Section 4: Week 7: Smart Cities

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# Smart Cities

The Internet of Things (IoT) attempts to widen the interconnectivity of computers to include interconnectivity of objects (Commission of the European Communities, 2009). These objects expose sensors that can aggregate into personalized data feeds.

These objects can share a contextual domain, such as a home, warehouse, or city to form smart locations. As the scope of these smart locations grows, so does the number of user scenarios that can be enhanced.

Developers can harness that data emitted from those scenarios to make intelligent recommendations and provide guidance around optimizations and safety decisions. These capabilities delight the inhabitants and encourage them to interact with more objects, continuing the cycle.

## Problem Statement

On the surface, smart cities are relatively simple constructs; there are some devices, a bit of networking, data published into the cloud, and users interact with it through their mobile devices. Where it becomes complex is during the interactions of each of those core entities.

First, a mechanism for securely interacting with the environment is required. An identity is needed for each entity so that it can connect to the shared wireless network. That network needs to provide security assurances, which comes from Software Defined Networking (SDN) as it virtualizes the topology. Then authorization policies need to control the interactions between both user-to-device and device-to-device traffic.

Second, a mechanism for data discovery and data cataloging is required. If the developers cannot identify the schemas and data feeds, then apps will not be written to utilize them. These feeds will originate from heterogeneously provisioned environments (Balduccini, et al., 2018). Balducci et al. describe a need for decomposing each *aspect* of the environment into

## Goals

## Relevance and Significance

# Literature Review

## Reasoning about Smart Cities (2018)

Balducci et al. define a smart city as a system of systems, including instances of Cyber-Physical Systems (CPS) and the Internet of Things (Balduccini, et al., 2018). They make the argument that the problem space is too ample for a single platform to address every facet of the required design. Because of this characteristic, all smart cities are naturally heterogeneous and must consider interoperability through open standards.

Cross-cutting concerns can be extracted from the problem and separated into distinct aspects (Kiczales, 1997). For instance, the notion of identity can become a centralized service that many devices and users jointly share and trust. The complexity to continue extending the smart city decreases, as more aspects of the system become available.

## IoT Smart City Architectures (2018)

Fahmideh and Zowghi build on this idea that smart cities are collections of connected services and devices. They reviewed nine different reference architectures and looked for commonalities between them. Key differences can be categorized based on which aspects were considered necessary to their designers.

For instance, British designs focus heavily on environmental sustainability solutions versus American Big Tech desired business integration scenarios. Groups, like Open Geospatial Consortium, have deep roots into academia and have extensive capabilities for machine-to-machine yet minimal functionality for users (Fahmideh & Zowghi, 2018).

The diverse collections of aspects provided by the system demonstrate that one size cannot fit all. That uniqueness makes sense, as a *smart city* is an extension of the *physical city* that contains it. Within those physical cities are diverse cultural expectations.

## The success of IoT in Smart Cities of India (2018)

Starting around 2015, the government of India pledged the equivalent of fifteen billion US dollars toward smart cities. Their goal was to purchase one hundred Information and Communication Technology (ICT) locations. They acknowledged that many people were abandoning the villages and moving into urban areas. Those new inhabitants would need access to the Internet and a transition toward purely digital lives (Chatterjee, Kar, & Gupta, 2018).

Chatterjee et al. describe a cycle where people interacted with physical and virtual objects, which in turn generated lots of data. Artificial Intelligence (AI) systems mine the data and propose recommendations. City planning and legislation decisions leverage those recommendations to customize the area to the needs of the people. More virtual and physical objects fill those needs resulting in even more data.

# Approach