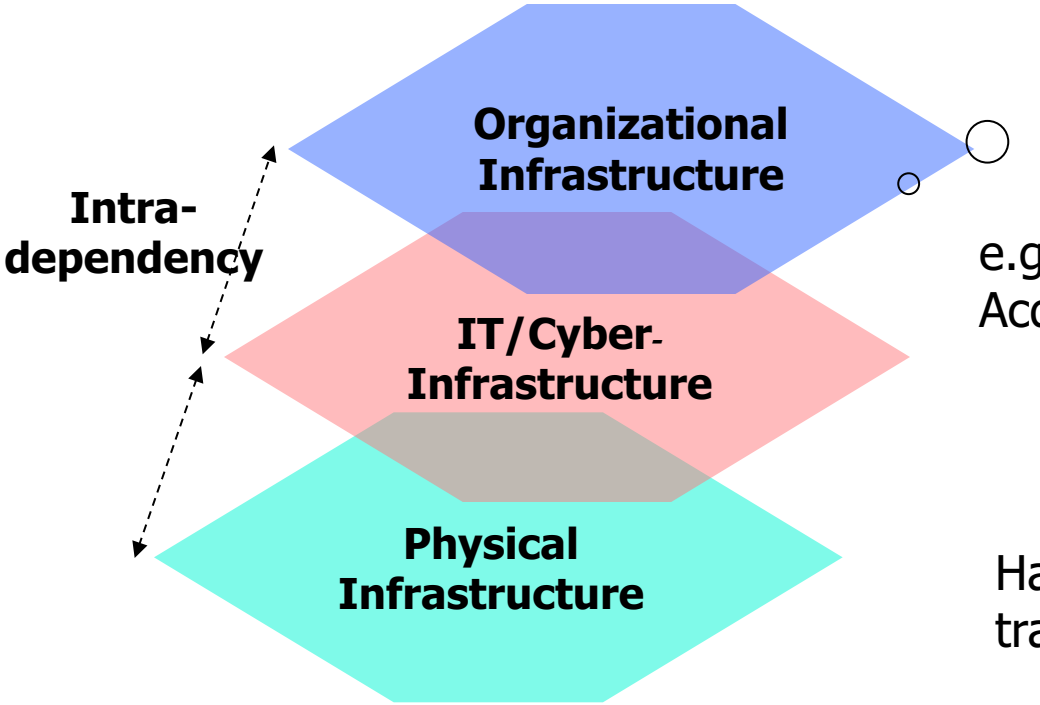
Now called Key Resources (KR)

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

Characteristics of CIs

There are three layers in most CIs:
Cyber-Physical Systems!



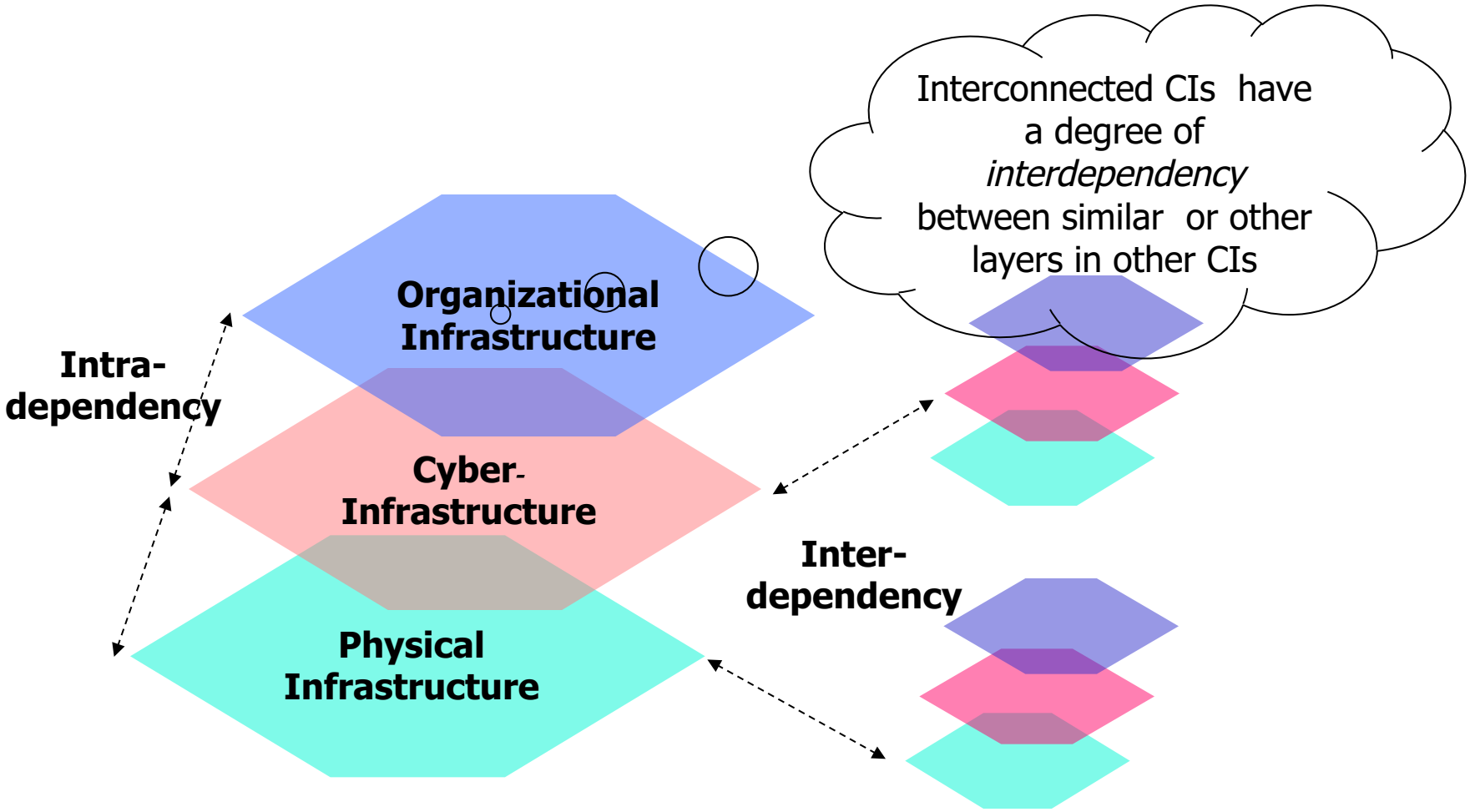
Each layer has a degree of dependency on the other layers

People

e.g. Supervisor Control and Data Acquisition (SCADA) systems.

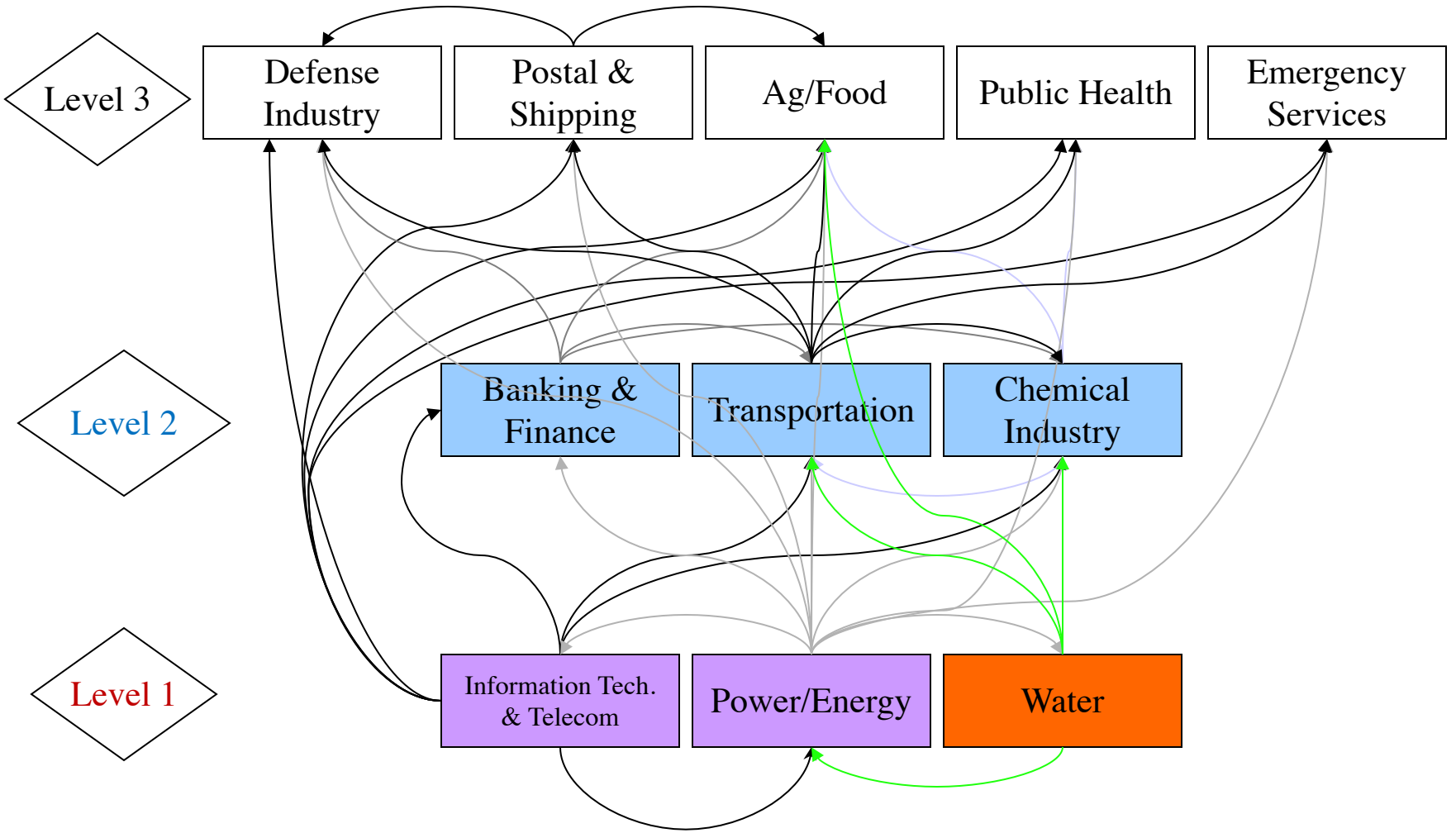
Hardware: e.g., pipelines, transmission lines, etc.

Characteristics of CIs



Interdependency leads to a hierarchy of CIs

Hierarchy of Critical Infrastructures



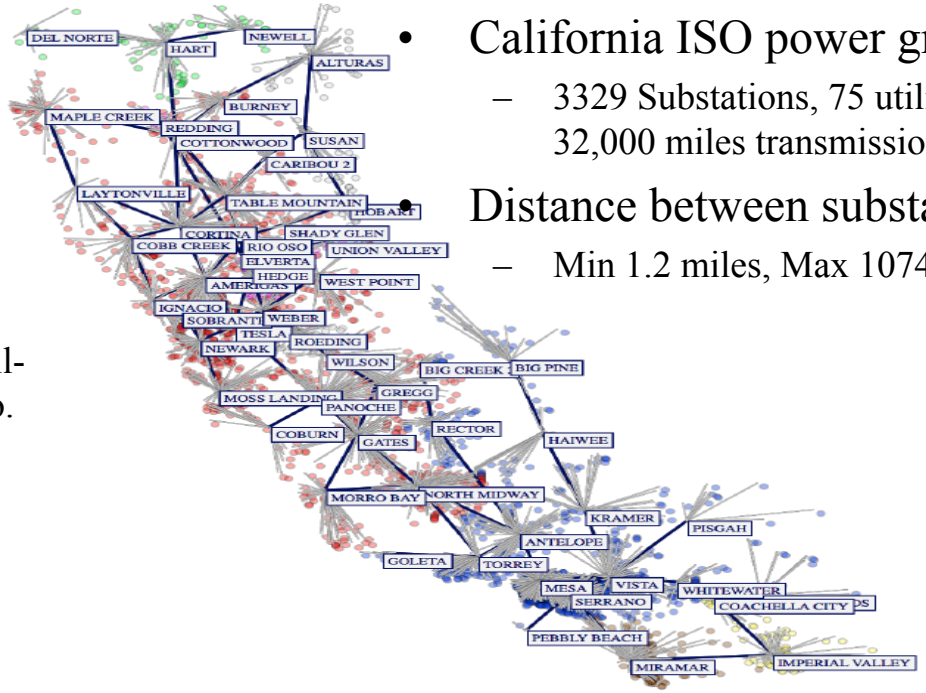
Interdependence and Resilience

- 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

V. Kounev, M. Levesque, D. Tipper, and T. Gomes, "Reliable Communication Networks for Smart Grid Transmission Systems," *Journal of Network and Systems Management*, Vol. 24, No. 3, pp. 629-652, July, 2016.

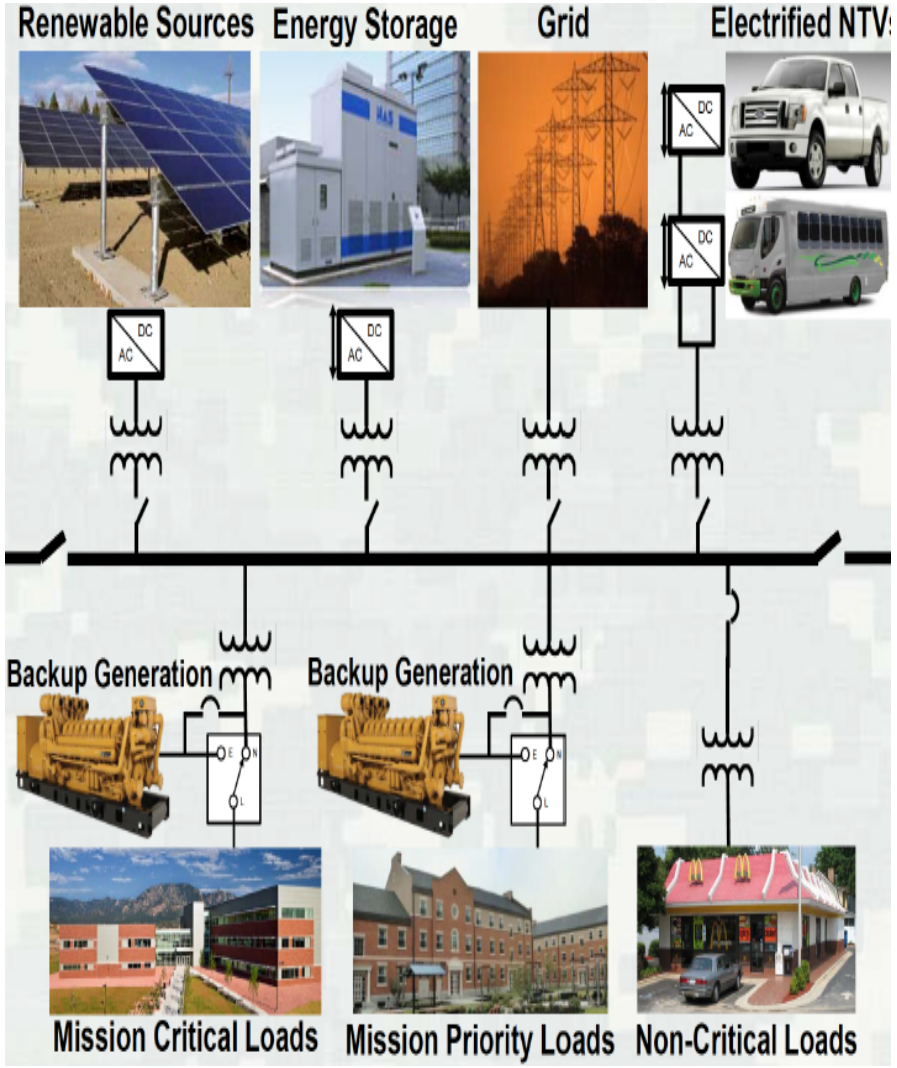
J. Silva, T. Gomes, D. Tipper, L. Martins and V. Kounev, "An Effective Algorithm for Computing All-terminal Reliability Bounds," *Networks,* Vol. 66, No. 4, pp. 282-295, Dec., 2015.

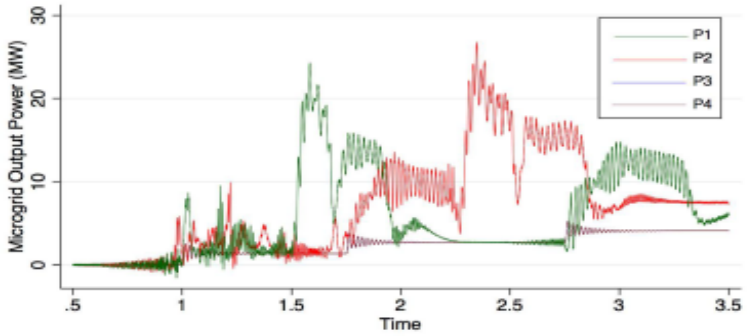


- California ISO power grid
  - 3329 Substations, 75 utilities, 32,000 miles transmission line
- Distance between substations
  - Min 1.2 miles, Max 1074 miles

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

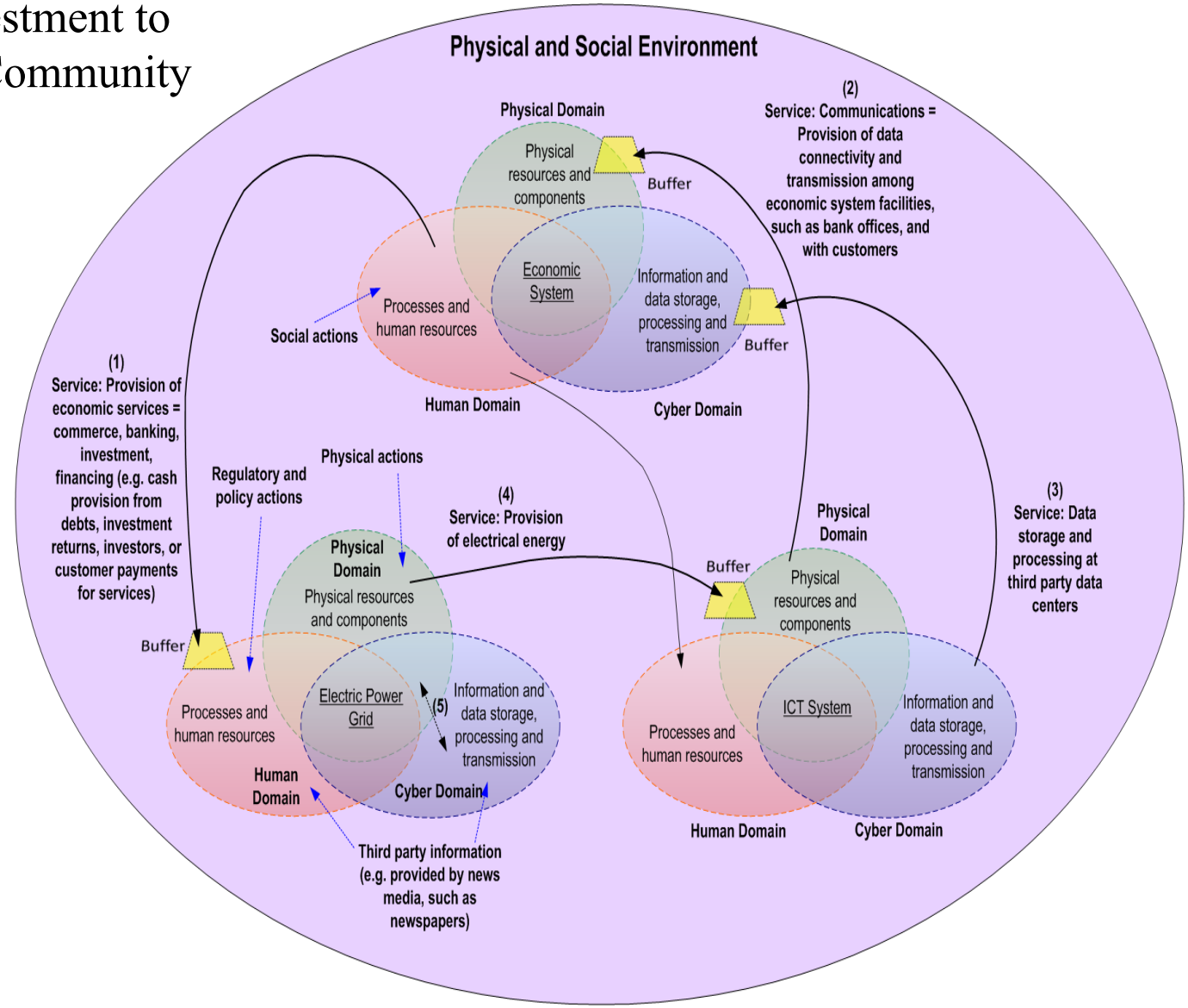




V. Kounev, D. Tipper, A. Yavuz, B. Grainger and G. Reed, "A Secure Communication Architecture for Distributed Microgrid Control," *IEEE Transactions on Smart Grid,* Vol. 6, No. 5, pp. 2484-2492, Sept., 2015.

Infrastructures in Smart Community

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