The Parking Project

By Tony Dewan

At a large, metropolitan, commuter university, one of the most frustrating things as a student can be the simple task of parking. At Indiana University Purdue University Indianapolis, a substantial majority of students drive to campus. Very few students live close enough to walk, and many of those that do often wish to drive during adverse weather.

As with any traffic related problem, there are certainly patterns and varying degrees of difficulty. For example, as schedules and enrollment adjust over time, parking difficulties invariably ease. Moreover, peak hours exist throughout any given day, influenced primarily by class schedules. During these peak hours, parking facilities are often not able to adequately meet demand. At the same time, traffic eases greatly during early and late hours, as well as later in an academic term. However, on a whole, finding a place to park can be a significant struggle for students, faculty, and staff.

This project aims to develop recommendations to improve the interactions of users of a particular parking system by designing tools and systems using appropriate technology, while respecting the goals and needs of stakeholders. In short, the goal of *The Parking Project* is to find ways to appropriately apply new ideas and new technology to make it easier to find a place to park.

What is This Document?

This document serves as a defense of ideas; it is a container to hold the recommended improvements and designed interactions, as well as the research and thoughts to back them up. To that end, this recommendations document is divided into two main parts:

1. Research
2. Recommendations

Research will help to adequately define the problem; it will help illuminate constraints. Constraints are derived from both the needs and desires of users, plus predefined aspects of the parking system. This will provide a foundation for the next section.

Recommendations will show how that research has been applied to discover new solutions to the stated problem. It will define an overarching system that improves the parking experience within observed constraints. Finally, it will include a case study to show how recommendations could be applied incrementally, within an existing framework.

A Point About Terms

The term *system* is used in this document extensively to describe the overall organism of parking at IUPUI. It is a generic term meant to describe the interconnectedness of the discrete and disparate actors and places: parking lots, parking garages, parkers, spots. It does not describe any particular installed technology or system provided by a third party.

Research

This research is divided between user research and research into the current system. User research contains both stakeholder and user interviews. Research into the current system provides facts and insights into the physical and technical context for which the recommendations should be designed.

User Research

In order to perform useful user research, the distinct groups of users of the parking system needed to be defined. The user base of the parking system are easily segmented into *parking services* and *parkers*. The *parking services* group, as the representative of the universities interests, is the primary stakeholder for this system. *Parkers,* who can be further segmented (i.e. students, faculty, staff), are the primary users of the system. The perspectives of each group are crucial in designing solutions that adequately meet the needs of everyone involved.

It should be noted that other, secondary groups do exist. These are tangentially influenced groups whose impact is not necessarily clear or important. For example, since the main thoroughfares of this particular university are also important roads in the Indianapolis road system, those drivers who may use these roads, but who are not associated with the university, represent another user group. However, the goals of these users overlap with the general goals of the primary user base, and so are not as important to consider as a separate group.

Parking Services

The mission of *parking services* is "Getting the campus community to their destination efficiently, conveniently and safely." *Parking Services* is tasked with the administration of the whole parking system at IUPUI. As such, their needs and goals are necessary to take into account and design for. In order to gain a better understanding of the needs, goals, and perspectives of this important group, Fred Hoover, Office Supervisor of IUPUI Parking and Transportation Services, was interviewed. He provided a wealth of important information, including information that would otherwise be too difficult to observe. This information was used primarily in the *Current System* research. He also provided insights into the goals and mission of *Parking Services.*

So, what does *parking services* want? They seem to be mostly occupied with maintaining daily operations. They want to provide the best parking experience possible. This includes the need for preventative measure against abuse; namely, ticketing. They want to make use of technology where appropriate. In fact, they have worked with Indianapolis based *T2 Systems* to pilot some new technologies.

Parkers

Parkers are those individuals who have one of the 32,797 parking passes currently distributed. They are students, instructors, and staff. Students (E pass) are by far the largest group, followed by staff and faculty (B and A passes.) These *parkers* represent a relatively diverse group in terms of schedules, roles, and motivations. However, as they relate to the parking system, the whole group generally has one, simple goal: to find a place to park quickly and easily. *Parkers* need, at the very least, a place to leave their vehicle. More than that, they want to park as close as possible to their destination.

So, how effective is the current system at helping *parkers* meet their goals? To find out, a small group of *parkers* was interviewed about their parking experiences. Overall, there was a feeling of frustration. *Parkers* considered parking on campus difficult, and were frustrated by the need to drive through many lots to find an open spot. One student said "It's nearly impossible to find parking, or tell if lots are full…" More interestingly, *parkers* are acutely aware of traffic patterns, and plan arrival times accordingly: "I usually have to get to campus at a certain time when people are leaving in order to find parking immediately." These behaviors are byproducts of a system in need of improvement.

Current System

One of the goals of this project was to design solutions to fit within the constraints of the current system. More specifically, it was important to develop realistic solutions that do not require extensive construction. Also, solutions needed to be based on realistic and available technologies. So, in order to better understand how these goals would be met and how appropriate solutions would be designed, it was necessary to learn as much as possible about the current parking system. This includes both observable, physical attributes, as well as unseen or difficult to observe ones.

The IUPUI parking system is made up of a series of parking lots and parking garages throughout campus. Garages and lots vary in size, shape, and distribution of spot types. They are spread across campus, around most major buildings. Some facts:

- There are 17,329 parking spots on campus serving 32,797 parking passes
- Garages are open from 7:00am to 12:30pm, while lots are always available
- A valid parking pass is required to park campus, except for meters and the pay garage
- There are substantially more "E" passes than "B" or "A" passes
- Garages require authentication (i.e. pass validation) to enter, while lots do not
- Garages provide "lot full" signs based on current count, though it's not always turned on
- "A" spots are closest to buildings, followed by "B" spots, with "E" farthest away
- All lots and garages are illuminated in darkness

Recommendations

Given system constraints and user goals, what can be done to improve parking at IUPUI? What is necessary to develop effective solutions?

On a high level, any solution requires more data.

There is currently only very rudimentary data collected by garage count systems. However, this data is easily invalidated and doesn't take into account current exiting traffic. Moreover, this data is only shared in a very limited way, and is not stored or maintained.

What kind of data is necessary? What would be useful to know? First, on a lot/garage level, accurate count of current load is required. In other words, the basic level of data necessary to develop useful solutions would be a current count of how many spots of each pass type are currently in use is. Second, a finer level of detail that shows load on a per-spot basis would prove even more useful. This finer level of detail would allow for much more sophisticated and robust solutions to be developed. This recommendation may seem obvious. However, it is the foundation for any sophisticated and useful solution.

How?

One of the requirements for this project was that solutions be reliant on currently developing and available technologies. So, how is such a fine level of data obtainable with current technology? The emerging field of short-range wireless communication provides a potential solution. More specifically, a technology like radio frequency identification (RFID) may provide a answer. RFID is a method for automatic identification that is based on a tag/reader metaphor that makes use of radio frequency for short-range communication. RFID is also unique in that RFID tags are built with built-in memory, and can therefore store data. RFID tags are currently used heavily for enterprise supply chain management, passports, transportation payment, and even libraries and museums. RFID is used primary for very short-range communication, but some tags can be read from several meters away.

RFID works like this: tags are embedded or implanted in objects and devices; when these objects or devices pass within range of an RFID reader, the data is transmitted between the two wirelessly.

The benefits of a technology like RFID in this particular system are threefold:

- Embeddable
- Passive
- Stored data

The embedded nature of RFID tags is crucial in ease of implementation: all *parkers* are required to have parking passes. This provides a unique and discreet item to embed with RFID technology. The fact that RFID tags can be read without direct actions of users means that there are no new requirements for *parkers* to use the system: they have only to park as normal. This also means that there is no need to install gates or authentication systems at parking lot entrances. RFID tags can store a limited amount of data, which is ideal for holding information about each pass; namely, the pass type.

These attributes make RFID, or a similar technology, ideal for gathering data in this scenario. RFID readers could be positioned at the entrances of lots and garages to maintain a count. Even more intriguing, they could be embedded throughout a parking lot, possibly in accordance with lampposts, to allow for the finer detail of spot-level data.

It is important to stress that this high level recommendation (that more data is required) can be scaled. That is, a sophisticated RFID solution isn't the only way to see improvement. Rather, any number of simple existing tools (magnetic switches, for example) could be used at the entrances to parking lots to maintain a count, which could then be displayed in the same location. This would be an immediate improvement over the current system, providing limited (but useful) information to *parkers* about the likelihood of finding a spot. Regardless of what technology might be used, more data used appropriately is a move in the right direction.

Why?

What do you do with such a high resolution of data? The goal of collecting highly detailed, real-time information is to get the most relevant bits of information to the people that need it most, when they need it. This opens up a whole range of exciting possibilities for both *parkers* and *parking services*.

For Parkers

Parkers need to know where the available spots are before they ever get to the parking lots and garages. There seem to be two ways to do this effectively: strategically located signage, and web-based tools.

There are several interesting scenarios for signage when working with this high resolution of data: a sign could be placed at a prominent intersection at the entrance to campus that shows real time data about current count for each lot. Electronic signage could be placed outside of a parking garage that shows how full it is (see the case study below for more information about garage signage.) Lampposts in parking lots could have electronic signs or that pertain to the spots directly around them. Perhaps this lamppost signage is based on simple colors, where a red sign means the spots are full, green means the opposite. Taking this metaphor and breaking it down to simpler implementation, secondary lights could be added to lampposts as apposed to higher resolution display.

All of these ideas work towards fixing one of the most frustrating problems that parkers have: driving around looking or a place to park. With these kinds of solutions in place, a parker need not waste time going where there are no available spots. A street level sign shows a parker that she should avoid a particular lot all together. With garage signage, she need not enter the garage to search for a spot: she can immediately see that the garage is full. With lamppost-based signage, she can immediately see that the whole north corner of that lot is full.

These tools could cause new traffic patterns and behaviors to develop. For example, as parkers start to follow signage, congestion might start to flow as a mass. A scenario that illustrates this point: the garage shows 30 open spots, so 50 parkers in the area move towards it. As those 30 spots fill, the other 20 parkers move towards a new area that shows openings. This is a simplistic representation of a traffic pattern, but represents a potential behavior change in the user base.

Of course, with generalized data, high traffic times can still be frustrating. These tools start to break down in a completely congested environment. That is, when every spot is full, the tools only make parkers more keenly aware of their frustrating circumstances. On one level, this is a success. Parkers don't have to drive around lots and garages searching for spots that aren't there. On another level, though, it doesn't help alleviate the problem. Parkers are still without a place to park. Personalized tools could help alleviate this problem.

Web-based tools allow for a more personal level of information than outdoor signage. A student could check a website before leaving for campus and get a personal recommendation about where the best place to park will be, based on historical trends and intended destination. With the growing popularity of mobile devices with advanced web browsing capabilities, a *parker* could even access a mobile version of a website to consult for this personalized information. These tools could become very sophisticated, integrating with student and university schedules to predict trends and make recommendations. For example, if the system is aware that 3 classes in one particular building end at around the same time, it can guess (and corroborate based on historical data) that a certain number of spots will be vacated around that building around that time. It could then recommend to parkers who intend to arrive around that same time to head towards these soon-to-be-vacated spots.

For Parking Services

Parking Services potentially gains much more than parkers might from this scenario. First and foremost, ticketing could be substantially more accurate. Assuming a spot-level detail of data, it would be immediately apparent when the wrong kind of pass is located in a spot. For example, a student ("E" pass) parked in a faculty ("A" pass) spot could send a message to the nearest ticketing official about the offense. Or, an expired pass could broadcast as such to whoever might be closest. In the scenario that a car without a pass is located in a spot, it would be quite obvious to a ticketing official with a real time map that shows spot-level accuracy: the system shows the spot as empty, but a car is parked there.

Much more interestingly, maintaining data over time means that a very in-depth and robust traffic analysis could occur. Trends could be tracked and logged; super accurate data about peak hours could be mined for useful information. These trends would be useful in multiple contexts: it would provide proof for requests for increases and changes to infrastructure. So, when traffic conditions get to the point that providing more parking might need to be pursued, there would be data to back up these needs. Also, the long term trending could be used to recommend more optimal class scheduling to prevent frustrating and harmful peak times. This could potentially make the whole university work that much more smoothly, meeting the stated mission of IUPUI Parking Services.

Case Study: External Garage Interface

The garage context is good testing ground for the recommended solutions from this project, because it is especially conducive the scaling nature of the solution. The garage already maintains some kind of basic car count. It also provides an existing physical structure on which to build signage. Finally, a solution could be implemented just in the context of the garage, without a system wide implementation of the solutions.

The outside of a parking garage provides and interesting challenge in effectively visualizing data. There are several important things to understand about the context of this environment. First, the information should be immediately clear. People are using the information while driving, and need to make decisions on a split second reading. Second, the visualization needs to be clear at potentially far distances. That is, it should pass the squint test. Finally, in the particular case of the IUPUI parking system, there are several discreet types of parking spaces. Ideally, the solution would also allow for more involved information to be presented as well.

First Iteration: Liquid Metaphor

The first idea in attempting to visualize how full the parking garage is, was to make use of the metaphor of liquid filling a container, seen in *figure 1*. This makes use of a commonly understood metaphor to represent fullness. This visualization is instantly understood, and easily passes the squint test. It makes use of the common cultural color association with the color red to represent negativity and avoidance. However, it doesn't allow for very much information to be display usefully. Namely, it ignores the point that multiple types of passes exist. So, there may well be 400 spots available, but how many are of the "E" spot type?

figure 1: An example of the first pass at garage information visualization. The line of fullness would be animated to look as a liquid might.

Second Iteration: Liquid Metaphor Applied to Multiple Pass Types

The first idea is very effective in conveying fullness. However, it isn't quite clear how this applies to the various pass types. It also does not provide more in depth information. *Figure 2* shows an example of this metaphor could be applied to the various pass types. It includes a large letter for each pass type. Of course, this assumes that the user base is aware of what these letters represent and how it applies to them. However, in the context of the IUPUI parking system, this is an acceptable assumption.

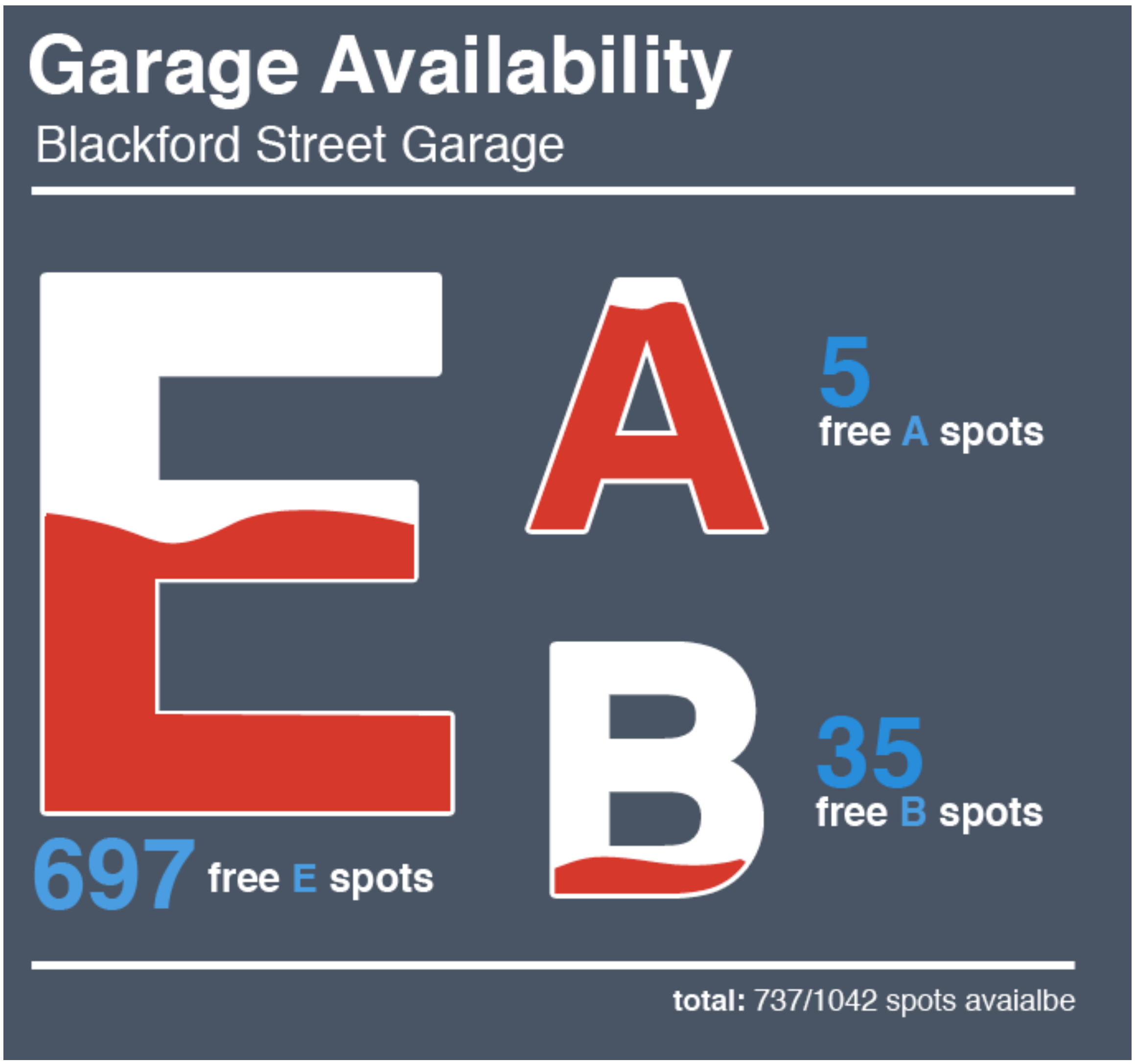
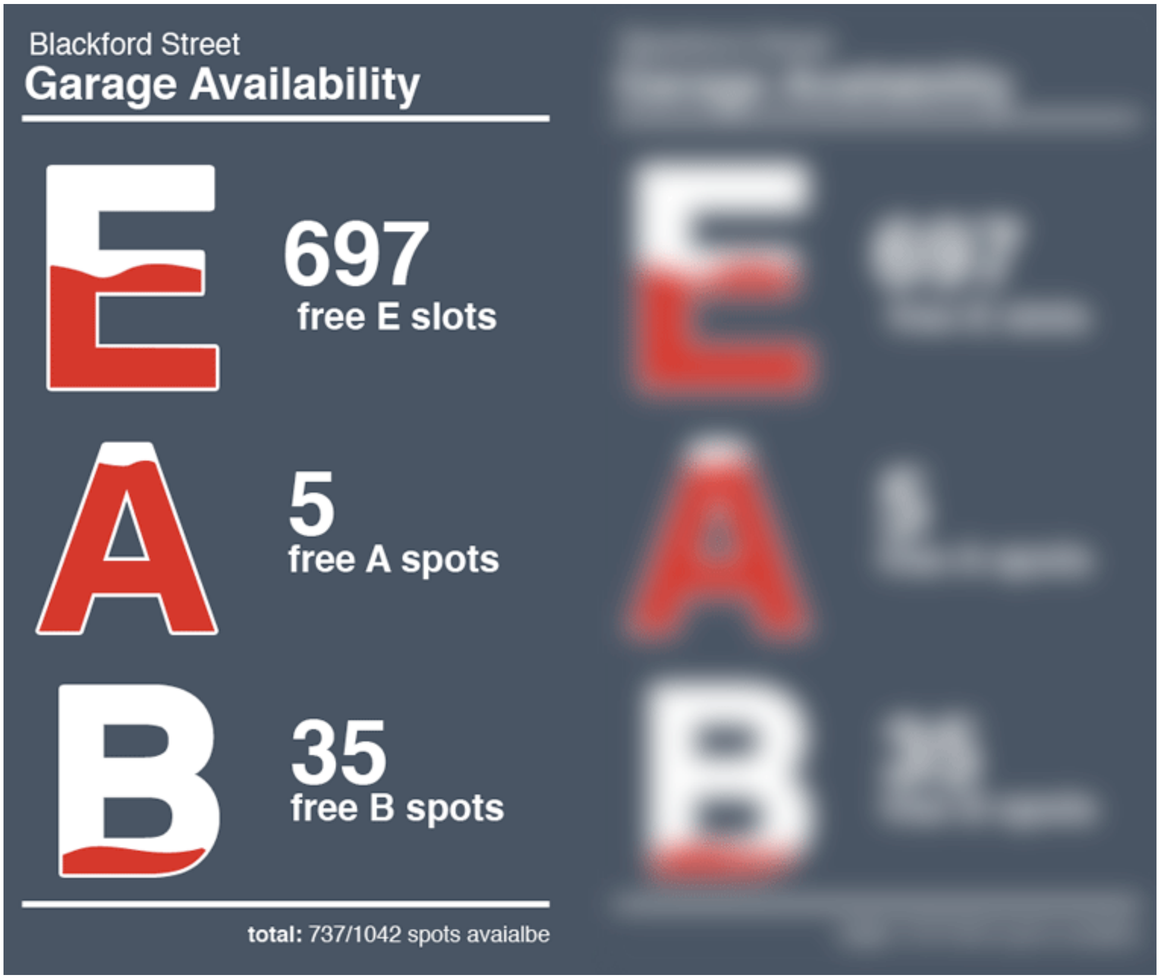


figure 2: An example of the second pass at garage information visualization. Again, the lines of fullness would be animated to look as a liquid might.

So, this example shows how many free spots of each pass type there are. Also, it provides an overall total. Finally, the size of the different letters represents the relative amount of spots of that type overall in the garage. So, since there are 10 times the "E" spots as "A" or "B", the "E" is larger. This makes the installation easier to read for the largest user group. As seen in *figure 3*, this mockup passes the squint test admirably.

figure 3: An example of the how the second pass at garage information visualization might be seen when viewed quickly or from a distance.

Figure 4 shows the positive changes made in the second pass applied to the form factor of the first pass. It also includes the squint test applied to that design. This example loses the variable size of the spot type, but gains an easier to read layout.



figuree 4: Another example from the second pass at visualization, plus it's squint test.

So far, these solutions have relied on large high-resolution displays. However, these design decisions could easily be gracefully degraded to a lower resolution technology. *Figure 5* shows the liquid metaphor applied to representations for each pass, but in a much lower resolution technology. This implementation would only need a matrix of a small number of lights.

figuree 5: A much lower resolution rendering of the design decisions from the second iteration.

Conclusion

This project was approached with the goal of creating a complete solution for the problems of parking on the IUPUI campus, taking into account user and stakeholder needs, and building on the current system. It was also important that specific examples were included of how the recommendation could be implemented. The solution should be based on research, and grow from an understanding of that research. It should be based on existing technologies, and therefore realistically implementable.

The recommended solution meets all of these goals. It works within and extends the existing system, provides both user groups added value and improved interactions, and is based on existing technology. Design decisions were based on insights from research.

At the same time, implementation of the described best case, including near field wireless communication, high-resolution signage, and advanced analysis algorithms, would be quite complex and expensive to execute. However, the basic recommendation can scale in complexity, where even incremental steps towards the best-case scenario make for effective and impacting results.