Review and Evaluation of Security Threats on the Communication Networks in the Smart Grid

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Outline

- **Background and Motivation**
  - Why Smart Grid?
- **A glance of the smart grid and security**
  - Architecture of the smart grid communication network
  - Classification of security threats
- **A case study for traffic-flooding attacks.**
  - A mini-showcase of the smart grid communication network
  - Delay performance measurement
- **Conclusion**

Networks in our daily life

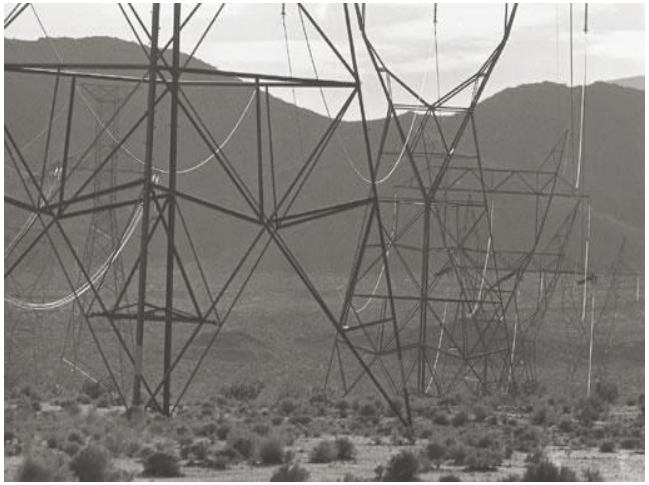
- **Evolution of information technology**
  - **the Internet paradigm**

30 years ago

Today

Why Smart Grid?

- **Evolution of power grids**



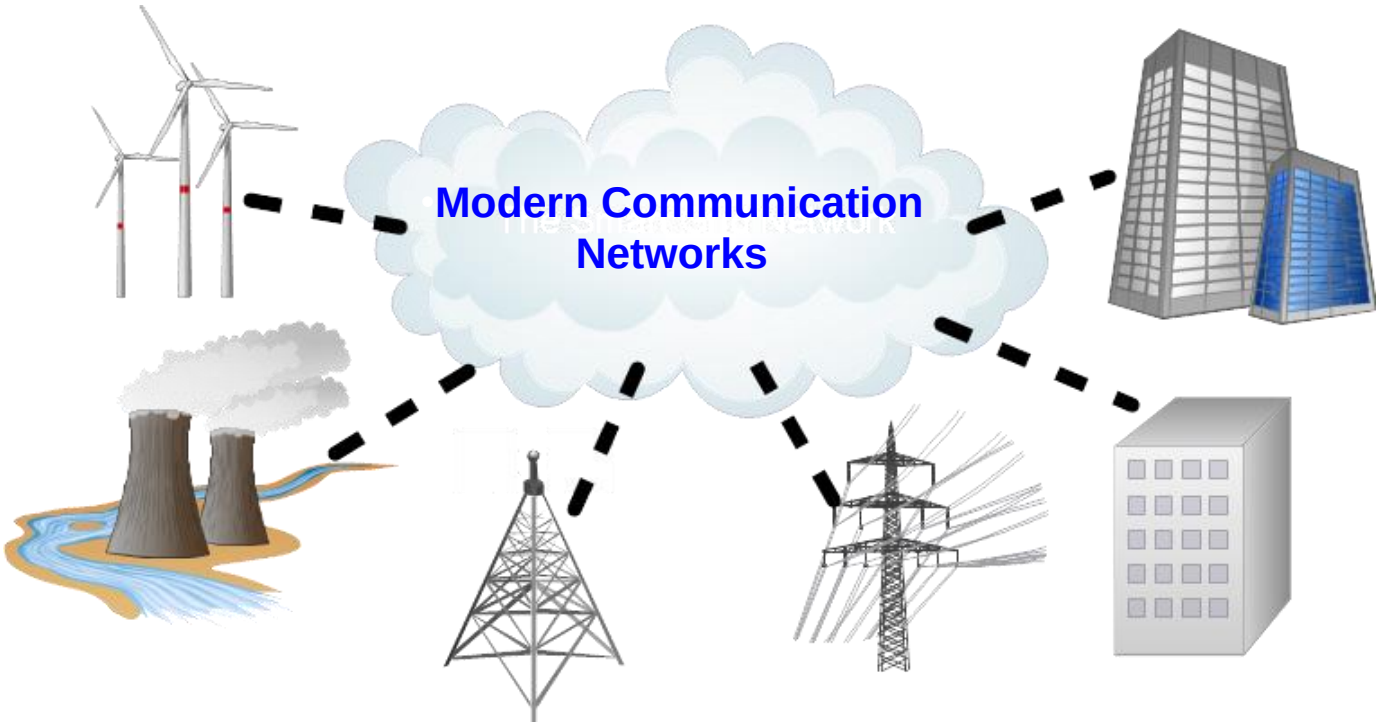
30 years ago

Today

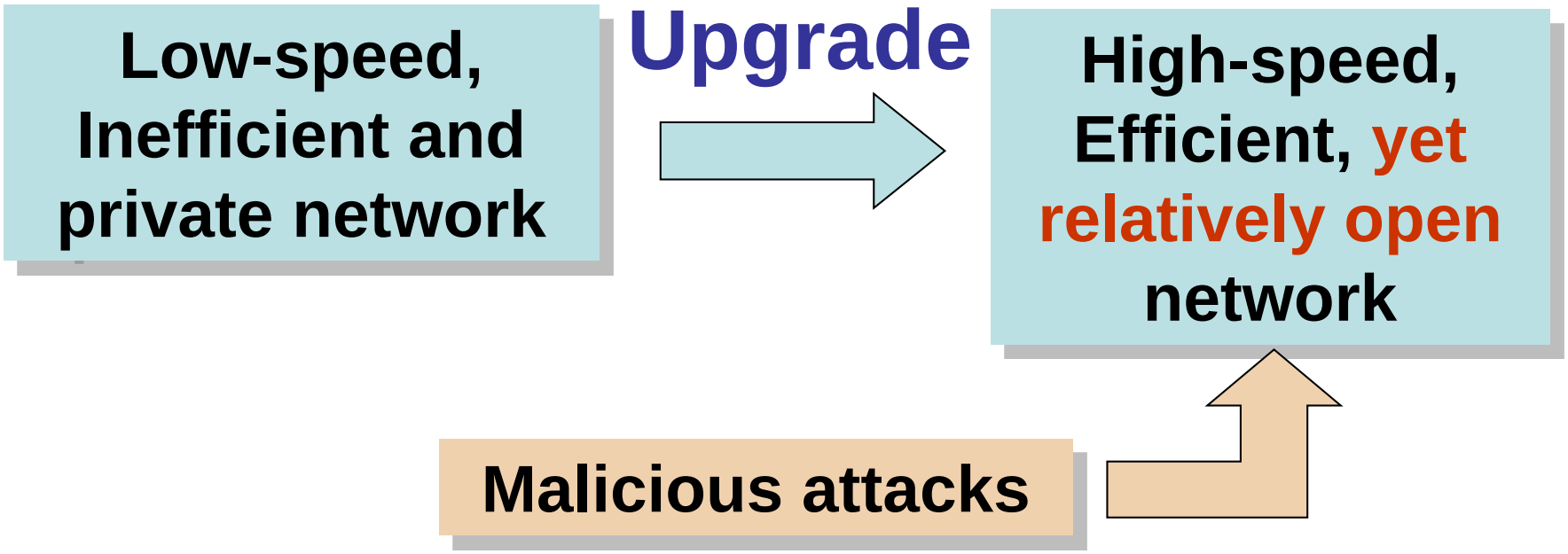
- **Smart grid: the next-generation power system. (Energy Internet!)**
  - **On Oct. 27 2009, the Obama Administration announced 100 grants, totaling $3.4 billion, for smart-grid efforts.**

Smart Grid Communication Networks

- **The smart grid is a new paradigm for energy management and delivery systems.**
  - **Advanced digital computing and networking system connects every single part of the grid.**



Network Security in the Smart Grid



- **In this work, we**
  - take a quick glance at network security threats in the smart grid;
  - use a simple case study to illustrate the attack impact on power networks

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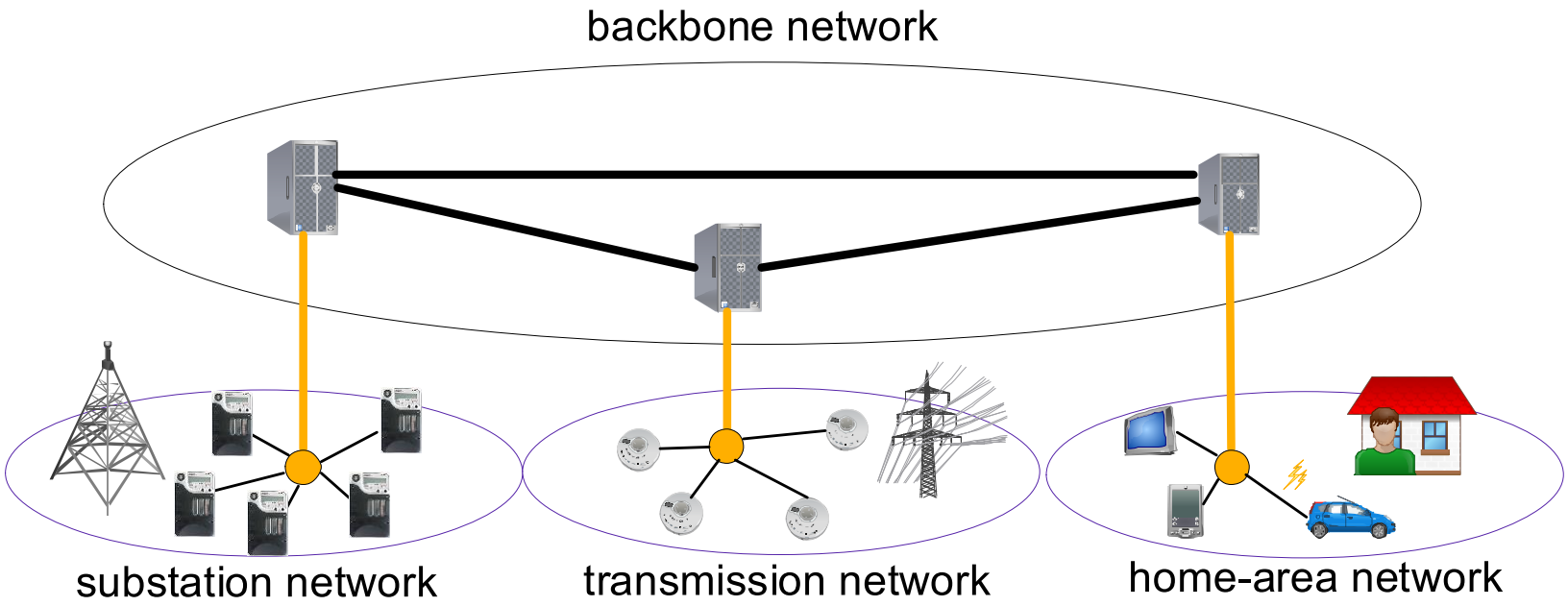
Fundamental Architecture

- **Hierarchical architecture.**
  - **Backbone network and local-area networks**



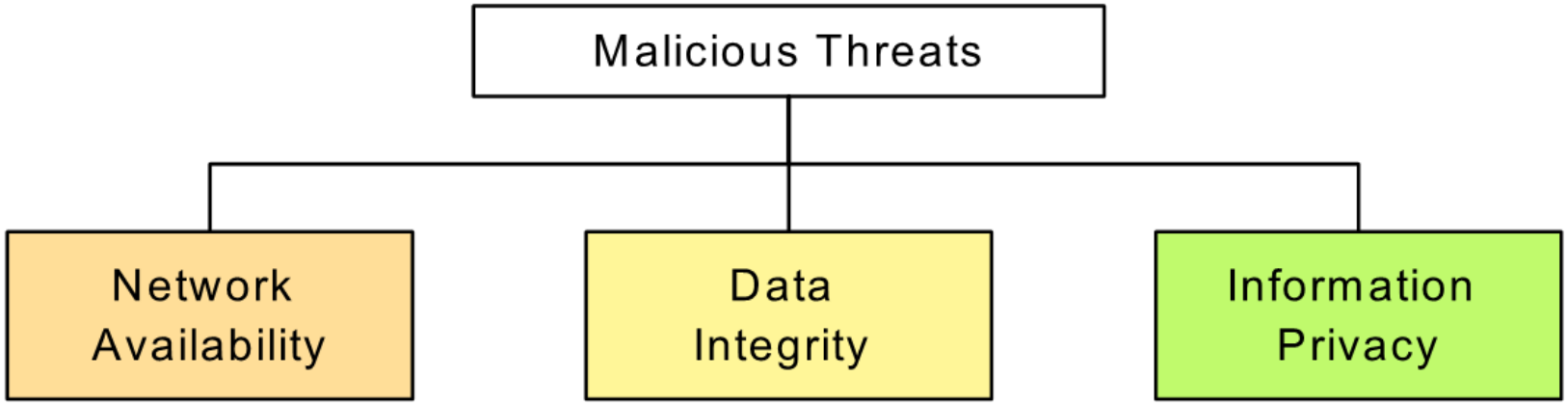
- **Various communication technologies: Fiber, Ethernet, WiFi, ZigBee, 3G, WiMax.**

Smart Grid Network versus Internet

	Smart Grid Communication Network	The Internet
Major Performance Metric	delay	throughput
Traffic Models	Periodic, constant	Power-law (WWW)
Communication Patterns	Bottom-up, top-down	End-to-end, peer-to-peer

Network Security Threats

- **Security threats in conventional networks**
  - **Selfish behavior -> fairness**
  - **Malicious behavior -> network operation**
- **Security threats in the smart grid**
  - **Malicious behavior**



Attacks Targeting Network Availability

- **Attempt to delay, block or corrupt information transmission to make network resources unavailable in the smart grid.**

- **Examples of potential attacks**
  - **Conventional DoS attacks: traffic-flooding, TCP sync attacks.**
  - **Wireless jamming. (Strasser'08, Popper'09)**

- **Differing from conventional networks.**
  - **Time-critical nature of traffic.**
    - **3-ms delay threshold in power substation in IEC61850.**

Attacks Targeting Data Integrity

- less brute-force yet more sophisticated
- deliberately modify information to corrupt data exchange in this smart grid.

- Example:
  - False-data injection attacks (Liu'09).

- Authentication in the smart grid
  - Time-critical traffic. (3 ms, 10 ms) (Wang'09)
  - Short information length. (e.g., 20 bytes in a packet)
  - Key management

Attacks Targeting Information Privacy

- **Attempt to eavesdrop on communications to acquire desired information.**

- **Examples:**
  - **Wiretapper.**
  - **Traffic analyzer.**

- **From the perspective of network operation, it has negligible effect.**
  - **The NIST smart grid report provides the priorities of the three security objective: (NIST Special Publication 1108).**
    - **Network availability**
    - **Data integrity**
    - **Information privacy**

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  - **Delay performance measurement**
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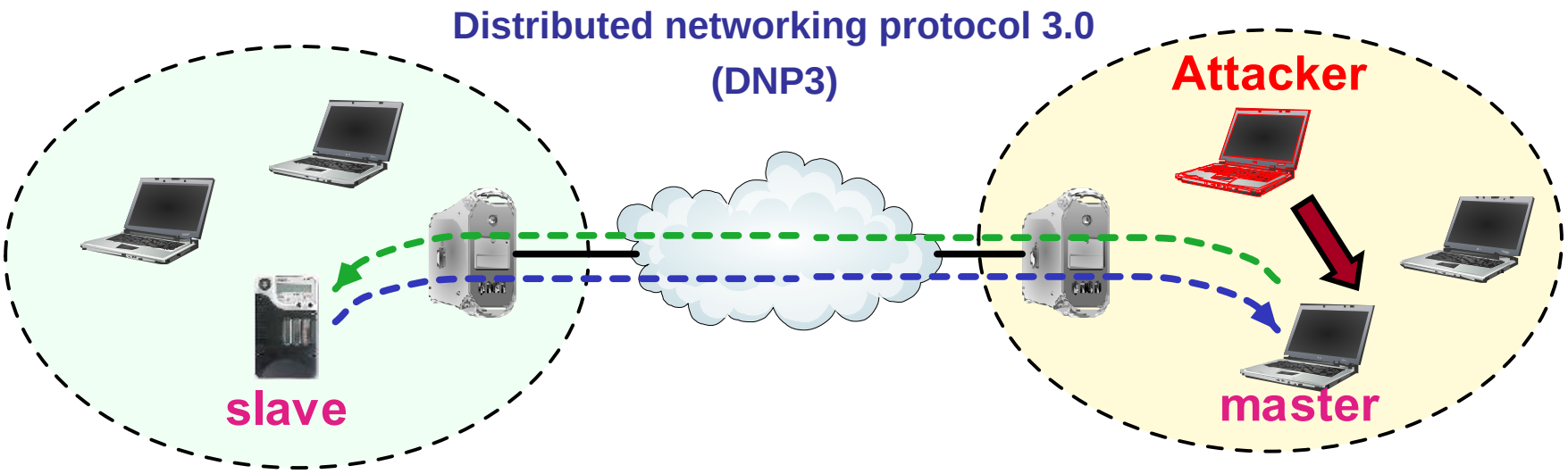
Experimental Power Network

- **Experimental power network in the FREEDM center at NC State university**

- **Backbone network:**
  - **Campus backbone network at NC State University**

- **Power substation networks:**
  - **Intelligent electronic devices (IED)**
  - **Intelligent fault management devices (IFM)**
  - **Interfaces:**
    - **Ethernet, WiFi, ZigBee**

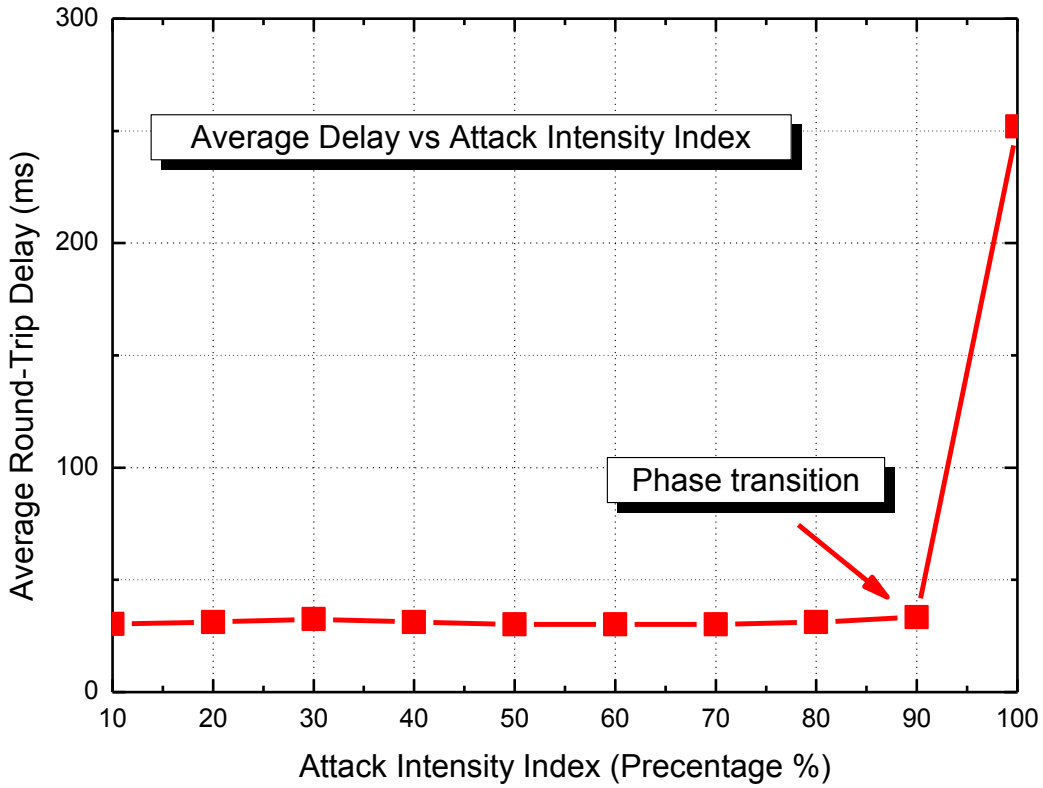
Case Study: Traffic-flooding Attack



- **Why traffic-flooding attack?**
  - A type of denial-of-service attacks. (Adkins'03, Yu'08)
  - The one of the most easy-to-be-generated attacks
  - Attack intensity index:
    - I = rate of flooded traffic / channel bandwidth.
- **Performance metric:**
  - round-trip packet delay.

Experimental Results (I)

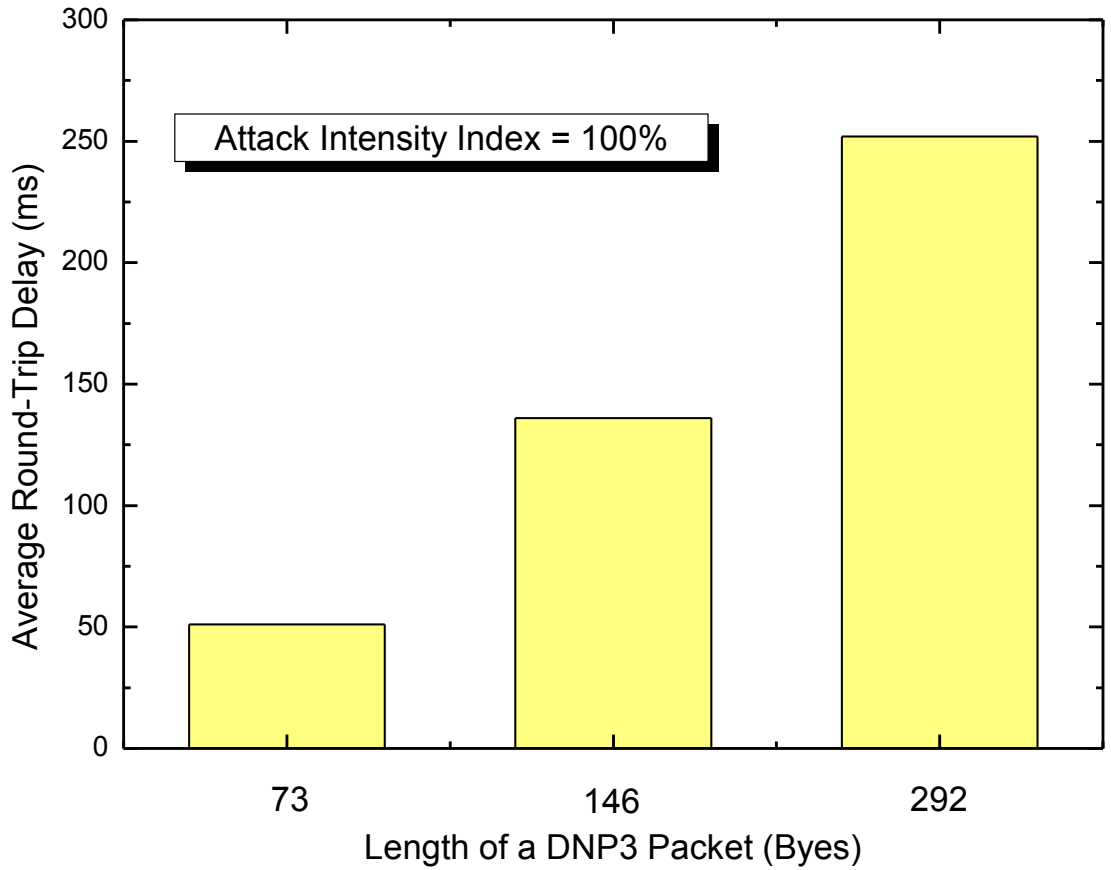
- **DNP3 packets are transmitted every 500 ms.**
  - **Very light traffic**



- **For light traffic, performance is significantly degraded when the attack intensity index approaches 1.**

Experimental Results (II)

- **DNP3 packets are transmitted every 500 ms.**



- **Short DNP3 packets are more resistant to traffic-flooding attacks.**

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Conclusion

- In this paper, we took a quick glance at security threats towards the communication networks in the smart grid.
- We used a case study to illustrate the impact of traffic-flooding attacks on a DNP3-based power system.
  - For light traffic in power networks, traffic flooding attacks only affect the delay performance when the attack intensity approaches 1.
  - Longer packets are more vulnerable to attacks.
- In-depth study via both analytical modeling and experiments is our future work.

Thanks!