Smart Cities: Towards a Functional Definition

Tayo Fabusuyi

T. Fabusuyi
University of Michigan Transportation Research Institute (UMTRI)
2901 Baxter Rd., Ann Arbor, MI 48109
Fabusuyi@umich.edu

1. Introduction

Increasingly, cities and urban areas are perceived as complex adaptive systems [1] with demonstrable emergent properties. Actionable insights on addressing this complexity are being obtained from data generated from smart technologies. However, rarely do these solutions explicitly incorporate the institutional sphere of the environment in which they will be implemented. Consequently, the value-added by these technological solutions can be incremental and sub-optimal at best. My talk will examine why this is the case and it will focus on the interoperability of data; the ill-structured and multi-dimensional nature of the issues at stake; the increasing interlinkages across the different parts of the system and the challenges of addressing goals emanating from a multitude of stakeholders.

Drawing from engineering, public policy and operations research literature, I will make the case for a robust smart cities framework that broadens and enriches conventional design principles to capture the subtleties inherent in many complex systems in the urban domain. This will be done in a manner that puts the community in the driver's seat of the design and implementation of smart solutions, and that promotes an environment of continuous learning. The objective is to create a two-way street approach that facilitates the conceptualization and design of a technological innovation while explicitly reflecting the context in which the innovation will be implemented in a manner that allows the documentation of process and outcome measures. All of this is with a view of identifying what is generalizable irrespective of geography, and what is context specific.

2. Nature of the Problem

Much ado has been made about smart cities; defined here as the "synthesis of hard infrastructure or physical capital with the availability and quality of knowledge communication and social infrastructure" [2]. But what, functionally, makes a city smart? Despite the proliferation of technological deployments in the urban space, only incremental improvements in performance have been documented [3] and oftentimes, these tools do not reflect community needs [4]. These observations beg the question – why the disconnect between smart city initiatives and the challenges cities face?

A plethora of issues constrain against the effectiveness of smart cities programs and rarely if ever is it the case that these issues can be addressed solely from a technological perspective. Mesh networks, for example, may be amenable to being addressed by focusing on the physical domain, but programs such as multi-modal smart mobility initiatives demand a more nuanced and layered outlook. This is particularly the case for smart cities solutions where data ownership and how these data are generated is balkanized among multiple stakeholders.

The proliferation of data in urban settings has made obtaining actionable insights from data generated from smart technologies the norm, and nowhere is this data proliferation more prevalent than in transportation. Geotagged data, for example, reveal a wealth of information including satellite enabled global positioning system (GPS) traces that provide rich breadcrumbs on travel patterns and on the locations people frequently visit. The preponderance of the sharing economy, via the transportation network companies (TNCs) in urban transportation, is directly responsible for the generation of hundreds of terabytes of data daily. However, like isolated pools of water, these data are often fragmented, leading to sub-optimal outcomes of key measure of interest [5].

Earlier research on designing and implementing a smart parking application provides a canonical example of such a situation [6], [7]. A key challenge that was encountered were problems related to data quality and interoperability created by the unique environment in which the smart parking application was deployed. Given that parking garages that featured in the pilot project were owned and operated by completely different entities, public and private, each parking garage had its own "culture" of determining how and when to identify the garage as "full." Addressing this problem requires going beyond a mechanistic approach to data interoperability, from one that focuses solely on the need to harmonize data from multi-domain or different data providers to one that explicitly recognizes the disparate idiosyncratic features that determine the data collection.

More important than the data interoperability issue is the need to address the disconnect between a technology solution and the contextual realities of the environment in which that solution will be implemented. Does the technology solution reflect the needs of the community, or are we solving the wrong problem – colloquially referred to as the "Type III" error? Which stakeholders have a voice and how do we agree on the best form of intervention given the different priorities or versions of truth for each stakeholder? How can we move away from a reductionist mindset to an emergent one that is better suited to addressing the complex, interconnected nature of urban issues? These questions require a framework robust enough to conceptualize and design smart cities solutions while making explicit consideration of the context in which the innovation will be implemented.

3. Proposed Methodology

My talk will provide an overview of earlier attempts that combine urban design with systems thinking with a focus on urban cybernetics [8], [9]; socio-technical systems [10]; or both [11]. The presentation will acknowledge the shortcomings from these approaches. I will attempt to improve on them by borrowing from Lindblom [12] and Wildavsky's social interaction and intellectual cogitation [13] mode of thinking. My basic premise equates the social interaction to the intervention's incremental process and the intellectual cogitation to the smart solution's technical domain. In contrast to Wildavsky, however, I see these styles of policy formulation as complementing each other in a mutually reinforcing manner. Using this approach, I will create a framework that not only addresses the social and technical dimensions of the issue(s) at stake but one that also facilitates community engagement. The balance of the methodology is a learning platform that engages the community in a reflective manner on the process and the key issues, particularly the location-specific (or the lack thereof) nature of the smart city solution. This is with the objective of identifying what is generalizable and what is context-specific with regards the initiative – a crucial requirement on being able to replicate the approach in a different environment.

A key contribution is the use of both a top-down and a bottom-up approach in enlisting stakeholders in defining the problem. This approach mirrors the boundary critique concept of Churchman [14] and Ulrich [15]. Reflecting stakeholders' input in the design process creates a platform on which they could deliberate on the key issues [16], table their concerns and discuss their expectations of the project with the product development team – a provision that furthers community ownership of the smart city solution. The incremental process detailed in the framework will facilitate continuous learning, an important element for which Campbell [17] makes a case, through interacting with and intervening in the system, while the innovative effort is oriented towards the more structured component of the system [18]. I will demonstrate the approach using, in a retrospective manner, a meta-analysis of programs in different stages of design and implementation; examining why some are successes and others, failures. In addition, I will describe how a smart cities solution was designed and implemented. This is with a view of attaining insights on creating a framework that addresses the social and technical dimensions of the issues at stake and which also facilitates community engagement in a learning environment.

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