Resilience Techniques in Software Defined Metro Optical Networks within the Scope of Smart Cities

Giap Le, Dec. 14, 2018

Outline

- Smart City: An Overview
  - ✓Components make a city smart
  - ✓Why it is necessary to do research on smart cities (ICT aspects)
- Resilience Techniques for Software Defined Metro Optical Networks
  - ✓Hybrid failure recovery in SDNs
  - ✓Controller resilience problem formulation in SDN in the scope of smart cities

Disaster-Resiliency Strategies for NG Metro Optical Networks

Key terms:

- ✓**ultra-reliable**, **low-latency** services (autonomous driving, augmented reality, telemedicine), **resilient** against largely-disruptive events
- ✓enable technologies: network-and-computing ecosystem, SDN, Edge Computing, and Slice Networking (NFV)

Research directions: (might be explored in order)

- ✓disaster-resilient **control plane** in NG-MAN: cognitive and hierarchical control plane that remains operational even main controllers fails
- ✓slicing protection for disaster-resilient NG-MAN **data plane**
- ✓rapid **recovery** during post-disaster phase

First Meeting Summary

A. Non-technical aspects

- Smart city: what is it (vs. unsmart city)?
- Ubiquitous connectivity to things
- Autonomous, continuous, proactive monitoring (for good health)
- Self-healing, self-organizing, and resilient in cases of disasters (flash crowd, attack, etc.)

B. Technical aspects (IT Infrastructure)

1. Application connectivity
   a) Class of services
   b) Degraded service tolerance
   c) Network slicing
2. Content connectivity
3. MDRUs and drones
4. Hierarchical compute/storage: Cloud, Fog, Edge, WiFi, APs
5. Role of flex-grid optical networks: IoT, SDx, NFV
6. **Resilient control plane**
7. Orchestrate data-plane optimization
8. Additional issues:
   1. Other critical city infrastructure: water, power, server traffic lights, etc.
   2. Need IT infrastructure support (inter-dependent networks)
9. Less-important issues
   1. Energy efficiency
   2. Not necessary to be overlay optical focused

In Summary

Object goals: **Disaster-resilient Metro Optical Networks**

- ✓ ultra-reliable, low-latency
- ✓ **resilient** against largely-disruptive events
- ✓ including novel concepts: SDN, NFV, Edge Computing, Slicing Protection

Research Problem Proposals:

- ✓ controller placement (physical place, number, topology)
- ✓ allocate switches to controllers
- ✓ content connectivity by distributed or backup data
- ✓ congestion-aware, disaster-failure-aware routing and wavelength assignment
- ✓ recovery using movable and deployable units
- ✓ self-organized and self-healing for SDN/NFV Metro Optical Networks

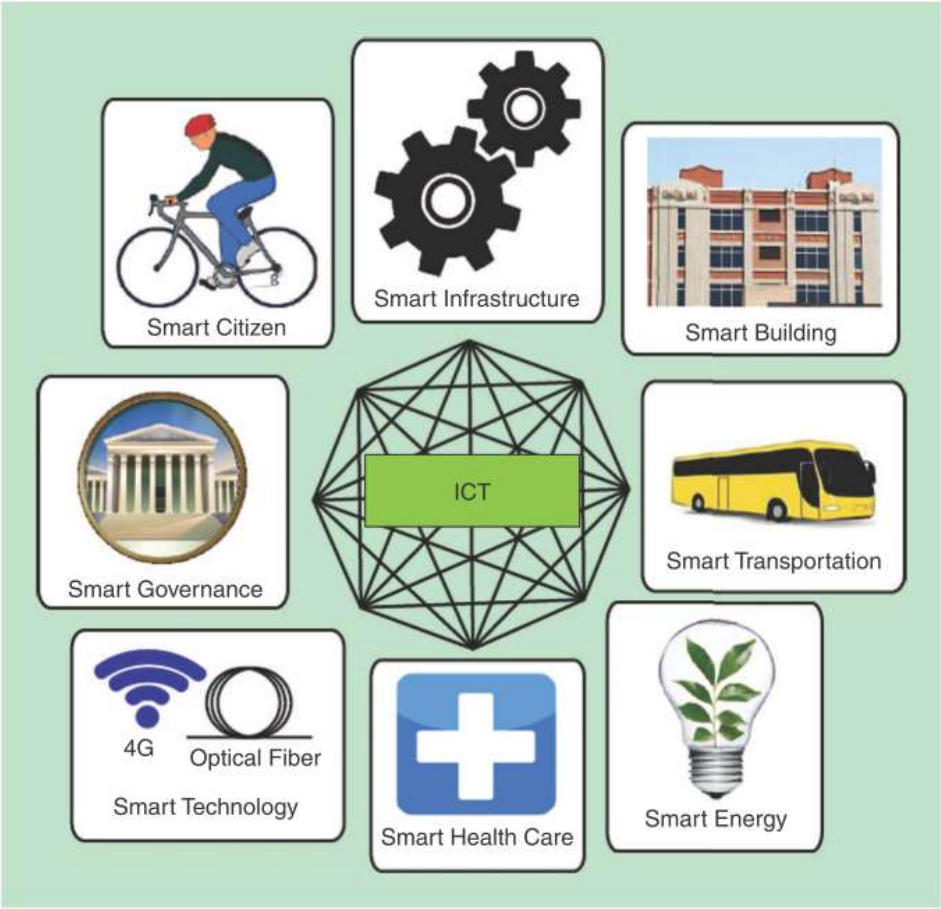
Smart Cities

- *Formal Definition*: "a smart sustainable city is an **innovative city** that uses **information and communication technologies** (ICTs) and other means to **improve quality of life**, **efficiency of urban operations and services**, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to **economic**, **social** and **environmental** aspects"

[1] S. P. Mohanty, U. Choppali and E. Kougianos, "Everything you wanted to know about smart cities: The Internet of things is the backbone," in *IEEE Consumer Electronics Magazine*, vol. 5, no. 3, pp. 60-70, July 2016.

Smart Cities

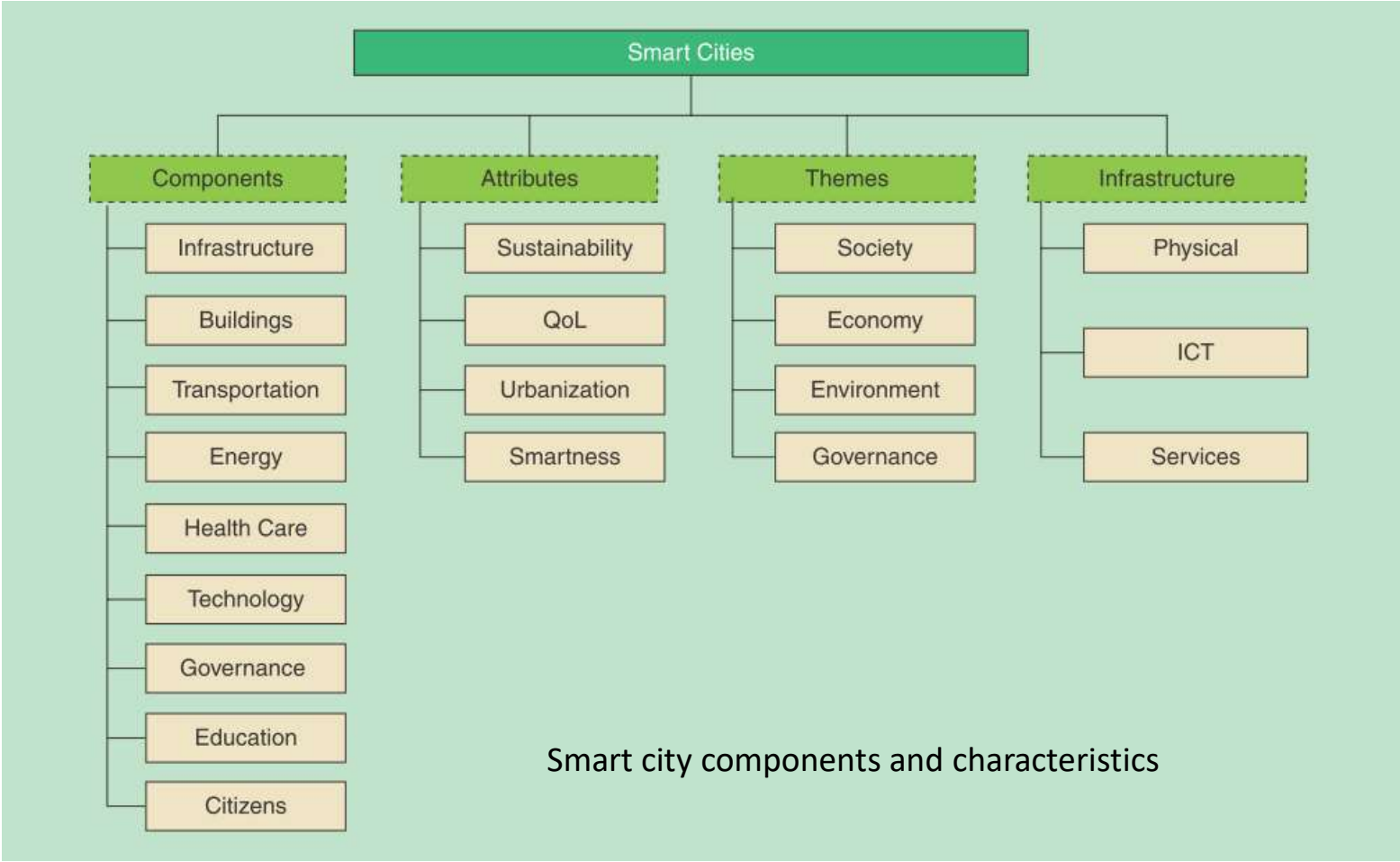
Smart City Components



- ✓ The **core** is ICT (what we are working on)
- ✓ Any **combination** of the components makes cities smart
- ✓ Details of several important components will be on the next slides

[1] S. P. Mohanty, U. Choppali and E. Kougianos, "Everything you wanted to know about smart cities: The Internet of things is the backbone," in *IEEE Consumer Electronics Magazine*, vol. 5, no. 3, pp. 60-70, July 2016.

Smart Cities

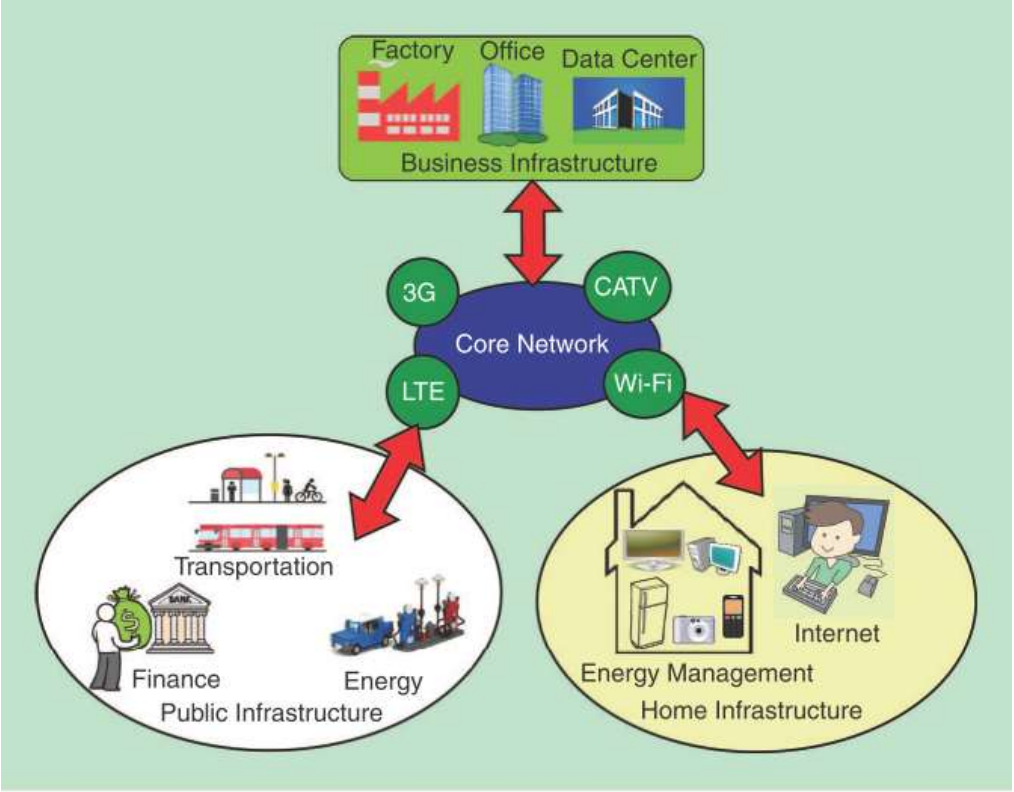


Smart city components and characteristics

[1] S. P. Mohanty, U. Choppali and E. Kougianos, "Everything you wanted to know about smart cities: The Internet of things is the backbone," in *IEEE Consumer Electronics Magazine*, vol. 5, no. 3, pp. 60-70, July 2016.

Smart Cities

- ✓ In the context of smart cities, anything **physical**, **electrical**, and **digital** that is the backbone of the smart city can be considered as its infrastructure.
- ✓ Core element: ICT infrastructure

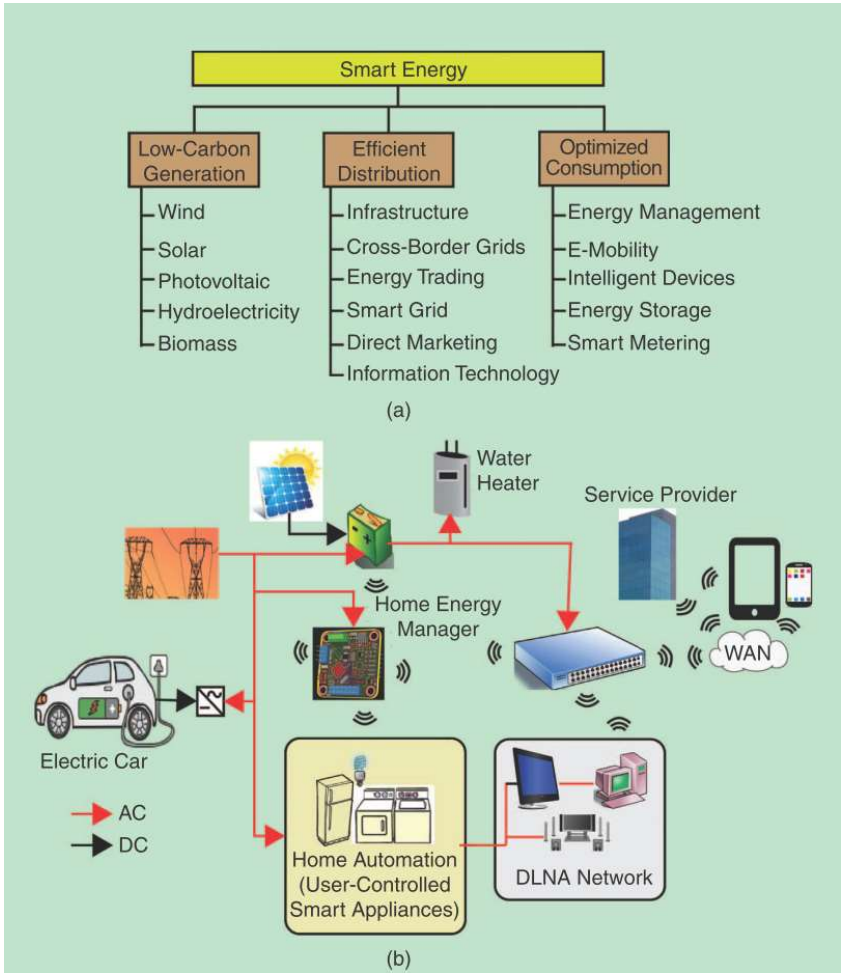


Smart City Infrastructure

[1] S. P. Mohanty, U. Choppali and E. Kougianos, "Everything you wanted to know about smart cities: The Internet of things is the backbone," in *IEEE Consumer Electronics Magazine*, vol. 5, no. 3, pp. 60-70, July 2016.

Smart Cities: Important Components

The smart transportation system allows passengers to easily select different transportation options for lowest cost, shortest distance, or fastest route.



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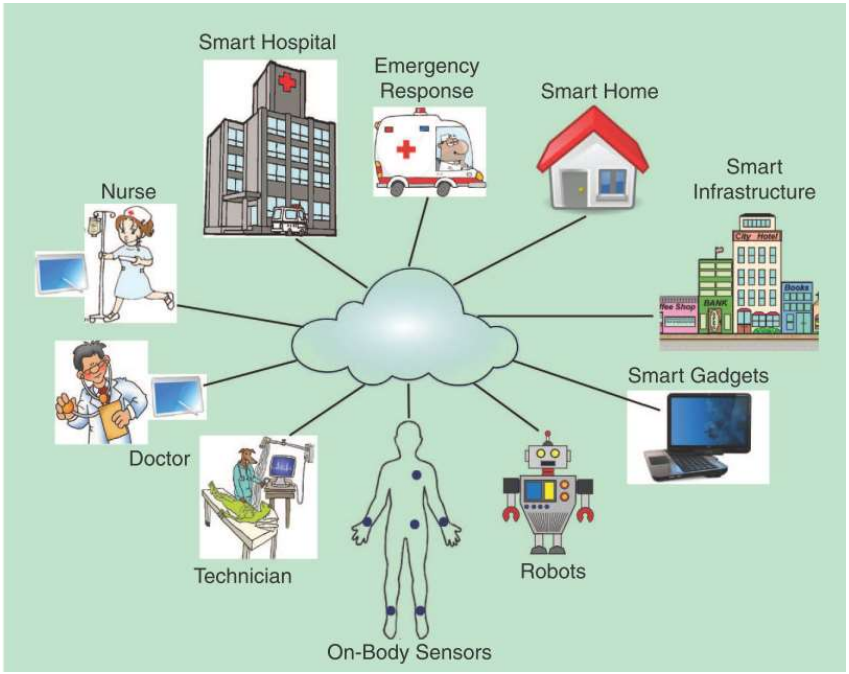
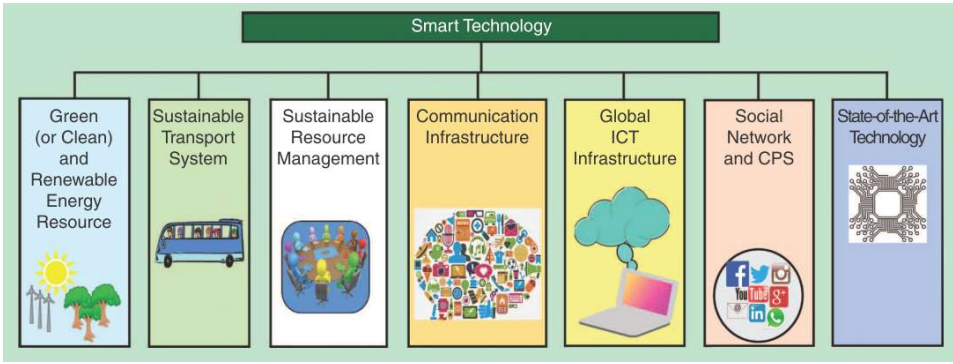
Smart Cities: Important Components





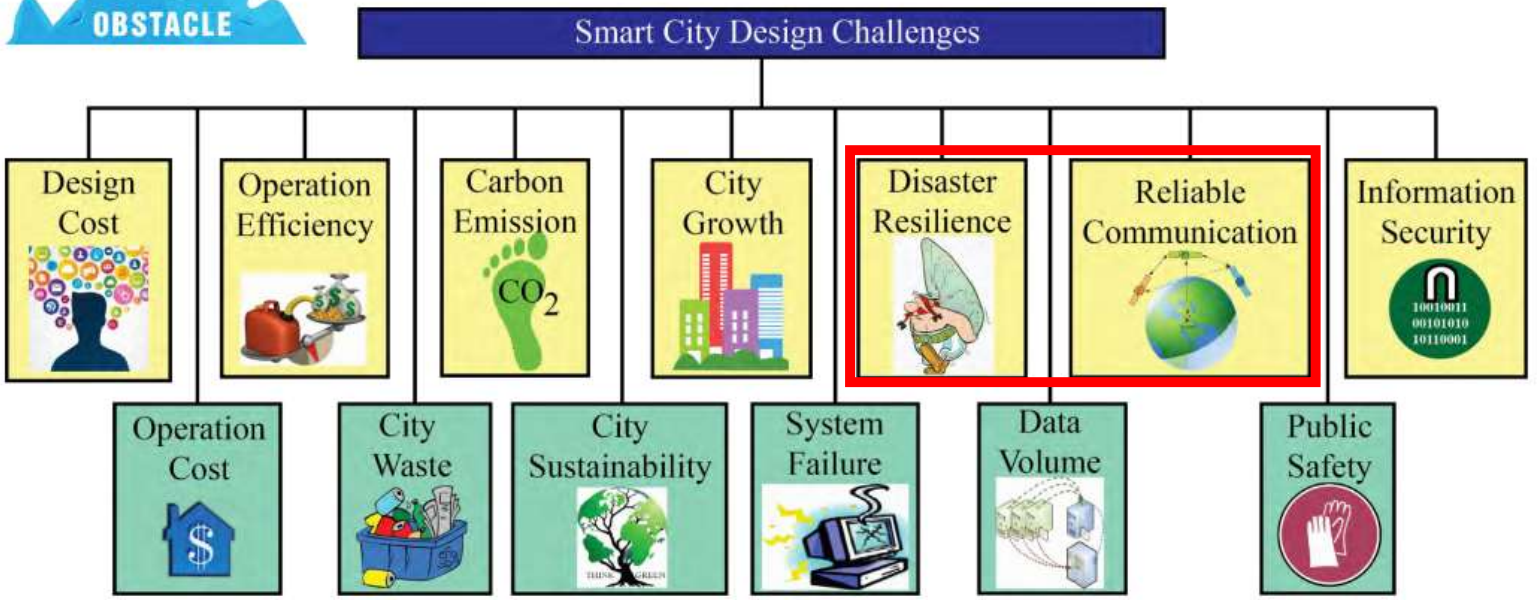
With limited resources and ever-increasing demand, traditional health care needs to be intelligent efficient, and sustainable; that is where smart health care comes in.

[1] S. P. Mohanty, U. Choppali and E. Kougianos, "Everything you wanted to know about smart cities: The Internet of things is the backbone," in *IEEE Consumer Electronics Magazine*, vol. 5, no. 3, pp. 60-70, July 2016.

GDL1

Smart Cities

Selected Design Challenges

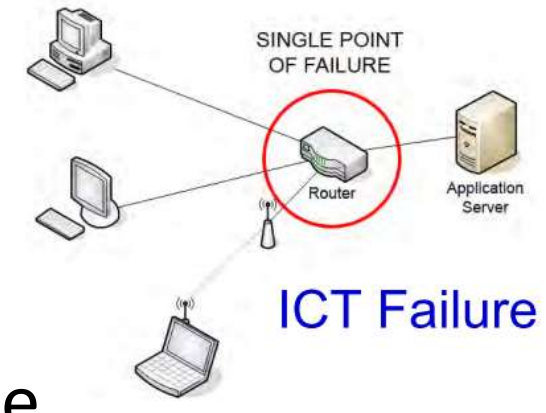


Source: Mohanty 2016, CE Magazine July 2016

Slide 12

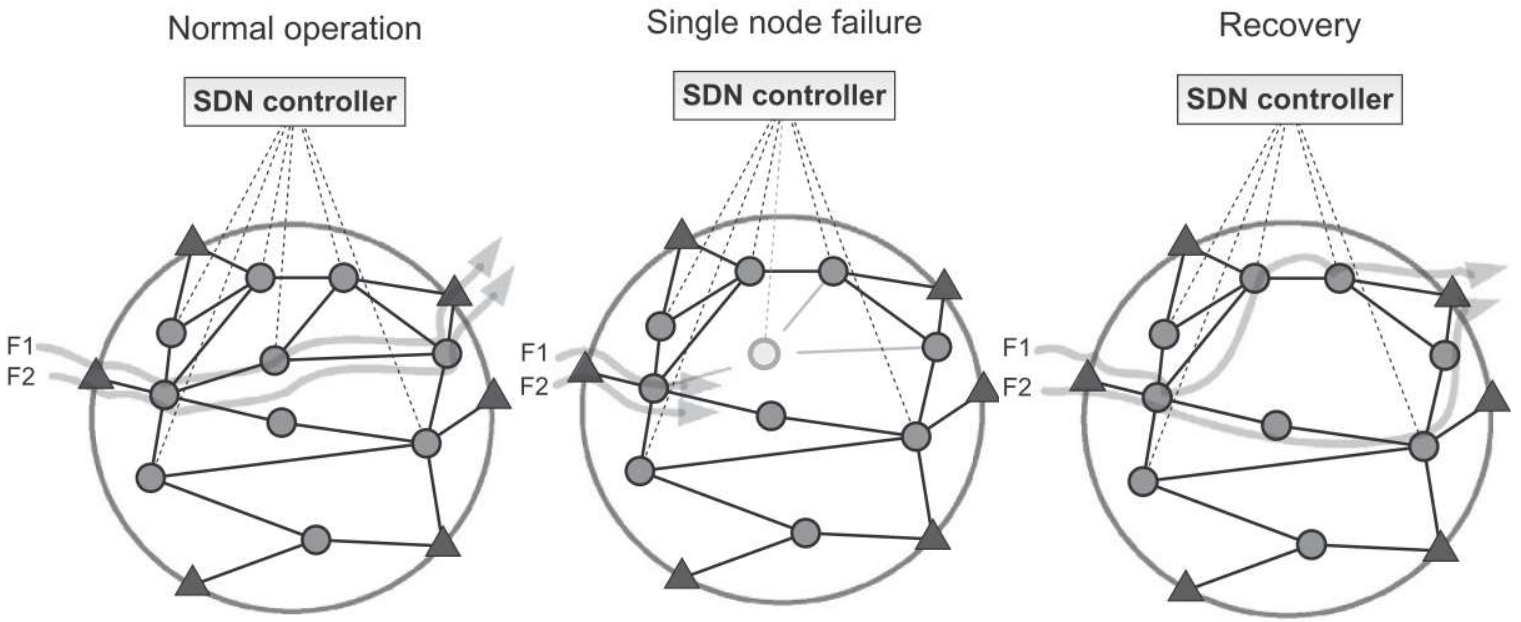
GDL1 Giap Dang Le, 12/13/2018

Smart Cities



Failure Tolerance and Resilience

Control Plane Resilience in NG MONs

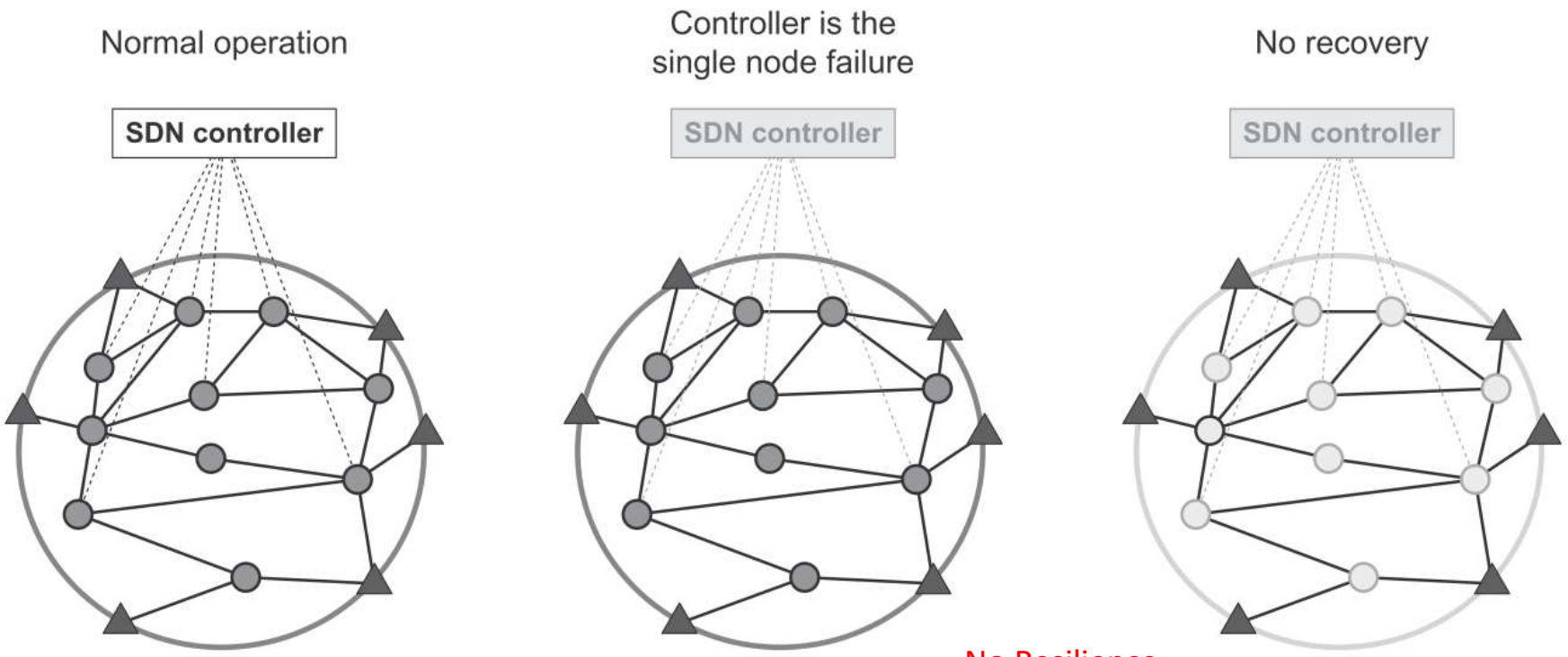


- ✓ **Three steps:**
  - Detect failures
  - Communicate to the controller
  - Recompute the shortest path
- ✓ **Two issues**:
  - Suffer long recovery time
  - Single point of failures in the controller

[2] P. C. d. R. Fonseca and E. S. Mota, "A Survey on Fault Management in Software-Defined Networks," in *IEEE Communications Surveys & Tutorials*, vol. 19, no. 4, pp. 2284-2321, Fourthquarter 2017.

[3] Paul Goeransson, Chuck Black, and Timothy Culver, " Software Defined Networks: A Comprehensive Approach," Elsevier 2017.

Control Plane Resilience in NG MONs



No Resilience

[2] P. C. d. R. Fonseca and E. S. Mota, "A Survey on Fault Management in Software-Defined Networks," in *IEEE Communications Surveys & Tutorials*, vol. 19, no. 4, pp. 2284-2321, Fourthquarter 2017.
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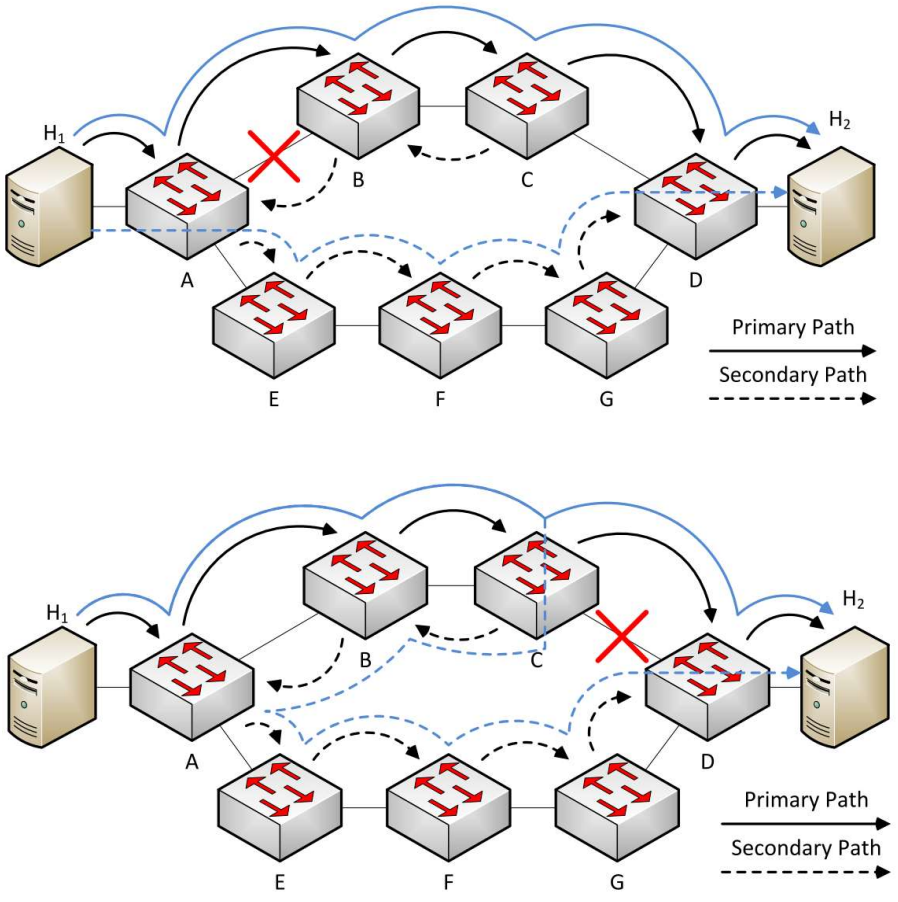
Control Plane Resilience in NG MONs

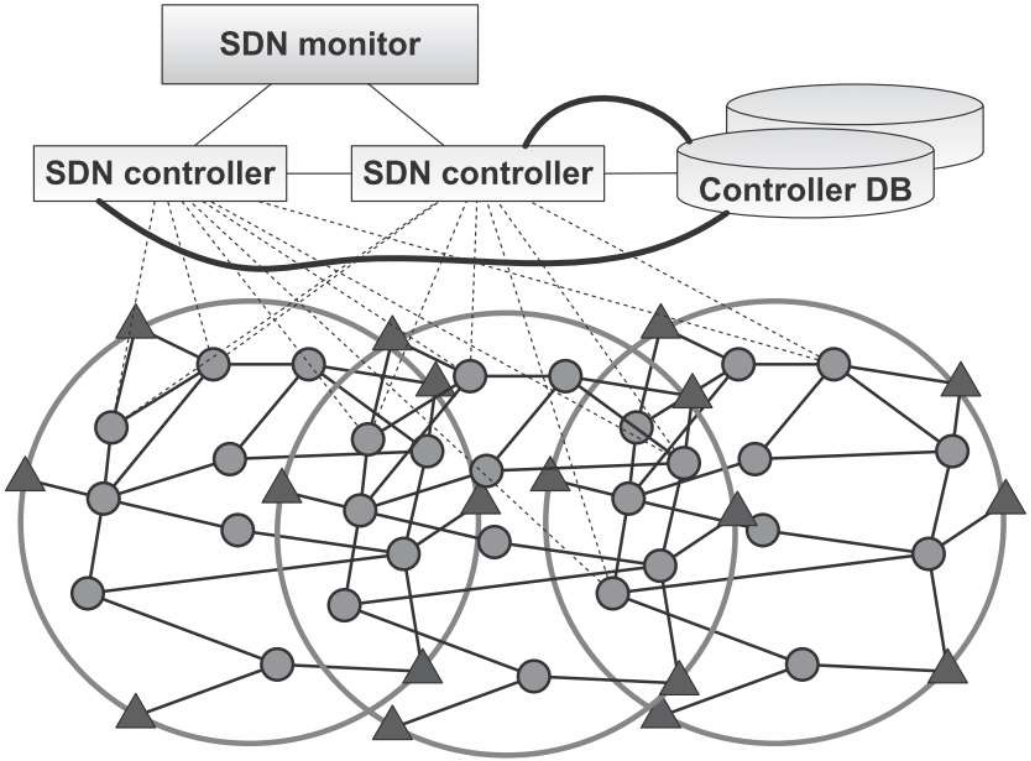
Hybrid (two-step) recovery in SDNs

- ✓ Each node has a pre-configured protection path
- ✓ Fast failure detection using per-link Bidirectional Forwarding Detection (need to read more)
- ✓ First, switches initiate the backup path
- ✓ Second, the controller computes the optimal path after failures
- ✓ May use backup path by crankback



Control Plane Resilience in NG MONs

This might be the resilient metro optical network for smart cities



Characteristics:

- ✓ Multiple, logically centralized, physically distributed, redundant controllers (high availability)
- ✓ Fast failure detection and backup path reconfiguration
- ✓ Backup database for controllers
- ✓ Resilient communications between switches and controllers and between controllers

In Progress Work

- Formulate the problem as an optimization/ ILP problem and simulate on computer programs
- Reading:
  - ✓RASCAR paper (Savas et al.)
  - ✓Other recently published papers to learn opening issues and their solutions
  - ✓Propose our solutions for the metro optical smart city network
- Time line:
  - ✓In the past weeks, did a literature review on what make SDNs resilient
  - ✓Now on, will do reviewing and simulation/calculation work in parallel
  - ✓Really appreciated to have suggestions and guidance from professors and labmembers