From Bit to It: The Demand for Networked Building Codes

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An interdisciplinary organization called the City Protocol Society recently proposed a universal format for urban data collection. Noticeably missing is a taxonomy of data-types to enable cross-referencing with an old form of city protocols—building codes. As smart cities move from data collection toward predictive formulas, this article argues that both smart city data and building codes must adapt to share attributes and test operations. Using computational theory as a framework, the reorientation of building codes toward networked response is considered as a link between urban material performance and the next phase of smart city formation.

FROM BIT TO IT

Today's smart city dialogue is advocating a move from information collection and system optimization toward a more integral use of data in defining the actual form of the city. One might say we're trying to move from 'bit' to 'it.' In order to make this critical leap from analysis to instrumentality, we must accept quantum physicist, John Archibald Wheeler's "it from bit" hypothesis[1] and identify the attributes and interactions of information as the fundamental particles of the city. An organization called the City Protocol Society has taken a necessary first step. In collaboration with urban studies experts, software engineers, and city leaders, this group drafted a classification and hierarchy of data types for the universal city. The goal of the "Foundation Ontology for the City Anatomy," published in May 2016, is to produce something akin to the internet protocol, but in this case for the "internet of cities".[2]

Although remarkable, both in its aspirations and its early drafts of formulation, the City Protocol document shows signs of falling into a typical smart-city trap. In its efforts to remain universal, the new protocol is failing to build in adaptation of existing city data-structures. Noticeably missing from its first document is a taxonomy of data-types that would enable reference to an old form of city protocols—city building codes. If this forward looking system is to launch the city's future, this article argues that it must incorporate and adapt to the granularity and boundary conditions of existing encoded systems.

Building codes have staying power due to their legal status, and understanding their efficacy and unintended consequence is immediately useful. However, more importantly, building codes tackle critical hurdles—including evidence and agency—directly related to the processing of smart city data. Furthermore, using the data structures as a framework, building codes have the potential to be fundamentally reconsidered.

This article will describe a required restructuring of building codes through a computational theory to offer the following potentials: (1) spatialized historic codes provide references for understanding data interactions, evidence of heuristic rule-based experiments played out over a century of city-formation, (2) current codes have agency to transfer information to the production of the built environment now and (3) future object-oriented codes can shift from static regulation to live, emergent equilibrium machines. By dissecting the impact of our oldest rule-based city system we can refine the interaction algorithms of today's urban bits.

SMART CITY PROTOCOL

The City Protocol Society was spearheaded by a partnership between Barcelona city officials and Cisco Systems. This effort is one of the more substantively intelligent developments in the smart city movement because it recognizes that the real smart city challenge has little to do with available technology. We already have the sensors and processing power to collect and analyze reams of real-time city data. What we lack is an obvious set of rules to help us understand data interactions and effects.

Consider the result when 1960s meteorologist Edward Lorenz rounded a few decimal places off of one weather simulation parameter. A tiny tweak led to drastically different cumulative weather patterns in what is now known as "the butterfly effect."[3] In 50 years of refining weather simulation, we've learned that not only do we need accurate data and fast processing, we also need to understand interactions, particularly boundary conditions such as atmospheres and the oceans.[4]

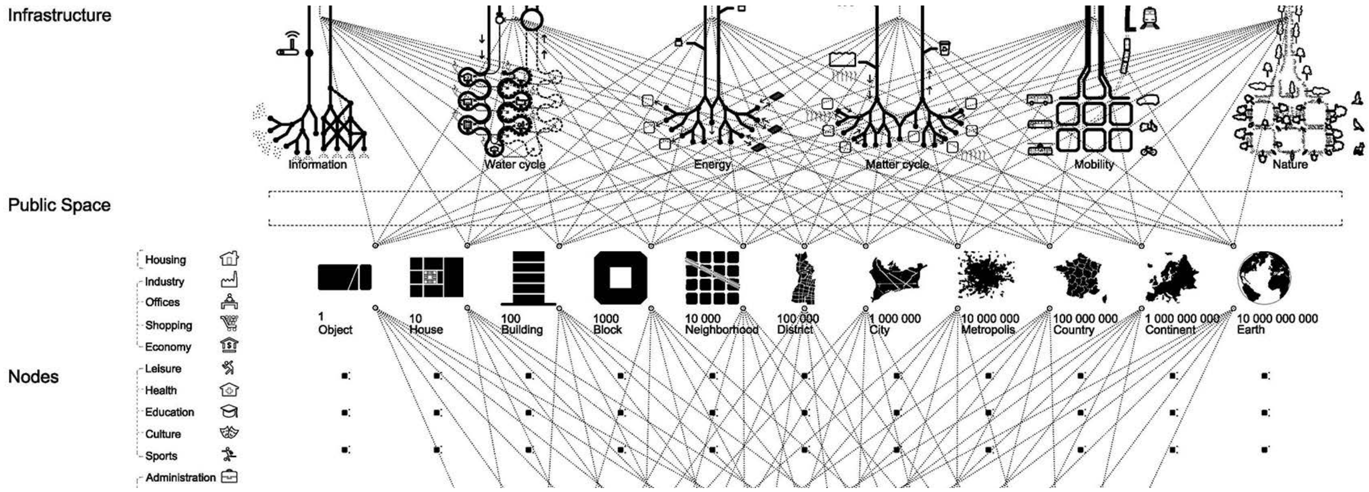


Figure 1: city data hierarchy in the smart city protocol © City Protocol Society

The City Protocol Society uses computation as an intellectual framework to define the systems of the city, name their attributes, and identify their relationships. They've sought to make these systems explicit (unambiguous), formal (machine readable), and shared (accepted by a group).[5] We can build on this effort, using a computational programming framework to consider how building codes might be adapted and integrated.

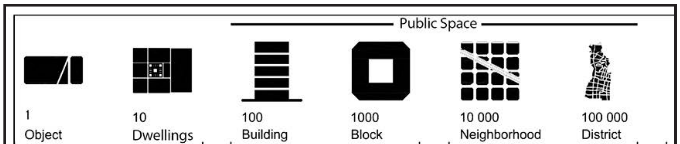
YOU DOWN WITH OOP?

In computational theory, an object has a very different connotation than in architectural theory. Rather than the implying controversial opposition between (building-)object and (context-)subject, objects within computer programming refer to networked data-types, embedded with intelligent relationships to context. For example, object-oriented programming (OOP) languages, such as Python, Java, and C++ enable customizable, intelligent objects (data classes) with associated instructions. Often, those instructions are contingent- upon or adjust-to the value of the object itself.

A restructuring of the building code paradigm is required to integrate them into the smart-city protocol. Rather than pure definitions and lists of instructions, we need to organize sets of rules as they radiate around and are contingent upon intelligent computational "objects." In this restructuring, the types of information monitored by the codes will be central. Those data types will then be tied to instructions, attributes, and operations. This would not change the legal rules themselves, but it would reorganize them into addressable pieces of information.

In this scenario, smart-object types might include construction type and occupancy, examined according to city-scale patterns and correlations to reveal otherwise invisible urban boundary conditions. The "orienting" between data and context not only makes city behavior and its connections to data more legible, it also allows either prescriptive or performance-based rules to adjust to those patterns. For example, how might we consider the choice of appropriate construction material based on resource scarcity, local industry expertise, or neighborhood-level material performance within a one-block radius?

THE BUILT DOMAIN



Class	Value Restriction
Built_domain	Structure_layer_component **some** Built_domain_element **some** Urban_function
Built_domain_element	CityAnatomyThing
Generic_built_domain_element	Built_domain_element
Specific_built_domain_element	Built_domain_element **some** Cost **some** Impact **some** Ownership **some** Use **some** sc:Place **some** Urban_function
Object	Generic_built_domain_element
Building	Physical_built_domain_element
Block	Physical_built_domain_element
Neighborhood	Physical_built_domain_element
Public_space	Specific_built_domain_element **value** public_use **some** publicly_owned
Use	CityAnatomyThing *private_use* *public_use*
Land_Use	Use *agricultural* *commercial* *industrial* *recreational* *residential*
org:Ownership	OrganizationThing
org:privately_ owned	org:Ownership
org:publicly_owned	org:Ownership
org:charitable_owned	org:Ownership
org:government_owned	org:Ownership
Cost	CityAnatomyThing Maintenance_cost Operation_cost Production_cost
Urban_function	CityAnatomyThing
Impact	CityAnatomyThing

Figure 2: built domain data types © City Protocol Society

In its current draft, the city protocol consists of three data domains: environment, infrastructure, and the built domain. Algorithms for interactions are defined according to local economy and culture, and measured by their effect on society. With its overall data structure in place, the protocol team's current focus is now determining the systems of interaction. This effort is divided among six active task teams, with foci ranging from resilience and security use-cases to building energy and emissions. Three more proposed task teams include promising titles such as "urban fabrics."

By studying data types and attributes published in the "Anatomy Ontology" document, we can begin to see what information will be accessible and what is in danger of remaining invisible. For example, it's encouraging to see "impact" as a class within the "built domain." Impact is currently measured according to three value variables: "economic_impact," "environmental_impact," and "social_impact."

However, the built domain (Figure 2) does not currently reach a level of granularity to enable interoperability with building codes. There is no reference to information such as material, density, zones, or occupancy. A building "function" variable is the closest the protocol comes to a municipal code-like descriptor. However function values reveal a city-centric logic—"health", "sports", "living", "working" are descriptions referring to urban ingredients. Building occupancy, by contrast, denotes structural and safety requirements, regulates heights and materials, and sometimes sets allowable locations. Being more specific about building use ties it to the evolution of city forms.

If building code information is not addressable within the city data protocol, we cannot point to it, cannot analyze its impact on or within the urban system, and most importantly cannot use it to create smarter regulations—that is, to create a smarter city.

PROTOTYPING CUMULATIVE EFFECTS: THE MATERIAL CITY

In an effort to prototype the potential of an object-oriented building code, the author's research practice conducted a city-scale data query of what we call, the "material city"—an analysis of material construction type as a representative data object pulled from the building codes and analyzed at a city scale. Chicago, IL and Denver, CO serve as our first prototype sites due to their large, accessible open-data stores.

The categorization of material construction types, from 'Type I' (non-combustible) to 'Type V' (unprotected, combustible) in our building codes emerged at the turn of the century to mitigate the threat of urban fires and evolved to meet highly localized conditions. In this way, construction types fit the description Ryan Smith recently used to discuss building technology as a set of abstract systems. "Most of them are correct, but many, when dissociated from their cultural underpinnings of building vernacular, and more importantly, their scientific basis and practice contexts, present challenges that cause buildings not to perform as intended, or worse, lead to physical economic, or social catastrophe."[6]

Urban fires themselves were unintended consequences of early city ordinances. For example, Chicago's early nineteenth-century decision to consolidate industrial land along the river, and to end "fire limits" outside of a then-small central business district allowed affordable

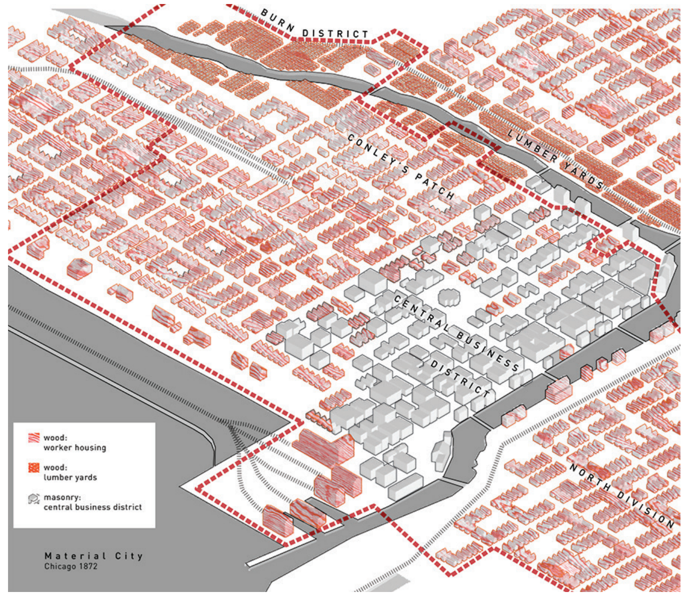


Figure 3: Chicago's material city, 1872 © Ripple Architecture Studio.

worker-owned wood-frame housing in most of the city.[7] The unintended result (Figure 3) was a lumber-yard fuse stretching along the river to ignite worker-housing kindling during the Great Fire of 1872. Codes have progressed to address threats to life safety at a city scale, but they also isolate one aspect of building-centric performance at a time. Data objects like construction-type are rarely analyzed against other city-wide correlations such as economic opportunity or social equity.

Our study redraws neighborhood boundaries according to construction type and highlights what we call the "Type V city" as the zones of dense wood-frame construction. We observed correlations between the boundaries of the Type V city and other vulnerability trends.

In Chicago (Figure 4), a clear correlation exists between low income blocks, high crime rates, and the Type V city. In Denver (Figure 5), the type V city is economically segregated. Type V neighborhoods are either high or low-income, not mixed. Type V zones are also more vulnerable to economic fluctuation. Most foreclosures between 2003 and 2012 were isolated within the Type V City. Because of the short life-span of Type V construction materials, it is believable that these structures are either depreciating assets or a larger financial burden during ownership. For the same reasons, the Type V City is also vulnerable to urban decay, a known health and welfare hazard.

The Type V city is built from vulnerable materials. Vulnerable materials repeated at a neighborhood scale are likely to exacerbate existing economic and maintenance challenges. Our analogue codes have produced clear lines, some intended, some by-products of limited scope. Yet our codes resist this level of scrutiny by narrowly considering material performance.

The object-oriented code offers an alternative, an active response to complexity and nuance. Rather than a list of material types defined only by combustibility, location within a single structure, and allowable occupancies, the object-oriented code would consider material as a class, with attributes, value restrictions, and operations.

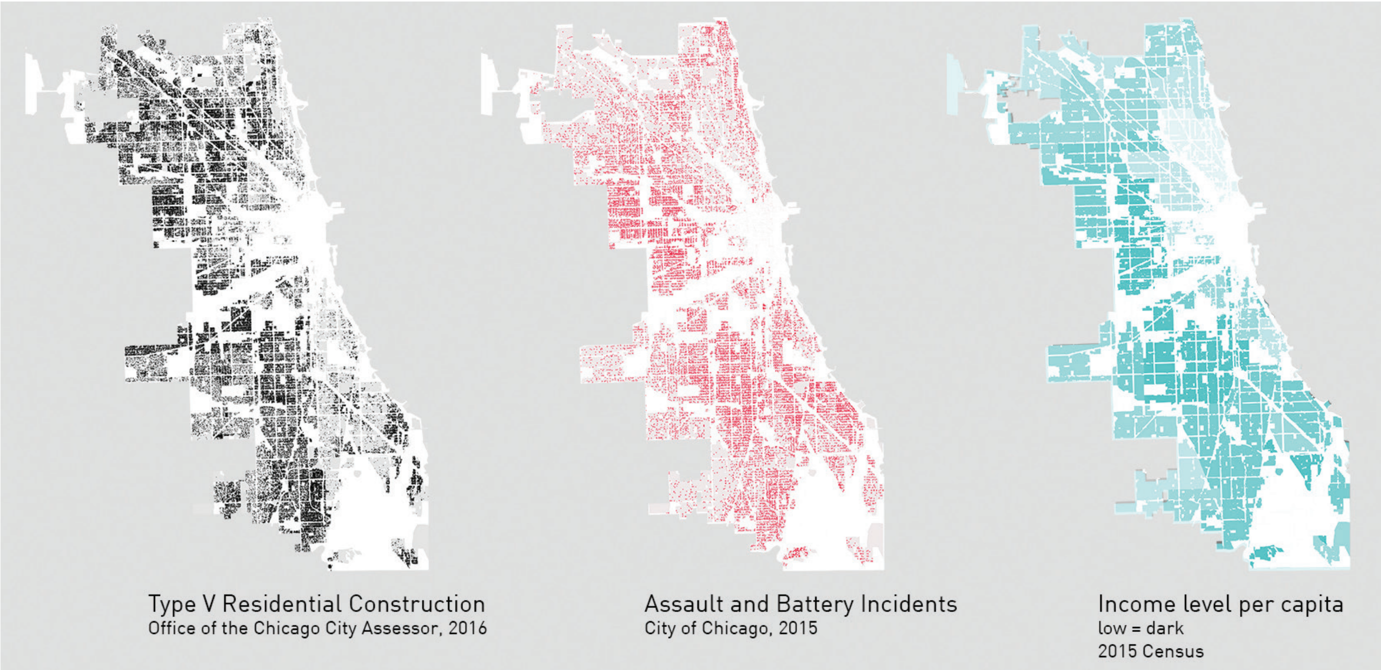


Figure 4: Chicago's Type V City, 2015 © Ripple Architecture Studio.

Combustibility and structural strength will remain important material attributes. In addition, measurable qualities such as thermal performance, embodied energy, maintenance and life-span averages could be embedded. Other attributes would allow us to tie materials in the built domain to social, economic, and industry trends. These might include associated labor trades, cost, cultural significance, percentage of renewable resources, research dollars spent, or associated patents filed by year.

CONCLUSIONS

The United States Environmental Protection Agency advertises examples of forward-looking communities using "smart codes" to enhance their cities or commercial centers. For example, Peoria, IL boasts that it will "reinvigorate 8,000 acres of residential and business areas" using a form-based code that includes 'illustrated, generic building form and architectural standards."[8] In Peoria, like most communities declaring the use of "smart codes," the system remains a static rule-book with no built-in mechanism for feedback. The claim to "smarts" references only use of the latest planning practices rather than embedded testing mechanisms.

By reframing building codes as a series of smart objects, objects that gather information and act upon that information, the current frame of reference for municipal codes moves away from a centralized, top-down attempt to predict and enforce toward a responsive, opportunistic equilibrium-seeking system. If embedded into the logic of a universal city protocol, trends and strategies will be indexed and analyzed across cities. Guidelines will respond to emergent, networked interactions of space, resources, and users. Hard lines of code-defined zones (implicit and explicit) will give way to shifting gradients.

Keller Easterling describes standards as the infrastructural "secret weapon of the most powerful people in the world… because [they] orchestrate activities that can remain unstated but are nevertheless consequential."[9] By reframing building codes as object-oriented systems and integrating them into a shared city protocol, today's invisible code-driven impacts will become explicit instruments informing smart city management and creating smart urban space.

ENDNOTES

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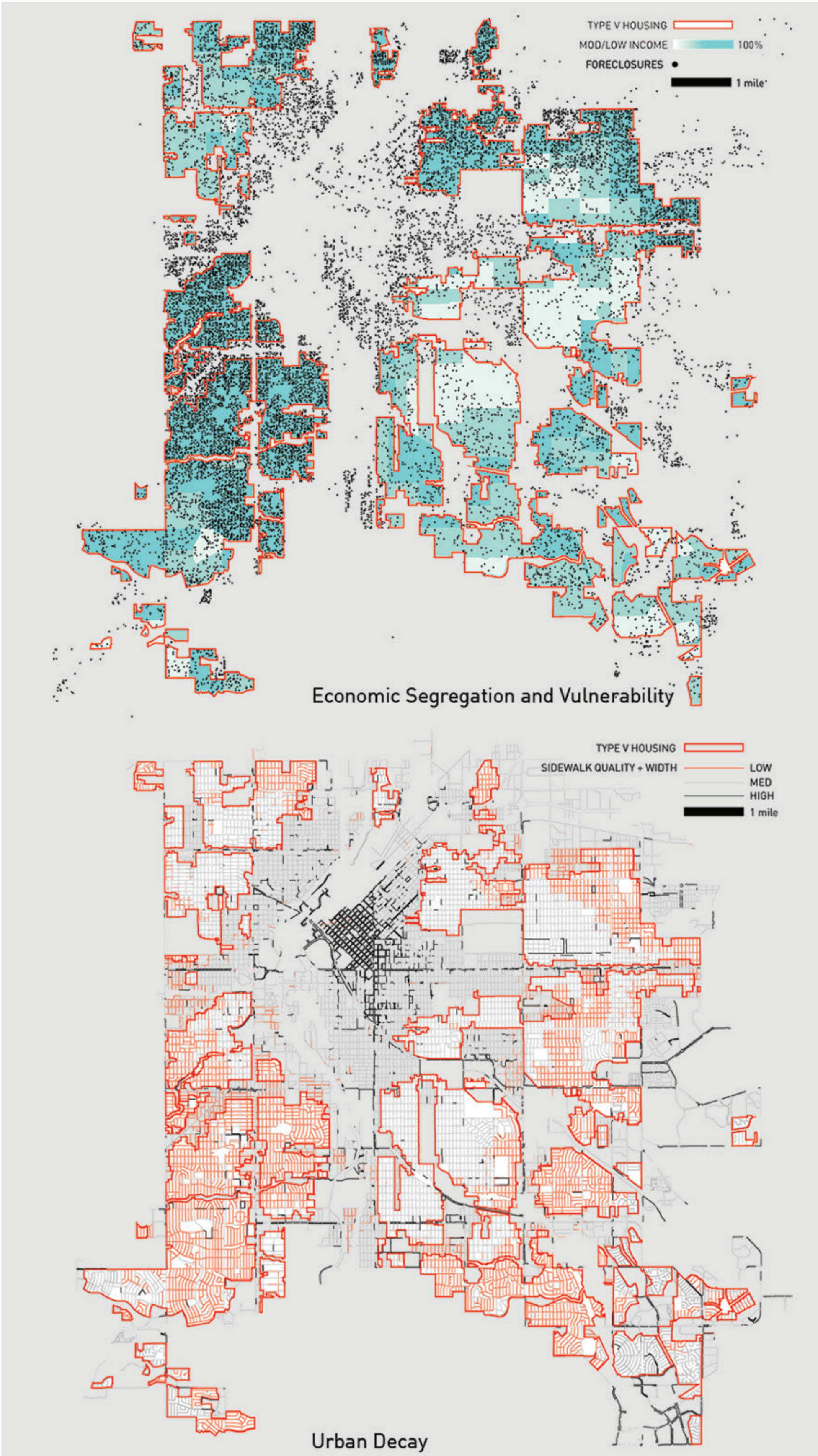

Figure 5: Denver's Type V City, 2015 © Ripple Architecture Studio.