

Bikeshare Technology White Paper



A Comparative Guide to the Different Technologies
Offered by Bikesharing Vendors

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Abstract:

Technology in the bikeshare industry has developed rapidly over the past few years, achieving greater levels of scalability, flexibility, and affordability. Keeping up with these technological developments, however, is no easy task. This paper offers a comprehensive overview of how bikeshare technology has developed, what the current technology is, and how bikeshare technology projects to develop in the future. To better understand the roots of bikesharing and the challenges that come with bikesharing, a historical background of the different generations of bikesharing is offered. Later, this paper analyzes how the current capabilities of third generation “smart-dock” systems compare to the capabilities of recently developed fourth generation “smart-bike” systems. Finally, this paper explores the newest potential development in the bikeshare market, namely the introduction of “smart-lock” technology, though challenges remain for this technology to be a viable option for municipalities. The bikeshare hardware and software providers analyzed in this report are “smart-dock” providers B-Cycle, Smoove/CycleHop, Alta/8D Technologies, DecoBike, “smart-bike” providers A2B Bikeshare and Social Bicycles (SoBi), and “smart-lock” providers Lock8 and BitLock.

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1. Introduction

Bikesharing is a system of fully automated rental stations within a community intended for short and one-way cycling trips. Technology in the bikeshare industry has changed rapidly. New features and efficiencies have been created at breakneck speeds in the bikeshare industry. Cost is being lowered each year. It can be confusing, however, to keep track of all the developments within the bikesharing market and the different technologies offered.

This paper takes a look first at the different generations of bikesharing, what each generation offered, and why the first two generations completely faltered. This paper shows the different technologies offered by different vendors and what makes each company different, the different features they offer, and the price points they come at. The essential divide currently in bikesharing is “smart-dock” and/or “smart-bike” technology, with “smart-lock” technology as an up-and-comer in the next year or two. A comparison of third and fourth generation bikeshare vendors will provide communities a thorough understanding of what each system and vendor has to offer.

The bikeshare hardware and software providers analyzed in this report are “smart-dock” providers B-Cycle, Smoove/CycleHop, Alta/8D Technologies, DecoBike, “smart-bike” providers A2B Bikeshare and Social Bicycles (SoBi), and “smart-lock” providers Lock8 and BitLock.



2. A History of the Four Different Generations of Bikesharing

According to the literature on bikesharing, there are four generations of bikesharing systems.¹ Some vendors and others from the bikeshare community claim there's a fifth generation, which finds a differentiation between solar powered kiosks from about 2010 and non-solar powered kiosks from the first systems in 2005, though the differences between the third and fourth generations under this differentiation are still IT-based systems, so the term fifth generation will be avoided in this paper. The four different generations are listed to the right.

First generation:

Witte Fietsen (White Bikes); Amsterdam, 1965.

Second generation:

Coin-deposit systems; Farsø and Grenå Denmark, 1991. Nakskov, Denmark, 1993. Bicyklen (City Bikes) in Copenhagen, Denmark, 1995.

Third generation:

IT-based "smart-dock" systems; Bikeabout, Portsmouth University, England, 1996. Velo'v by JCDecaux, Lyon, 2005. B-cycle, Denver, 2010. Various systems since in 5 continents.

Fourth generation:

Demand-responsive, multi-modal "smart-bike" systems; Buffalo, NY, SoBi, 2013. Lansing, MI, A2B Bikeshare, 2014.

¹ Two sources used for the distinction between different generations:

Source for the names and basic information about the four generations: Shaheen, Susan / Martin, Elliot / Cohen, Adam / Finson, Rachel (July 2012) "[Public Bikesharing in North America: Early Operator and User Understanding](#)" Mineta Transportation Institute, San José State University.

Source for the history behind each generation: DeMaio, Paul (May 2009). "[Bike-sharing: Its History, Models of Provision, and Future](#)" Journal of Public Transportation, Vol. 12, No. 4.

First generation Bikeshare

The first bike-sharing program to debut began on July 28, 1965 in Amsterdam with a system called the White Bikes (Witte Fietsen). There were regular, ordinary bikes that were painted white, which signaled that they could be used by the public. One could find a bike, ride it to his or her destination, and then leave the bike for the next user.



Promoting the Witte Fietsen bikes.

While this system held the ideals of bike-sharing well, the system went awry within days. The bikes didn't use locks. There was no accountability or identification system in place to see who used the bike. The system was simply leaving white bikes on the streets. The system collapsed completely within days. Some bikes were thrown into canals and rivers, others were stolen.² This failed experiment showed that bikesharing cannot rely on the ideals of responsible human behavior, but rather required a well-organized system complete with robust security and reliable user accountability.

Second Generation Bikeshare



Bycyklen bikes.

Denmark was the pioneer for second generation bike sharing systems, which started in 1991 in Farsø and Grenå, and later Nakskov. These programs started out small (Nakskov was a 26 bike, 4 station system), and could be picked up and returned to specific locations throughout the city with a coin deposit, similar to a bike rental program.³ The bikes also were designed more robustly than first generation bikes, using airless tires for example to withstand intense use.⁴

² DeMaio, Paul (May 2009). "[Bike-sharing: Its History, Models of Provision, and Future](#)" p. 42.

³ Ibid, p. 42.

⁴ Ibid, p. 42.



Lock of the bike, 20 Kroner coin needed to unlock the bike.

Overall, second generation systems were more formalized than the White Bikes system in Amsterdam. The system reached greater scale and lasted longer than first generation bikesharing, with the largest program taking place in Copenhagen in 1995 with a program called Bicyklen (City Bikes).⁵ The non-profit organization operated the program and had greater security than Witte Fietsen, but the theft problem continued largely due to the anonymity of the user. Improved customer tracking remained the challenge for bike-sharing, which required an innovation in technology to solve the user identification problem.

Third Generation Bikeshare

While second generation solved the security problem, it did not solve the accountability problem, meaning theft and vandalism persisted throughout the second generation. This led to the need for a bikeshare system that could identify individuals. The first of the third generation bikeshare systems was Bikeabout in 1996 at Portsmouth University in England, where students needed to use a magnetic strip card to rent a bike.⁶ Technological improvements came throughout the era to increase the capabilities of bike-sharing, including electronically locking racks, smart cards, telecommunication systems, solar powered kiosk stations, mobile phone access, and on-board computers.



NYC CitiBike Kiosk

Third generation bikesharing never truly took root until 2005, when Velo'v launched 1,500 bikes in Lyon by JCDecaux.⁷ Denver's B-cycle system was the first large-scale municipal US system to take root in the summer of 2007.⁸ Third generation bike sharing has been enormously successful and still continues today, but issues still remain.

⁵ DeMaio, Paul (May 2009). "[Bike-sharing: Its History, Models of Provision, and Future](#)" p. 42.

⁶ Ibid, p. 42.

⁷ Ibid, p. 42.

⁸ Denver B-Cycle [About Page](#), Retrieved 25 June 2014.

The first and most troublesome issue that comes with third generation bikesharing is the high capital and operations costs. A third generation bikeshare system only works optimally in large, dense urban centers, but even larger communities often have trouble funding these systems. The reason: third generation systems are rarely financially sustainable, the major exception being DecoBike, which charges higher than average fees. Some systems, such as Washington D.C.'s Capital Bikeshare, use government subsidies to balance the losses, but not every government is willing to subsidize the annual losses of a bikeshare program. New York City's CitiBike program, for example, was promised to be financially sustainable with \$48.5 million of private funds from CitiBank and MasterCard, but due to lower than projected tourist ridership and unforeseen maintenance costs, the system is running a loss and is under threat of needing to file for bankruptcy despite huge system popularity.⁹



The hardware provider for Capital Bikeshare, CitiBike, and other major US bikeshare systems, Bixi, Alta's former hardware

provider, filed for bankruptcy in January 2014. Bixi's bankruptcy and Alta systems running a deficit demonstrate the costs of third generation systems, which means that a need exists for capital and operational costs to be significantly reduced.



Bikesharing has become increasingly popular in the US. Image source: Greater Greater Washington¹⁰

Operation costs and inefficiencies also remain another major issue for third generation bikeshare systems. With a kiosk, there's more equipment and wiring to maintain, which drives up operations costs. There's also a single point of failure with the kiosk based system, i.e. if one kiosk breaks down, the entire bike fleet at that station is rendered inoperable. CitiBike highlights the difficulties involved with maintaining and operating a large-scale bikeshare system. According to NYC officials, Alta experienced difficulties keeping up with redistributing their bikes and had technological issues with kiosks and broken credit-card readers.

⁹ CitiBike funding and management difficulties: Dusseau, Brigitte (April 2014) "[NYC's Popular Citibike Bike Share Program Desperately Needs A \\$14M Investment](#)" Retrieved 25 June 2014.

Request for government aid: Campanile, Carl, Cusma, Kathryn, Harshbarger, Rebecca (March 2014). "[Citi Bike on the brink as de Blasio refuses bailout](#)" NYPost.com. Retrieved 25 June 2014.

¹⁰ Malouff, Dan (January 2014) "[Here are America's largest bikesharing systems in 2013](#)" Greater Greater Washington. Retrieved 25 June 2014.

Developments need to be made in bikeshare technology to make large-scale operations more manageable, because currently only a well-funded maintenance crew can maintain these large scale systems. Major developments in software are likely to help solve this issue.

Third generation systems, due to the nature of the kiosk, offer little flexibility for station size and locations. Stations require a minimum of about 10 bikes to make sense financially due to the high cost of a kiosk. A four or six bike station would not be financially prudent enough to justify the cost, which limits smaller communities and expansion into less dense areas of a community. Kiosk-based systems require intense installation, which leaves less room for error in the planning process and little ability to correct a station location if a station needs to be moved (low demand, property conflict among potential reasons). Kiosk based systems also receive complaints about being an eye sore to historical areas, which would be reduced with a less obtrusive station found from fourth generation systems.



Alta station installation.

Taking the technology and wiring out of the kiosk and putting it on the bike has become a possibility. Third generation bikeshare systems have been unable to meet the new

demands for a more responsive, more flexible, and more cost-efficient bikeshare system. With these demands met through fourth generation bikeshare, new communities will be able to enjoy the benefits of a bikeshare system, while communities with financially unsustainable bikeshare systems can eventually switch over to a more manageable system.

B-Cycle, Alta/Bixi/8D technologies, and DecoBike systems are the three main bikeshare hardware providers for third generation bikeshare systems across the US, with Smoove/CycleHop looking to expand into the American market as well. Use section 5 of this report for a detailed summary of each of the companies listed above.

Fourth Generation Bikeshare

Fourth generation bikesharing separates itself from third generation systems by ridding itself of the expensive kiosk. This feat has been accomplished because the technology has been placed on the bike, which allows for new possibilities and reduces costs significantly. It's still nebulous what exactly makes a fourth generation bikeshare "fourth generation," but putting modular technology on the bike rather than on the kiosk and having well-developed back-end software is how this report marks the attributes of a fourth generation bikeshare system. A2B Bikeshare and Social Bicycles (SoBi) are the two best examples of fourth generation bikeshare vendors in the US. The "smart-bikes" employed by both systems use modular technology, which reduces redundancy and costs found in kiosk-based systems while performing the same functions found in a kiosk (i.e. payment, locking, etc.). This cuts capital costs by about 50%, and the capabilities of these systems is expanding rapidly.



Other systems that cannot yet be described as fourth generation due to certain key technological deficiencies are "smart-lock" systems, namely BitLock or Lock8. This type of bikeshare does not exist on any large

scale at the moment, and could not exist in its current form on a large scale due to the lack of proper back-end software and accessibility issues. The idea, however, has potential to become larger scale in the future. The idea is that you use a smartphone to unlock the bikes, and with Lock8, you can share the bike remotely due to GPS tracking capabilities. "Smart-lock" systems need to be tested and exist on a larger scale before they can be labeled as fourth generation bikesharing.

Fourth generation bikeshare companies are developing the technology necessary to making maintenance and operations more manageable for communities. More accurate bikeshare data will be collected, greater efficiency will be achieved, and capital and operational costs will be significantly reduced, making fourth generation bike share the way of the future.

Summary:

Bikesharing has gone through many changes in the past few years, which can make it difficult to follow the technological developments seen within the bikesharing market. The jump from third generation to fourth generation bikesharing is analogous to the jump from the home telephone to cell phones. Both function very similarly on some levels (i.e. calling, saving contact info, etc.), but the cell phone allows for greater flexibility and distribution. The functionality of a home telephone can be improved, but cell phones will always be inherently different from home phones and be able to do more than a home phone ever could. Fourth generation bikesharing will also undergo many innovations and developments over the upcoming years similar to that of the cell phone.

3. The Industry-Standard Bikeshare Bike

Bikeshare bicycles distinguish themselves from average bicycle in durability and accessibility. The bikes are meant to withstand the harshest of weather conditions and the heaviest utilization. From a feel standpoint, bikeshare bikes are solid, sturdy, and easy to ride. There is little difference in the bike itself from vendor to vendor. Industry-standard bikes are step-through, have a robust frame designed to give any rider excellent balance and control, have puncture resistant, airless tires, come with a front light, have an adjustable seat, can shift a few gears, use a chainless shaft, and use proprietary components to protect against vandals. Below is an example of Smoove and SoBi bicycles, which adequately show what comes industry standard.



A2B Bikeshare bike with touchscreen console mounted between the handlebars.



Smoove outlines the different bicycle parts.

Individuals come in many unique shapes and sizes, thus a bikeshare bike must be accessible to most sizes and try to accommodate to varying heights and weight. A bikeshare bike must also be accessible to different riding skill levels. They ride well in cities, though due to weight are very difficult to ride up steep hills, and are not meant for mountain/outdoors biking. As a rule, bikeshare vendors are able to fully fulfill the requirements that communities are looking for with bicycles. Through a comparison of these two bikes plus the information given above, it should be clear what to expect from the bikeshare bicycle industry standard. The next section will detail the technology that separates the vendors from one another.

4. General Similarities and Differences Between American Bikesharing Vendors

This report will analyze the similarities between the bikeshare vendors before divulging on their differences.

Every vendor uses the same bikeshare bicycle model. As detailed in the section above, the bikes are durable, step-through bikes with proprietary equipment to deter theft, baskets, robust wheels (some are fully solid, others are durable air tires), adjustable seat heights, and space for advertising.

Beyond the industry standard bikes, all other municipal systems have these similarities to varying degrees:

- **Security:** Highly secure and highly vandal proof systems (the big exceptions being DecoBike and CitiBike).
- **User Identification:** One major issue with second generation bikesharing was the inability to identify users.
- **Durability:** Bikeshare bike systems must be prepared for every climate and extreme wear and tear.
- **Fully automated rental process:** If people are supervising the system, it becomes a bike library or bike rental program, not a bikesharing program.
- **Software:** Each vendor offers a back-end administrative software management tool, which can collect data (i.e. miles ridden, bike availability, etc.). Software will be

changing and developing significantly in the upcoming years.

- **Accessibility:** Bikes must be easy for first time users to rent and return. Third generation systems and A2B Bikeshare offer a friendly walk-up and rent model, something SoBi and “smart-lock” systems have yet to offer.
- **Scalability:** Some systems are easier to scale than others, but a system must be able to expand and contract in size.

The major divide between different bikeshare vendors is if they use a kiosk or do not use a kiosk. These are the attributes that are negatively effected by a kiosk:

- **Price:** Each kiosk costs about \$10,000 and is a major piece of equipment to maintain, which makes third generation systems more expensive. Fourth generation systems eliminate this cost completely.
- **Flexibility:** Due to the high cost of a kiosk, a certain number of bikes need to be placed at a kiosk to make the kiosk cost worth it. Stations also require metal platforms and take up more space, which limits station placement. These problems result in little flexibility with a “smart-rack” system, whereas with a “smart-bike” system, the financial and extra space problems that come with a kiosk-based system are eliminated. This allows for new possibilities such as small station sizes or mini trial programs.

- **Reachability:** While both third and fourth generation systems can be fully scalable, a third generation system is more limited to denser urban areas and requires greater financial support. Fourth generation systems can reach more communities, universities, and corporate campuses while requiring less financial support. “Smart-lock” systems provide the potential for further reachability.

Other miscellaneous features which can differ between different vendors that doesn't involve the kiosk:

- **Operations:** Some vendors, such as Alta, offer operating services. Most hardware providers require a partnership with a bikeshare operating company. The three major business models for operating a bikeshare system currently employed in America are the non-profit owned and operated model, the publicly owned, contractor operated model, and the privately owned and operated model.¹¹ An analysis of the communities with a bikeshare system by 2013, approximately 61% of communities used the non-profit model, approximately 18% used the public model, and approximately 21% used the private model.¹²
- **Maintenance:** Different vendors offer different methods for helping with maintenance. Currently there are rudimentary methods being employed to help with

maintenance and operations, among them regular check-ups from a maintenance crew and using miles ridden data as a measure for when a bike requires maintenance, but nothing past a rudimentary algorithm exists yet. A2B Bikeshare is looking to solve this problem through data analytic tools that uses machine learning to understand how bikes flow within a city and which areas are in demand at which time, thus making redistribution less guesswork and more effective. A2B Bikeshare and other fourth generation vendors are also looking into smart-learning incentivized pricing, which would enable the possibility of having riders ride to less desirable areas and pay extra for using a higher in demand area, which will offset more maintenance costs.

- **American made:** Some bikeshare vendors within the US, such as A2B Bikeshare, are fully American made and manufactured. Not every bikeshare vendor can claim the same feat. For municipalities, this can be relevant according to the Buy America Provision.¹³

Analyzing beyond the current debate between “smart-racks” and “smart-bikes,” a new divide could be developing, namely the divide between “smart-bikes” and “smart-locks.” “Smart-lock” systems do not yet fulfill all the qualities listed above as similarities between different bikeshare systems. Until “smart-lock” systems are properly tested,

¹¹ Shaheen, Susan / Martin, Elliot / Cohen, Adam / Finson, Rachel (July 2012) “Public Bikesharing in North America: Early Operator and User Understanding” Mineta Transportation Institute, San José State University.

¹² Gaegauf, Tucker (May 2014) “Funding White Paper: A How-to Guide to Getting Funding in Your Community” A2B Bikeshare, p. 8.

¹³ The Buy America law provision, which was created to support high quality, cost-effective American made products, is Section 165 (49 U.S. Code § 5323j). The provisions in this law [Link to Buy America provision](#). A community that receives federal funding for a transportation project should give deference to manufactured goods produced in the U.S. unless it's against public interest, not of reasonable quality, or would increase the cost of a project by more than 25%.

offer functioning management software necessary on a large scale, and offer accessibility to everyone (i.e. those without smartphones, internet access, etc.), they cannot be considered a legitimate municipal bikeshare solution. “Smart-lock” systems do have their place, however, on universities and corporate campuses, and soon could fulfill the requirements necessary to operate a municipal system.

The next 3 sections will detail what each vendor offers. They are divided up by generation, which leaves B-Cycle, Alta/8D Technologies, DecoBike, and Smoove/Cyclehop in the third generation category, A2B Bikeshare and Social Bicycles in the fourth generation category, and Lock8 and BitLock in the “smart-lock” category.

5. Third Generation American “Smart-Dock” Bikesharing Vendors

As detailed in section 2 of this report, third generation bikeshare is still easily the most common type of bikesharing in the US. The two current major American vendors are B-Cycle and Alta/8D Technologies (formerly Alta/Bixi), which both provide and oversee bikeshare systems in large US cities. DecoBike, which employs the privately owned and operated business model, is the only other major third generation bikeshare system operating in the US. A hybrid third and fourth generation system called Smoove is looking to expand into the US market with CycleHop, though it must be labelled as a third generation system because it requires a kiosk.

A company overview, technology overview, summary of the rental process, summary of the company planning and implementation process, summary of operations and maintenance, and an overall summary will be provided in each section. The source information for every vendor comes from a mix of information found on the vendor's website page and previously submitted RFPs to different municipalities.

B-Cycle

Company Overview:

B-Cycle is a third generation bikeshare vendor that has implemented and operated over 25 systems throughout the US, including the first bikeshare system in Denver CO, and others in cities such as Madison, WI, San Antonio, TX, and Charlotte, NC. B-Cycle offers experience and well-tested technology, though relies on a kiosk, which comes at the higher price point with lower flexibility and reachability seen from third generation systems.

Technology Overview:

B-Cycle is a kiosk-based system that has three main components, the bicycle, the stations, and the software. The B-Cycle is designed by Trek Bicycle Corporation and is industry-standard. The bike is equipped with proprietary self-charging GPS technology that can track ride data, including distance and actual route ridden, which can later be aggregated to and managed by an administrator. Bikes are locked to and recharged at the stations.

Station Technology:

The stations use kiosk technology and wiring that requires installation from B-Cycle. Stations are solar-powered, which means that the docks are powered on their own independent of grid power. Docks can have a single or double-sided layout and are normally bolted to the ground, though

temporary, non-bolted stations can be installed for any major public event (e.g. the Olympics, festivals, etc.). Each station houses a custom controller board, a proprietary locking mechanism, LED user notification, and an RFID (Radio Frequency Identification) reader for inventory control. One pitfall with B-Cycle systems is that if a kiosk fails, the entire station is unusable. Installation is also cumbersome and requires their team to install, which increases costs.



Rental Process:

Riders use the kiosks to rent out a bike. Most members would use the kiosk, though if one becomes a B-Connected card holder, they can bypass the kiosk and check out bikes at the docking stations by swiping their membership card over the reader. B-cycle stations use RFID technology that allows for intelligent inventory control and returns placement balancing. Users can return a bike at any B-Cycle station and the RFID tracks all rentals and returns, updating the software user interface with valuable real-time asset information. This allows users to locate nearby B-Cycle stations with rental or return availability. Overall the rental process is highly accessible, does not require a smart-phone (though there is a B-Cycle app for those who do want to track bikes and stations), and is relatively easy to use and straightforward. The only disadvantages are

potential waiting times and a lack of software responsive pricing capabilities.

Planning/Implementation Design:

B-Cycle has experience with implementing their systems and works with communities to plan and design a system. The stakes for planning are higher because of the difficulty in installing a station, which makes the need for feasibility studies higher and increases the difficulty of moving a station, which increases costs significantly and reduces flexibility.

Operations/Maintenance:

Tracking and inventory are not a problem, but the software capabilities for B-Cycle systems is limited. It cannot offer user-incentivized redistribution, for example, which lowers redistribution costs. Operators can manually change price schemes, but there is no smart pricing system available. Due to the redundant and cumbersome technology used with the kiosk, maintenance costs are higher.

Capital Costs:

About \$5000-\$5200/bike.

Overall:

B-Cycle systems have seen success and high usage rates, though it can be limiting for smaller communities who cannot afford the cost and inflexibility of a B-Cycle system. The flaws of a third generation system still exist with B-Cycle, but they offer robust security, B-Cycle also offers experience and reliability with their systems, which makes them a favorite option for larger communities in the bikeshare market.

CycleHop / Smoove

Company Overview:

CycleHop is an operator company that in the past has partnered with Social Bicycles for cities such as Tampa and Phoenix (more on SoBi in section 6), but has now recently submitted RFPs with Smoove, a French bikeshare vendor.



Technology Overview:

Smoove uses an integrated rental control box placed on the front of the bike that uses an RFID card reader to check out the bike. The bike uses proprietary fork-locking to secure the bikes with dual locking pins, providing highly secure locking without the need for costly RFID readers at each dock. The fork lock also allows users to temporarily lock the bike when away from a station. The bikes are equipped with an internal battery that has a minimum 3-year life span, continuously recharging through the bike's hub Dynamo system, which means the bikes do not rely on solar power. The system tracks miles ridden per bike and other data, which is what is ultimately used to track maintenance.

Station Technology:

Smoove uses solar-powered kiosks that require no wire connections since the bikes are battery powered. No RFID technology is attached to the dock, reducing the price of their kiosk stations.

Rental Process:

Members with a program member access card have easy access to the bikes. Those who are first time renters or casual users can go to the kiosk or app to receive a temporary access code to enter in their rental box unit.

Planning/Implementation Design:

CycleHop does design, planning and implementation work for Smoove and would work with the community to ensure proper planning and effective communication.

Operations/Maintenance:

CycleHop and Smoove have developed together a specific set of operations to maintain a system. The pair offers a specially equipped maintenance vehicle fleet of electric bikes that can transfer up to four bikes to other stations or nearby maintenance centers. The staff then uses these bikes to either perform minor adjustments or diagnose the bike at the station. Their maintenance plan requires daily inspection of the stations and bi-weekly inspections of each bike, where someone equipped with a hand-held computer records each station they visit. Each time they work on a bike, it gets transferred to a central computer and recorded in a maintenance software program. Redistribution is done manually, but uses a sophisticated algorithm and thorough inspection to keep maintenance costs down.

Capital Costs:

About \$3500/bike.

Overall:

The development of CycleHop working with Smoove instead of Social Bicycles for the University of Virginia RFP is an interesting development in the US bikeshare market. The two use a hybrid third and fourth generation system, though because

CycleHop uses a kiosk, it must ultimately be placed in the third generation category forwarded by this white paper. The system offers an easy rental process, though does require members to hold a card and still depends on the kiosk. No other vendor uses the battery used by Smoove.



Alta & 8D Technologies

Company Overview:

Alta Management was formerly partnered with Bixi to offer large-scale bikesharing to major American cities such as Washington D.C., Chicago, and New York City. Alta broke off their partnership with Bixi after Bixi filed for bankruptcy in January 2014.¹⁴ Bixi, a bikeshare hardware provider from Montreal, formerly provided Alta the bikes, software, and kiosk technology necessary for a large-scale bikeshare system. Alta Management partnered with 8D Technologies in February 2014 to provide the software and kiosk technology for Alta systems.¹⁵ 8D Technologies does not provide the bike hardware for Alta, and it's unclear who will provide bike hardware for Alta in the future.



¹⁴ Interview between NPR's Renee Montagne and Montreal Gazette Journalist Andy Riga (January 2014) "[Drowning In Debt, Bike Sharing's Bixi Files For Bankruptcy](#)" NPR, Retrieved June 25 2014.

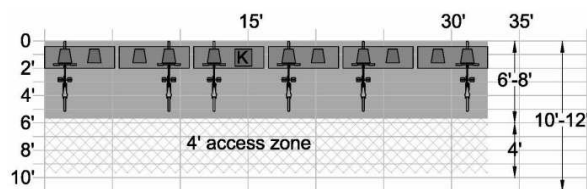
¹⁵ 8D Technologies (February 2014) "[Alta Bicycle Share and 8D Technologies Forge New Strategic Partnership](#)" Retrieved 25 June 2014.

Technology Overview:

Alta systems used to have Bixi provide the industry-standard bikeshare bike, but now it is unclear which bike they offer. The kiosk, bike and software technology used to be run by Bixi, but the company filed for bankruptcy in January, 2014 and has been unable to fulfill their hardware orders for Alta systems.¹⁶ 8D Technologies recently formed a partnership with Alta in February 2014 to provide the kiosk and software technology.

Station Technology:

Alta systems use solar-powered “smart-dock” kiosk technology very similar to B-Cycle. The stations require wiring and use proprietary locking. Dock size options are 11-19 stations. Size of the dock offered below.

Spacing Specs, Toole Design Group¹⁷

Rental Process:

Very similar to the B-Cycle rental process. The user can either choose to receive a daily, monthly or annual key. The user then signs up online or would go to a commuter store to receive the membership and key. Once this step is complete, a user can step up to any bikeshare bike, unlock it, then return it within

30 minutes (fees for longer rentals). A user can also purchase a 1 or 3 day pass from the kiosk, which allows the user to swipe their credit card at any kiosk for unlimited rentals for 1 or 3 days. It's a relatively easy and straightforward rental process and is very accessible to tourists and those who do not want to or cannot purchase passes online.¹⁸



Planning/Implementation Design:

Alta management has a long history of bikeshare planning and implementation design. Many of the feasibility studies for bikeshare are done by the Alta design team. Alta Design has completed many feasibility studies for communities inquiring about the possibility of bikesharing in their community, demonstrating great experience and ability in design.

Operations/Maintenance:

Alta has overseen effective systems in the past, though there are high costs that come with Alta systems. Some systems, like Capital Bikeshare in Washington D.C., have received adequate funding and have a well-organized system to maintain the bikes optimally.¹⁹ Alta systems have also been

¹⁶ 8D Technologies (April 2014) "[8D Technologies, historical partner of the BIXI™ project, files a \\$26 million lawsuit against PBSC](#)" Retrieved 25 June 2014.

¹⁷ Toole Design Group / Pedestrian and Bicycle Information Center for USDOT Federal Highway Administration (September 2012) “[Bike Sharing in the United States: State of the Practice and Guide to Implementation](#)” p. 17.

¹⁸ Capital Bikeshare “[How it Works](#)” Page, Retrieved 25 June 2014.

¹⁹ Capital Bikeshare “[CBBikeCheck Round Up](#)” Page, Retrieved 25 June 2014.

cited for technology malfunctions and maintenance neglect. New York city officials have been concerned by Alta's performance in repairing kiosks with broken credit-card readers and "rebalancing" bikes evenly across the city, stating that Alta has failed to fulfill their end of the maintenance part of their contract.²⁰ Maintenance costs were higher than expected due to higher than projected ridership while tourist ridership has been lower than projected. Software to make the system more manageable would significantly reduce costs and increase efficiency in maintaining large-scale operations.

Capital Costs:

\$5000/bike (estimate)

Overall:

Alta and Bixi historically have provided bikeshare equipment and management for a large portion of the North American bikeshare market, but this has been threatened by the lack of financial sustainability of these systems. Bixi was not able to remain financially solvent for their systems, and the high cost of Alta systems has been a problem for places that do not offer government support, the major example being CitiBike in NYC. Technology difficulties still trouble Alta managed systems, and it's unclear still who provides the bicycle hardware for Alta systems.

DecoBike

Company Overview:

DecoBike owns and operates their bikeshare systems and collects revenue from the system, which is unique for a bikeshare hardware vendor. The municipality bears none of the costs. Their system is third generation and uses the kiosk, but they run one of the only financially profitable bikeshare systems on the market. This is not due to the technology of the bicycle, but rather due to locating stations in only financially profitable areas and charging the highest user fees of any bikeshare system to date. DecoBike's most famous location is Miami Beach, FL, where a 1000 bike, 115 station system has generated a modest profit. A monthly membership for unlimited 30 minute rides is \$15/month, and for unlimited 60 minute rides is \$25/month, which both come out at \$180/year and \$300/year respectively.²¹ These monthly memberships are for residents only and have a minimum 3-month commitment. For casual users, only hourly passes are available. A DecoBike system will be able to run profitable in an area that has many tourists, but it is the most expensive bikeshare system for riders and doesn't use the most efficient technology, as will be explained in further detail below.

Technology Overview:

DecoBike uses the familiar "smart-dock" technology and relies on a kiosk very similar to the other third-generation vendors. Particular issues with the DecoBike system have been high amounts of vandalism. There are major security issues with the bikes. In

²⁰ Karni, Annie "[Citi Bike operators doing shabby job of maintaining bikes and docking stations; money problems cited](#)" New York Daily News

²¹ DecoBike Website [Pricing](#) Page. Retrieved 25 June 2014.

2013, 143 bikes were stolen, and an additional 137 bikes were heavily damaged or vandalized. This heavily increases long-term operations costs.



Station Technology:

DecoBike uses a solar powered kiosk that also controls the rental process. Similar to other third generation bike share station technology, there are limits with station flexibility, the kiosk is expensive, and overflow can be a problem for more popular stations. There is no temporary locking option available.

HOURLY RENTALS	
30 MIN ACCESS PASS	\$4
1 HOUR ACCESS PASS	\$5
2 HOUR ACCESS PASS	\$10
4 HOUR ACCESS PASS	\$18
8 HOUR ACCESS PASS	\$24
ADDITIONAL USAGE FEES	
Each additional 30 minutes	\$4

Rental Process:

There are two different ways to utilize the DecoBike program, through a membership or hourly rental. Rates can be seen above.

Renting is done at the station, where either a user inserts their credit card or rental card, then inserts a unique bike number into the system, and finally the user unlocks the bike from the station. The user must return the bike to a station before their designated time is finished, lest the user wants to incur overtime charges.

Planning/Implementation Design:

DecoBike does all the installation and maintenance of the system, though they communicate with the municipality and gain formal approval for site location and installation.

Operations/Maintenance:

DecoBike has high maintenance costs due to stolen and vandalized equipment plus kiosk technology maintenance, though the community pays for none of it. For the municipality, there is no responsibility to maintain or operate the system, which means that DecoBike won't work in many communities.

Capital Costs:

For the community, \$0/bike. Costs of bike equipment is not publicly available knowledge. The city would gain a small cut of bikeshare profit in return for offering public space (Miami Beach received \$190,205 for 2012-13).²²

Overall:

DecoBike offers something that no other third generation bikeshare offers, a bikeshare system that does not require public funding that is also financially sustainable. It's unclear, however, whether the DecoBike model would work in most communities. The system is not ideal for accessibility or places

²² Miller, Michael (May 2014) "[DecoBike Currently Costs Miami Beach Money, But City Is On Pace To Break Even](#)" Miami New Times Bike Blog. Retrieved 25 June 2014.

with low tourist usage. San Diego, which just recently implemented a DecoBike system, has seen some complaints from bike advocacy groups such as BikeSD with regards to station location. Many parts of San Diego will not receive bikeshare coverage,²³ showing that DecoBike will have the final say on bike locations, and it may not offer desirable enough coverage from the public's perspective, though it also won't cost the taxpayer any money. DecoBike offers the only fully private bikeshare system on the market, though it's not the only financially self-sustainable system on the market.

²³ Burks, Megan (May 2014) "[Not Everyone Is Happy With San Diego's Bike Share Locations](#)" KPBS San Diego Public Radio. Retrieved 25 June 2014.

6. Fourth Generation American “Smart-Bike” Bikesharing Vendors

The fourth generation “smart-bike” vendors offer a product that does not rely on the kiosk and offers multi-modal capabilities, meaning the system is fully modular and can integrate with itself, and in the future be able to integrate with other transportation modes. The product is also demand responsive and can accomplish feats such as smart pricing, i.e. the ability to adjust pricing based on location demand statistics, incentivized pricing, i.e. the ability to offer discounts for those who ride to undesirable stations, thereby reducing redistribution costs, and live information about which stations are full or empty. This section details the two different “smart-bike” vendors currently on the market, namely A2B Bikeshare and Social Bicycles, also known as SoBi.

A company overview, technology overview, summary of the rental process, summary of the company planning and implementation process, summary of operations and maintenance, and an overall summary will be provided in each section. The source information for the two vendors comes from a mix of information found on the vendor's website page and previously submitted RFPs to different municipalities.

A2B Bikeshare

Company Overview:

A2B Bikeshare is a hardware and software provider for bikeshare systems founded by a group of engineers out of a need for affordable and sustainable bikesharing. The A2B Bikeshare “smart bike — dumb rack” system was created to reduce the technological redundancies seen from a “smart-dock” system, which reduces both capital and operational costs by over 50%. Unlike any other vendor, A2B Bikeshare uses a touchscreen console to control the rental and locking process, providing all the functionality of a kiosk without the disadvantages that come with it. A2B Bikeshare offers a highly scalable, affordable, and fully American-made bikeshare system.



Touchscreen module, powered by 2 solar panels, controls the rental process, locks the bike, and sends data to the administrative suite.

Technology Overview:

A2B Bikeshare uses a unique on-bike console to control the rental process, locking, and data collection. The technology is modular and designed to be highly scalable and flexible. Features include GPS tracking, a card-swipe rental process, a user-incentivized redistribution algorithm, an operations administrator suite, and extra advertising space on the touchscreen. A2B Bikeshare offers a unique on-bike touchscreen console that makes for a highly fluid and intuitive rental process, offering the features of a kiosk without the cost of one. Link, the A2B Bikeshare website and mobile app for riders, offers new ways to engage and manage their bikeshare account.



One pin is attached to the console pictured above, which attaches to the rack pictured to the right.

Station Technology:

A2B Bikeshare powder-coated steel racks are made to lock with the A2B Bikeshare module through a highly secure dual-pin locking system. As seen in the picture above, one pin is attached to the console, the other to the rack, and the console can reliably recognize when the bike is locked into the station. The bike also can do stationless locking pictured on the next page to the right, which allows riders to securely lock the bike

and quickly visit a café or run into a store, but it does not end the rental. A2B Bikeshare racks can be configured to accommodate any space needs while requiring no power, which creates the opportunity for smaller station sizes. A2B Bikeshare also offers a 2:1 bike to rack ratio, which significantly reduces the need for redistribution and largely avoids the problem of bicycle overflow. Overall, the A2B Bikeshare system allows for the full security and locking/bicycle identification of a third generation system without adding the cost and inflexibility of a kiosk.



A2B Bikeshare racks with bikes attached.

Rental Process:

A2B Bikeshare uses an on-bike touchscreen console to create a highly fluid and intuitive rental process, offering the convenience and easy accessibility of the kiosk without the costs associated with it. First-time riders swipe their credit/debit card (can also work with an ID magnetic strip card once an account is set up), create an account on screen, and ride, while members must only swipe their credit/debit/ID card to ride. To end the ride, a rider just reinserts the bike into an A2B Bikeshare rack to lock up the bike and immediately end the ride.



Bike rental screen

Planning/Implementation Design:

Like other bikeshare vendors, A2B Bikeshare communicates with the community to ensure proper planning and implementation design. A2B Bikeshare also can reach out to various national bikeshare operating companies to help with planning and implementation. Machine learning predictive station location software is also being developed to create smart planning and explore bike share planning in an unprecedented way.

Operations/Maintenance:

A2B Bikeshare works with different entities such as a national operator or local non-profit to run operations of a system. A2B Bikeshare helps wherever possible to make maintenance and operations easy, efficient, and cost-effective. Much of A2B Bikeshare's efforts are spent in making maintenance easier and smarter than before. Through comprehensive on-bike feedback and cutting-edge predictive machine learning programs, A2B Bikeshare is working to make recurring maintenance significantly easier to manage, which will centralize the maintenance process and make large maintenance crews less necessary, lowering costs. A 2:1 rack-to-bike ratio also makes redistribution significantly more cost-effective.



Stationless locking screen. To stationlessly lock up, one removes the pin with the chain attached and wraps it around a regular bike rack, which safely locks up the bike while not ending the ride.

Capital Costs:

\$2,100-2,200/bike



Overall:

A2B Bikeshare pulls the best innovations from all generations of bikeshare hardware and software to create an efficient, sustainable, all-American bikeshare solution. The on-bike technology means that all rental and locking interaction takes place through an on-bike touchscreen and card reader, allowing for a speedy and intuitive rental process. A2B Bikeshare's on-bike technology enables flexible, scalable, and low-maintenance bikeshare systems.

Social Bicycles (SoBi)

Company Overview:

Social Bicycles is a “smart-bike” bikeshare start-up based in New York. SoBi has implemented wireless technology and GPS tracking into the bikes to drive down costs, though have yet to fully free themselves of the kiosk. With data-tracking and login capabilities on each bicycle, SoBi bikes offer more capabilities than third generation bikes, though the bikes still require kiosks like other third generation systems for an accessible first-time rental process, proper locking, and proper bicycle identification.

Technology Overview:

Each SoBi bike is equipped with an integrated data/GPS tracking device that controls the rental process for users with accounts, a basic u-lock, and solar-powered technology. SoBi systems use GPS tracking technology to set locations for where the bikes are, meaning they use a stationless system. Stations require a kiosk to offer first time users access to the bikes, but an app and computer on the back of the bikes makes it possible for users to rent the bikes without a kiosk. The lock cannot identify when a bicycle is properly locked, leaving SoBi bikes prone to locking errors and theft.



Station Technology:

Social Bicycles can implement either a stationless system or a kiosk-based system, where their bikes lock either at a bike rack that uses geofencing to identify where the bikes are located or at a kiosk station. With the stationless system, bikes can be locked to other bikes or improperly locked to the rack, which compromises security. SoBi has no way of guaranteeing the bike is locked because the lock does not interact with the data tracker on-board; it's only a simple U-lock. Stationless systems historically have had problems with people making locking mistakes, e.g. locking 2 bikes together or simply failing to fully lock the bike. SoBi counteracts these problems by using a kiosk, which compromises its ability to be a flexible fourth generation system and makes it more like a hybrid system.



Rental Process:

The SoBi rental process uses a computer equipped with a keypad on the back of the bike to control the rental process for established users and a kiosk for first time users. For an optimal renting experience, an account needs to be created online or on a smartphone before using the bicycle. The bike then requests your 6 digit account number and 4 digit pin number to unlock the bikes. A user also has the option to rent from the bike using the keypad. A stationless system alone is usually not acceptable on a community level for accessibility reasons, which can make the kiosk necessary.



Phoenix SoBi system (launching later this summer), which will require kiosks in central locations similar to third generation systems.

Planning/Implementation Design:

SoBi has urban planning experience and offers consulting for the planning and implementation of a bikeshare system. CycleHop has also partnered with SoBi in the past to help with planning and feasibility studies.

Operations/Maintenance:

CycleHop partnered with SoBi in past systems to do operations and maintenance, such as Phoenix or Tampa, but it is unclear who partners with SoBi currently. SoBi is a hardware and software provider, thus needs a partner to do operations and maintenance. SoBi bicycles all contain an on-board computer with real-time GPS tracking through a GSM connection that communicates with central servers to make maintenance and operations easier. Real-time activity and previous history of users, bicycle distribution, maintenance, payments and messaging is searchable on the administrative platform.

Capital Costs:

About \$2800-3000/bike with kiosk,
\$2100-2200 without kiosk.

**Overall:**

Social Bicycles is quickly emerging within the bikesharing market. SoBi offers the promise of a fourth generation system, though the system functions more like a hybrid third/fourth generation system, i.e. the bikes rely on a kiosk for rental accessibility and security purposes, but also have a data tracker/login device on the bikes to offer further capabilities than other third generation systems. Their 2014 product has experienced multiple delays, but should be launched and fully operational by the end of summer 2014.

7. Fourth Generation Future American “Smart-Lock” Bikesharing Vendors

A new type of fourth generation bikeshare has yet to emerge, but it is coming out on the North American market soon and will likely be more prevalent come 2015. The two companies listed below are looking to maximize the amount of bicycles available through a lock. Lock8 offers a fully “smart-lock” that has GPS tracking capabilities, while BitLock offers a robust lock with static tracking. The two products in their current form could not be adequate for municipalities looking to grant accessibility to all riders, offer an easy rental process for first time riders, and manage maintenance on a large-scale. The two products are great, however, for micro-bikeshare, which could be between a small group of users, corporate employees, universities, bike rentals, etc.

A company overview, technology overview, summary of the rental process, summary of the company planning and implementation process, summary of operations and maintenance, and an overall summary will be provided in each section. The source information for the two vendors comes from a mix of information found on the vendor’s website pages.

Lock8

Company Overview:

Lock8 is a recently formed start-up based in both Berlin, Germany and London, England that currently retails robust and secure “smart” bike locks. Their aim is to transition to scalability and sell business to business, specifically trying to get into the bike share market. Their product is still untested in the bikeshare market, but there is a place in the bikeshare market for cheap, flexible, and highly secure “smart-lock” systems. The system has garnered much attention in the bike sharing market and has recently partnered with Foxconn. It is prepared to launch internationally by 2015.



Technology Overview:

Lock8 uses a geolocator to track where the bike is and let others know your bike is stolen, a “smart” cable that sets off a 120db alarm when attacked by a bolt-cutter, a gyro accelerometer when attacked by a saw,

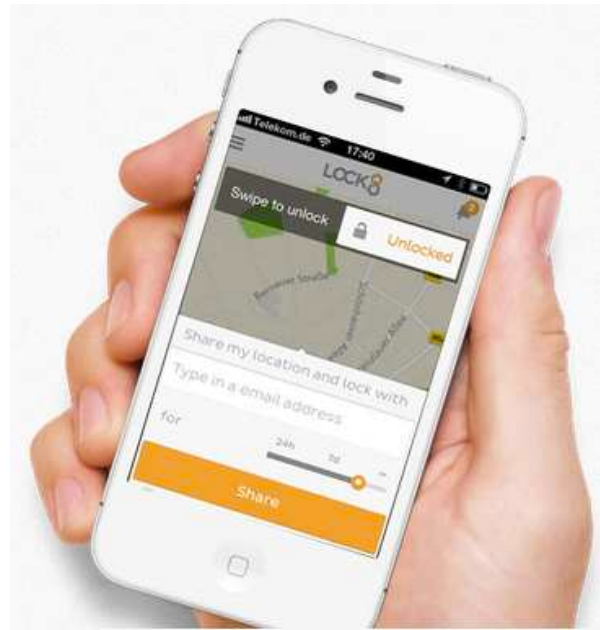
hammer, drill, etc., and a temperature sensor when attacked by heat or ice spray. The security that Lock8 offers is extraordinarily robust, and it can be attached to about 95% of bikes out there. The lock uses a durable, built-in, rechargeable battery, industrial strength casing, connectivity through Bluetooth Low Energy, a bike attachment (various sizes offered), and the alarm and sensor system. The system is compatible with Apple iPhone 4S or later with iOS6 or greater and Android 4.3+ devices with bluetooth 4.0 coming soon. The Lock8 app allows users to share their bikes within a user-defined group, enabling small-scale bike sharing.

Station Technology:

There are no defined stations with a Lock8 system; all the technology is on the lock. Currently stationless, may change that in the future. Geofencing can be used to create virtual station locations.

Rental Process:

Lock8 requires a smartphone and access to up-to-date blue tooth technology to unlock the bike. A user can also rent out their bicycle and earn money with it, allowing for a potentially robust micro-bikeshare.



Planning/Implementation Design:

It still remains unclear how Lock8 will plan and implement their bike share systems. So far, only micro-bikesharing has happened, which is a bottom-up approach. It's unclear how they would implement using a top-down approach.

Operations/Maintenance:

Lock8 is not a bike share operator and would not maintain the systems, and it's unclear how they would operate systems and how maintenance would be managed on a municipal level. Without a well-defined maintenance plan, liability becomes a concern (e.g. who is responsible for bicycle damages or medical expenses if bikes are not properly maintained?). Lock8 requires better developed maintenance software and a partnership.

Capital Costs:

\$249/lock. Does not include price of bike or any operations and services, just the retail price for the lock.

BitLock

Overall:

It's unclear how these systems would be maintained on a larger scale. The rental process also has more barriers than third and fourth generation bike share systems, which offer first-time riders easily accessible rentals. Operations and maintenance are also unclearly developed. A bottom-up approach works in some cases, but there's too many questions with maintenance and liability for it to work on a municipal level at the moment. There is great potential in a system like Lock8, but it still remains to be seen if Lock8 develops the software and accessibility necessary to run large-scale maintenance and operations.

Company Overview:

BitLock is a start-up that also retails a "smart-lock" similar to Lock8. BitLock currently retails their lock at \$119 (pre-order is \$95), but the hope is to expand into bike sharing, similar to Lock8's aspirations. The product is set to launch in November, 2014.



Technology Overview:

BitLock uses Bluetooth Low Energy from cell phones, which activates the locking/unlocking mechanism exactly like Lock8. The lithium battery combined with low power usage allows for a 5-year battery life under average usage (5 lock/unlock operations per day) before needing to replace the battery. You're able to share access through your phone with others, though both users need an active data connection on their smartphones to share the bike. As for security, BitLock is made of reinforced and cut-resistant steel, uses a high security disc locking mechanism, a bent shackle leg, and robust data encryption similar to that of online banking.



BitLock allows people to create their own micro bike shares through permission groups where one adds people to these groups, sets appropriate access policies such as availability and geographic area inside bikes should be returned to. Registration of each bike and profiles are inside the app. A powerful web administration dashboard allows a community to manage and administrate a bikeshare fleet. Through the dashboard, one can track and monitor bike usage, look at and analyze access and payment logs, open and respond to bike repair tickets, and manage fleet size and users with ease.

Station Technology:

Stationless system, the smartphone app uses GPS from the phone to bookmark the bike's location, i.e. there is no live tracking or GPS tracking on the lock.

Rental Process:

BitLock allows people to create their own micro bike shares through permission groups where one adds people to these groups, sets

appropriate access policies such as availability and geographic area inside bikes should be returned to. Registration of each bike and profiles are inside the app. A powerful web administration dashboard allows a community to manage and administrate a bikeshare fleet. Through the dashboard, one can track and monitor bike usage, look at and analyze access and payment logs, open and respond to bike repair tickets, and manage fleet size and users with ease.

Planning/Implementation Design:

There is no planning or implementation design currently with a BitLock system. It's unclear how BitLock can do top-down planning, though people who are part of the BitLock network can use a bottom-up approach to plan a micro-bikeshare.

Operations/Maintenance:

Similar to BitLock, it's unclear what exactly the large scale operations and maintenance plan is, however BitLock does offer a web administration dashboard that allows a community to manage and administrate a bikeshare fleet. Through the dashboard, one can track and monitor bike usage, look at and analyze access and payment logs, open and respond to bike repair tickets, and manage fleet size and users. Liability also remains a concern if operations and maintenance is not well structured.

Capital Costs:

\$119/lock. Does not include price of bike or any operations and services, just the retail price for the lock.

Overall:

BitLock is similar to Lock8, but unlike Lock8, the BitLock app communicates only with the lock. There is no communication between the lock and the phone. BitLock has high potential to work on a micro-level, i.e. for a corporate campus or for a network of users equipped with up-to-date smartphones, but on a community-wide level, the technology is just not there. There is no software backend capable of maintaining a system, and unlike Lock8, no lock communication to make a large-scale system truly functional.

A mix of “smart-bike” and “smart-lock” bikeshare systems are likely to be seen in 2015 while “smart-dock” systems start becoming more phased out. If the software, planning, liability, and operations become more developed, there is great potential for “smart-lock” technology to find its way into the bikeshare market.

8. Concluding Remarks

This report first offers an overview of the different generations of bikesharing, then compares and contrasts third and fourth generation systems, and finally details the major American bikesharing hardware providers and the different services that they offer.

The differences between third and fourth generation systems were the main focus of the first part of the analysis between the different vendors, which found that fourth generation systems offer more flexibility, are more affordable, offer more potential to the developments in demand responsive technology such as incentivized pricing, machine learning maintenance technology, or multi-modal transportation integration. Third generation systems will be phased out in favor of fourth generation systems as the technology within fourth generation systems develops.

The debate will shift from “smart-dock” v. “smart-bike” to “smart-bike” v. “smart-lock” as the “smart-lock” technology develops. “Smart-lock” systems still require better accessibility, easier first time rental capabilities, and a more robust maintenance software back-end to be able to handle the rigors of maintenance before a municipality can seriously consider them a bikeshare competitor, but future technological developments could change that.

As of today, fourth generation bikeshare systems offer the best combination of price, flexibility, and technology.



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