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.

## Relationship Between Smart Cities, Policing and Criminal Investigation (2018)

Users of the smart city have specific roles within their community and need data that improve their effectiveness, and efficiency — police, medical, and fire & rescue teams are prime examples of this scenario. In traditional cities, police officers need to rely on eye witness encounters that might be racially biased (Kaja & Bostjan, 2018).

Instead, safety officials can deploy sensors into high-risk environments and record evidence as the crime unfolds. Systems such as ShotsSpotter can detect gunshots and report the incident to an emergency hotline. Unfortunately, these systems are still aways out, but the technology is progressing (Drange, 2016).

## Smart Cities: an IoT-centric Approach (2014)

As technology progresses, it generates an ever-growing volume of data that needs to be efficiently indexed. Smart cars will need to consume data feeds from traffic lights, road sensors, accident reports, and construction schedules, to name a few. One solution is to decompose smart cities into smart city *hubs*, where a hub is a logical unit such as a shopping district or residential neighborhood (Lea & Blackstock, 2014).

Lea and Blackstock examined the implementation of two smart cities, one in the United Kingdom the other in Canada. With both locations, an efficient data catalog was critical to the project’s success. They attributed this to reducing the learning curve, resulting in more developers creating more applications available.

Over the last five years, several American cities, such as Seattle and New York, have created open data platforms. The easy access to data has enabled dozens of high-quality applications; however, they are specific to that location.

Small development studios are willing to build dedicated apps for a given city, but more prominent corporations are unwilling to enter the space. Their userbase spans the entire country and needs it to be usable on a national level. If they must implement a data adaptor of every metropolitan area, the development cost will be too great to justify. Until businesses, city planners, and hardware manufacturers agree on open standards; there will be challenges sharing the data and making it fully discoverable.

## NDN IoT Content Distribution Model (2016)

An alternative solution to making content discoverable is through Name Data Networks (NDN). Under NDN, publishers create signed content under a namespace, and then consumers can request those resources through standardized names. Metadata about those resources can be cached and served directly from OpenFlow routing tables (Shilton, Burke, Caffy, & Zhang, 2016).

The requested names can be relative and can leverage the shared context of the entities logical and physical features. For example, a smart car can ask for the status of the next stoplight by querying name /local/route/stoplight/2. The software-defined network can response with route forwarding policy to the associated RESTful endpoint.

In effect, the query name functions as a small internal domain-specific language. Integrating legacy systems is straight forward as the NDN maintains metadata and pointers. The caller could also encode their desired format, through additional child path annotations (e.g., stoplight/2/foo+xml).

## Smart City as a 5G Ready Application (2018)

The document structure returned from the NDN endpoint, could be given with an arbitrary schema. Network services need to exist for translating into a format understood by the user or device. One approach is to leverage the Service Mesh of 5G infrastructure,

# Approach