By Robert C. Hampshire and Tayo Fabusuyi

The Pittsburgh Cultural District is home to the arts and entertainment scene supported by the Pittsburgh Cultural Trust (PCT), a nonprofit arts organization established in 1984 to lead the cultural and economic development of downtown Pittsburgh, primarily through the use of the arts. Since its inception, the PCT has seen significant increases in attendance and patronage in and around its venues. This development has placed considerable strain on the existing amenities within the district, particularly parking facilities, and the situation has been further compounded by the scale of sports activities on the North Shore and the added demand for parking from fans there.

To address this problem, PCT, with funding from the Benter Foundation, initiated ParkPGH, a smart parking system that uses historical parking and event data in a prediction model to provide real-time information on the availability of parking in the cultural district's eight parking facilities. The program enhances the existing off-street parking facilities within the district by providing real-time parking information through a host of information delivery methods, including an iPhone application, traditional and mobile websites, text messaging, and an interactive voice response system.

Figure 1: ParkPGH representation of Pittsburgh's downtown map with available parking spaces

The architecture and software development for ParkPGH were completed by technology and design firm Deeplocal, Inc. The primary goals of the program are to reduce search time and search time variability when finding a parking space in the Cultural District and to reduce anxiety related to parking issues, making it a more desirable destination. Other goals include reducing late arrivals to PCT performances, decreasing greenhouse gas emissions and congestion by reducing circling to find a parking spot, and attracting new patrons who were previously deterred by the uncertainty of parking availability.

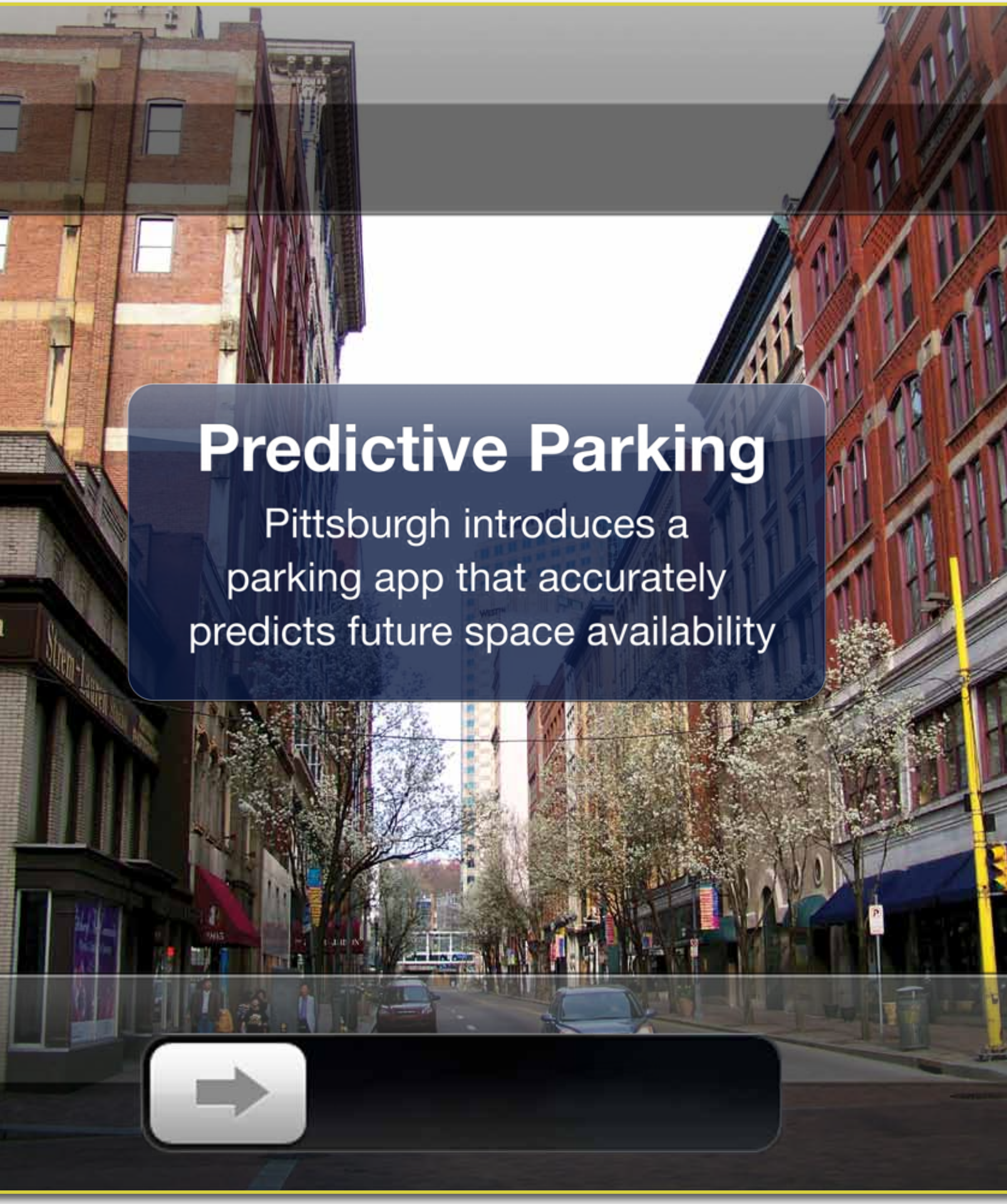
Technical Approach

We have employed an innovative approach that combines system development and integration with a parking prediction algorithm. The system development and integration module collects real-time parking information from both public and private parking garages. This was made possible through the use of a web API and infrastructure that collects, validates, and stores parking information in real time. The system integration also includes the development of an iPhone text message gateway, and an API that provides third party developers access to the ParkPGH data.

The prediction model uses as inputs historical parking and data on events occurring downtown, and provides estimates of the available parking spaces for each garage. The prediction model was trained on a historical parking data set. This dual-prong technological innovation was deployed through a pilot program that monitors eight parking garages with a total of 5,000 parking spaces, representing approximately 20 percent of the total parking supply in downtown Pittsburgh and more than 90 percent of the total parking supply in the cultural district.

Parking information that is updated every minute is delivered through channels that include websites, the iPhone app, SMS text, voice, and a mobile version of the website that provides the same information as the traditional website, optimized for mobile devices such as BlackBerry and Android phones.

Our development team embraced traditional traffic sign colors to provide information to patrons looking for parking spaces. The green, yellow, and red color coding is complemented with numerical figures that show the number of available parking spots, except in cases where a garage is deemed full or close to full capacity. A snapshot



Predictive Parking

Pittsburgh introduces a parking app that accurately predicts future space availability

Figure 2: ParkPGH iPhone Predicted Parking Demand

of the website showing destinations within the Cultural District, garages, and the available spaces is provided in Figure 1.

The iPhone app and mobile website feature scrollable views that list each available parking facility and its parking space availability. Clicking on a garage reveals more information, including the facility address, map, and pricing. In addition to parking garage information, popular destinations are displayed so visitors can locate their targeted destination and find the closest available parking.

Figure 2 is a screenshot of the ParkPGH iPhone application. It shows both the real-time and prediction capabilities of ParkPGH. In the pictured scenario, a popular garage, Theater Square, is currently designated as "Near Full." In addition to this real-time information, a plot of predicted parking demand is provided on the lower half of the screen. The predicted parking demand plot shows the average or baseline parking demand for the garage based on historical data. Additionally, the demand exceeding the average is also provided. In this scenario, the excess demand is predicted based on two events occurring near the Theater Square garage that will influence future parking availability. This predictive capability is a distinguishing feature of ParkPGH.

Key Management Challenges

One of the key challenges we encountered in implementing ParkPGH was a problem created by the unique environment in which the smart parking application was deployed. The parking facilities featured in the pilot program are owned and operated by entities with different management structures. The fragmented ownership and diverse management structure make it extremely difficult to design a standard approach that will be amenable to all the garages. When the project was conceptualized, it was thought that there was a uniform method of determining the number of currently available parking spots in the garages, along with a way of determining when the garage could be identified as being full. However, each parking garage has its own method of determining how and when to identify the garage as full. Variables that factor into that decision include the number of leased spots to hold open, use of valet parking, the threshold level at which the "full" sign goes up, and garages that distinguish between hard and soft full.

This lack of standardization made for significantly increased complexity in the algorithms used in the ParkPGH application. We have addressed this, in part, by developing a novel web portal for garage managers. This platform allows the documentation of lease management strategies and process issues that shape the idiosyncratic features exhibited by some garages. The information is shared with the software development team to allow these garage-specific traits to be taken into consideration when the smart parking application is being fine-tuned. Secondly, we have accommodated the subjectivities emanating from different management structures through the level of granularity of information provided. An example is the decision to suppress the information on the number of parking spaces available when the garage is deemed full or close to maximum capacity. The possible options by which information is relayed to the public were pilot tested to ascertain the ideal level of detail, especially when garages are close to full capacity.

Evaluation and Impact Assessment

An integral part of the product development phase is the evaluation process. The objective there was to establish the value added by the program and provide information that could be used to make modifications to the smart parking app. The evaluation includes a summative and a formative evaluation piece, with the summative module identifying progress made towards ParkPGH program goals and the formative evaluation providing the core of a feedback mechanism that generates information on usability and accuracy of the smart parking tool to program developers.

Findings from the evaluation reveal that one out of every two respondents says the application has reduced the time it takes to find a parking space. The magnitude of the reduction in search time ranges from as little as a minute to more than six minutes, with the majority of individuals reporting a four to six minute reduction in search time. We have used this information to estimate the program's impact on the dollar value of reduced gas expenditure, congestion reduction benefits, and the time value of money. The annual impact is estimated at $313,272 and the annual potential impact at planned full-scale deployment is estimated at $1,253,089. A crucial assumption is that the observations used in generating these figures is representative of the population sampled.

This information and the accolades generated by ParkPGH have encouraged the PCT and other key stakeholders to scale up the pilot to cover downtown Pittsburgh. Added functionalities are also being planned that will increase the app's functionality.

Authors' Note: *We would like to thank Marc Fleming and John Mumper of the Pittsburgh Cultural Trust for guidance and Merrill Stabile, Jim Funovits, and Don Levkus from Alco Parking for providing us with the parking data set, events calendars, and many valuable suggestions. The Pittsburgh Parking Authority and the Pittsburgh Downtown Partnership were also instrumental in the success of ParkPGH. Thanks are also due to our co-authors, Katsunobu Sasanuma and Victoria Hill. Finally, we would like to acknowledge Deeplocal Inc. for building the ParkPGH application. This work was supported by the Benter Foundation and Carnegie Mellon University initiative called Traffic 21.*

ROBERT C. HAMPSHIRE is assistant professor of operations, research, and public policy at Heinz College, Carnegie Mellon University. He can be reached at hamp@andrew.cmu.edu.

TAYO FABUSUYI is the lead strategist at Numeritics, a Pittsburgh based consulting practice. He can be reached at Tayo.Fabusuyi@numeritics.com or 412.542.5005.