Dynamic Network Model in Urban Design: Structure Effects

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Abstract— **We present research on the integration of network model and visual analytic paradigms to understand structure effects in urban design decisions on Charleston peninsular. Our goal is to consider the physical environment and social dimensions simultaneously. The architectural brief is a conceptual urban infrastructure proposal for the Clark Parkway site on Charleston Peninsular that directly confronts issues of occupation, circulation, form, and access to downtown facilities. Combining the efforts of twelve designers of architecture and landscape, with a consulting team of city planners and transportation engineers, we develop a taxonomy of location property, physical connectivity. This taxonomy constitutes preliminary network model heuristics for dynamic assessment for in urban design settings.**

I. INTRODUCTION

In fast-developing cities, our physical environment and social systems have become dependent on networks of enormous complexity.The overlapping phenomenon has made the behavior of these systems increasingly hard to reason about and risky to tinker with. The idea of networks has made its way into this discussion at both general and local level. Because the flexibility of networks, it's especially applicable to depict the structure of urban infrastructure and provide the framework for reasoning about the behavior and interaction with in network context. Our interest in urban network model investigates the relationship between the flow of people and the urban form of the city. Our effort is focused on developing pre-design methodology and understanding of project existing conditions using specific on-going evidence of transportation as an indicator of the spatial accessibility in the city, and conversely how the network structure of the urban grid influences people's behavior. Transportation data is an ideal empirical source for such an analysis, combining spatial, temporal and topical information and providing large data sets for analysis. It is important and naturally structured data.In this paper, we present two models of how to approach the analysis and use of transportation data. The first one focused on accumulating and assorting large-scale spatial data. The second is a visual analytic interface. This work provided multi-dimensional views and we continued to use the insights to propose design strategies for targeted site.

II. PROJECT BACKGROUND

A. National Policy (Urban Renewal)

In 1967 a new thoroughfare linking the recently completed Interstate 26 with Highways 17 South and 17 North, providing for the first time in recent history, a direct connection between the East-West and North-South major roadways through the peninsula. Developed at a time when a federal strategy utilized major urban infrastructure projects to establish a modern national, interconnected road system and to purge urban centers of blight and under-performing business cores. This formalized national policy came to be known as Urban Renewal, affecting cities throughout the nation. The political climate at the time prioritized rebuilding of Americas cities to improve economic development. Using public infrastructure projects such as multi-lane, high speed road systems and other large redevelopment strategies, systematically purged urban cores of business districts, neighborhoods and other institutions, with the intent of re-charging city centers and encouraging new public-private investment. City centers had deteriorated significantly and accelerated white flight to the suburbs resulting in significant shifts in the demographics of urban areas, reducing tax bases and diminishing business and commerical enterprises.

B. Maintaining the Integrity of Historic Charleston

Charleston officials were eager to improve economic development as the economy of the city as had bdeen stagnant since the Civil War. Prioritizing economic development by means of highway infrastructure meant there was little empathy for the plight of established neighborhoods in the path of the thoroughfare. The route through the peninsula was determined largely on engineering prerogatives with less regard for the integrity of established neighborhoods and cultural imperatives. What resulted is a pathway that bifurcates the western peninsula and disrupts the extant structural block patterns. As a peninsula, Charleston presented particular challenges to connecting development communities to the south and north separated by two major rivers, resulting in the thoroughfare as is presently constituted. The roadway is officially named Septima Poinsett Clark Parkway but is most commonly known as the Crosstown. The thoroughfare is 50 years old and continues to be a major arterial as well barrier in the city. City government has invested millions to improve drainage and streetscaping to improve the Crosstown in recent years but little has been done to address the roadway as a barrier and pedestrian safety issues.

III. DYNAMIC URBAN NETWORKS

This idea of network is found in many incarnations: in the rapid growth of the Internet and the Web, in the flow of traffic as well as urban development around the world with surprising speed and intensity. These are social phenomena that involve networks, incentives, and the aggregate behavior

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of groups of people; they are based on the links that connect us and the ways in which each of our decisions can have subtle consequences for the overall outcomes. There are three distinct reasons why we employed in large-scale studies of networks towards urban infrastructure. One is about the interesting broad picture. Another is that we're using the model as a proxy for a related network that may be impossible to measure in reality. A third possibility is that by looking into network properties, we found a similar effect in unrelated settings which can suggest that it has a certain universal nature. These motivations are working simultaneously in this research.

A. *Graph Theory*

Graphs are powerful mathematical models of network structures, appearing in many domains, whenever it is useful to represent how things are either physically or logically linked to one another in a network structure. For urban infrastructure networks, quantitative planning techniques like contraction hierarchies (Geisberger et al. 2008) and transit nodes (Bast etal. 2007) enable shortest path computation in the least time on graphs with a finite number of nodes and edges.

B. *Structural Models*

Digital maps are most accessible sources of urban dynamic network; nodes represent locations and directed edges represent links from one location to another. Location stands out both in its scale and role. Urban facilities are wired together by links. And clearly it is not just the architecture as a node that is of interest, but the social and economic structures that stand behind the physical environment.

C. *Structural Balance for Networks*

Structural balance principles are based on research theories in social psychology dating back to the work of Heider in the 1940s [2], and evolved to the language of graphs beginning with mathematicians Cartwright and Harary in the 1950s [3]. The strong argument of structural balance is that because unbalanced triangles are sources of stress or psychological dissonance, people strive to minimize them in their personal relationships, and hence they will be less abundant in real social settings than balanced ones. Fig.1 shows the Heiders POX diagram:

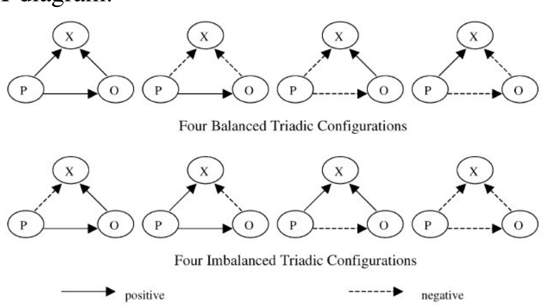

Fig. 1. Balanced and imbalanced triadic configurations.

D. *Limitations of physical Networks*

Oriented towards the urban infrastructure network, we need to consider the limitation of formulating the structure of physical networks. In particular, our network model thus far has been fairly dependent on two respects:

- It applies only to complete graphs. While the city boundary is open and expanding, not tactic or closed.
- Additional resources to an urban infrastructure network can affect performances at balance. This was articulated by Dietrich Braess in 1968[4]

Even with these limitations, the balance structure still suggests an applicable way that we can assess the urban networks from a local view as well as a global view, and generate high-dimensional insights and knowledge.

IV. Design Strategies

We now switch our discussion of structural effects from the urban network level to the local design strategy level. The links in the social network encode strong ties, where the two endpoints of each link attract each other. We consider situations where coordination across broad social networks is important, and the underlying resonance is serving to stimulate people's willingness to make connections. The procedure worked in two main steps: the first step is to convert the network to a reduced graph in which there are only negative edges, and the second step is to solve the problems on this reduced graph by establishing connections over negative edges. We defined each intersection of street and avenue as location nodes and assigned the nodes with geographical and social properties, the physical environment was transformed into dynamic digital networks which provide support for urban design research.

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