



Location Analytics Post Pilot Evaluation Report

Prepared for SMC Labs, County of San Mateo
by
Strategy of Things
March 11, 2020

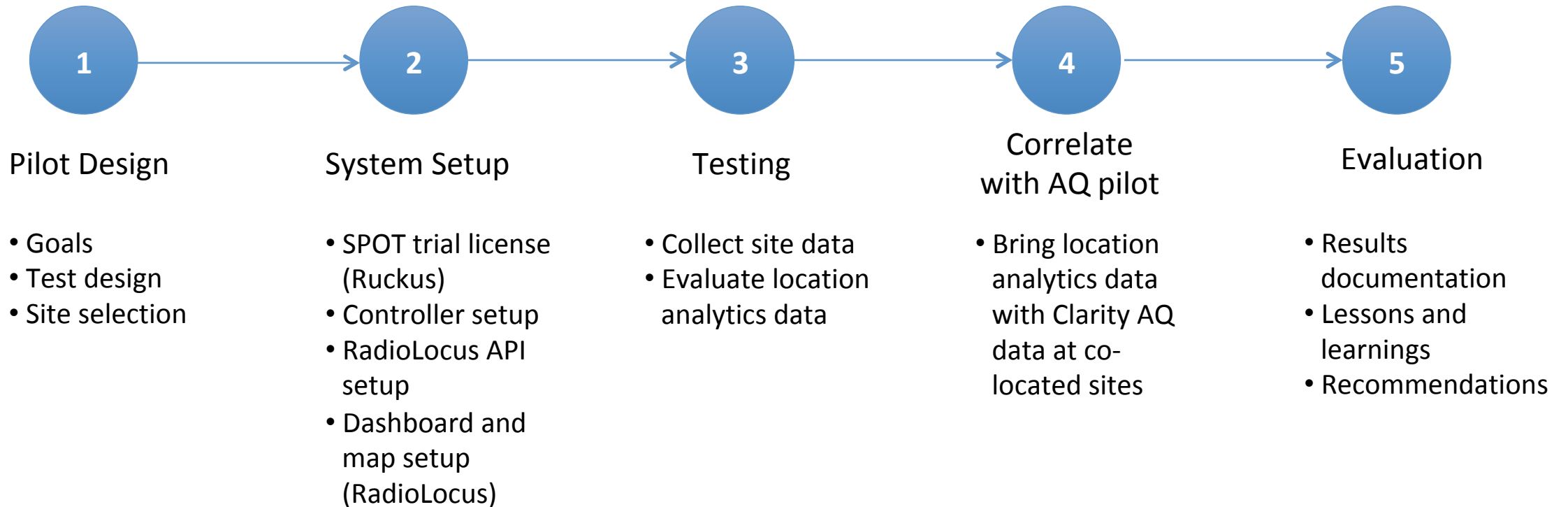


STRATEGY OF THINGS

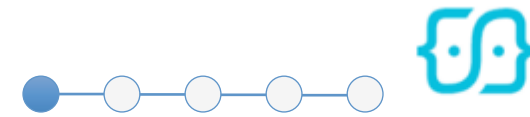




What are we doing?

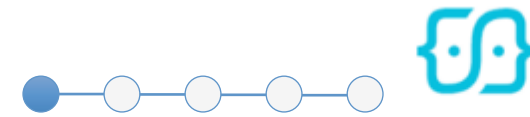


What are we doing?



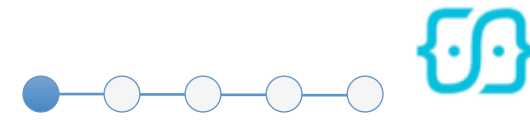
- Use San Mateo County's existing public wi-fi infrastructure to generate visitor location analytics around Coyote Point Recreational Area and Pescadero
- Identify ways that the location analytics data collected can be of use to other public and private organizations, including economic development, sustainability, transportation, downtown merchants and business organizations
- Co-locate with air quality sensor pilot at Coyote Point, and Integrate the data with the air quality sensor data, to further quantify the impact of air quality and number of people impacted

Why are we doing this pilot?



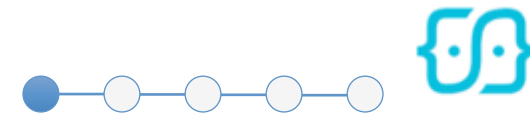
- Problem: Municipalities have limited awareness of how pedestrians, visitors and commuters move around within a city and selected areas. This lack of understanding results in services that don't match people's expectations, suboptimal citizen engagement and experiences.
- Questions to be answered:
 - How many people are visiting in a particular area?
 - How long do they stay?
 - How often do they come back?
 - When do they come?
 - Where are they coming from?
 - Where do they go next?
 - What services should we create in those areas that best serves the needs of visitors?

Pilot objectives



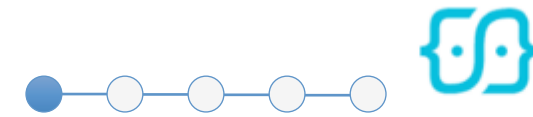
- Setup and activate a small number of Ruckus access points to collect and process location analytics. Understand the setup process.
- Understand what issues, limitations, costs, etc. are involved in set up and operation. Understand the issues surrounding privacy.
- Understand how the information collected can be of use to other public and private organizations
- Create justification for expanding to public wi-fi network running on other SMC access points
- Validate the functional usefulness of collecting location analytics data

Pilot overview



- Enable tracking of wi-fi enabled wireless devices at Coyote Point Recreation Area (San Mateo) and Pescadero. Ninety day test period.
- Use existing SMC Public wi-fi access points (Ruckus) to collect the data and routed to a RadioLocus cloud based service for analysis and reporting
- Total of 21 access points will be used to collect data (11 at Coyote Point, 10 at Pescadero)
- No new hardware is needed. Ruckus SPOT license must be activated (90 day trial). Information collected by Ruckus access points routed to Ruckus SPOT server and accessed by RadioLocus via API.

What does the pilot technology look like?



Hardware



Wi-Fi Access Point

Use existing Ruckus Wi-Fi access points (APs). We just need to activate the SPOT license and configure the wireless controller units.

Cloud



Analytics and Machine Learning Platform in the Cloud

The data is collected and analyzed behind the scenes in the cloud.

The data is stored for a one year period. The data belongs to SMC.

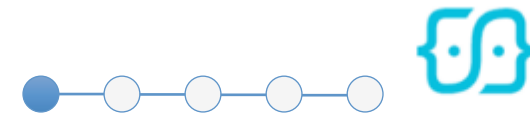
Insights



Analytics Dashboard

The insights generated from the data are displayed on the RadioLocus web dashboard that is accessed online.

How does it work?



1



Mobile Device
Scans for Wi-Fi
Hotspots

2

Hardware



Wi-Fi AP detects
device scans
and collects a
small set of info
(device ID,
distance from
sensor, etc.)

3

Cloud



Info and
metadata is
Aggregated,
Normalized,
Cleansed,
Anonymized
and Stored in
the Cloud

4



Machine
Learning
Algorithms
Analyze Data to
Create Insights

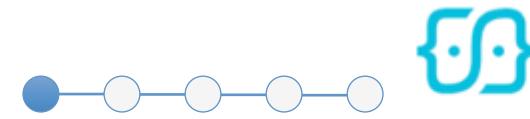
5

Insights



Insights are
presented to
planners on a
web based
dashboard

Key analytics reported



Location



- Total # of people over measurement period
- Times of the day with most and least people
- Times of the day where people spend the most and least time
- Frequency of repeat visitors per location by day over measured period

City Services



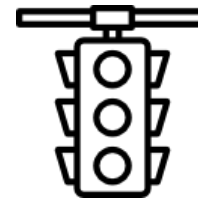
- Highest visitor times
- Highest visitor engagement times
- Brand discovery routes
- Visitor flow

Zones



- Total # of people
- Frequency of repeat visitors by day
- Times of the day with most and least people
- Times of the day where people spend the most and least time
- Common zones visited
- Top travel routes
- Visitor flow

Traffic



- Vehicle density by hours
- Vehicle frequency
- Travel time
- Traffic patterns

Brands



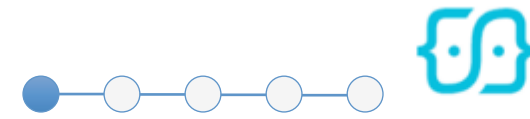
- Total # of people exposed to “brands”
- Frequency of repeat visitors
- Times of the day with most people
- Common zones visited

Mobile Devices



- # of devices measured by brand

Privacy

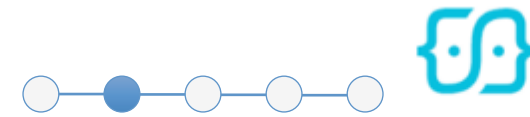


- Mobile phone users can opt out of data collection by disabling wi-fi on their mobile devices and phones, or by entering their MAC address in the smart place privacy website.
- Each individual device ID (MAC address) is assigned a unique ID code on RadioLocus end. This code is uniquely assigned through a one way hash. Once this is done, the individual device ID information is deleted.
- Vendor and technology compliant with Future of Privacy standards. Audits confirmed compliance levels have been met.



Test Setup

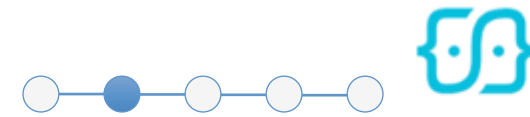
Initial pilot sites



Location	Description	Test objectives	Access Points
Pescadero + Puente Center	Mobility tracking within a small area –	see how people move around a concentrated area with multiple access points	Pescadero + Puente (10)
Coyote Point	General visitor analytics	See how many people were there, how long did they stay, when did they come and leave (Hours), and repeat visitors	Marina area – 9 Magic Mtn – 1 Golf Course - 1

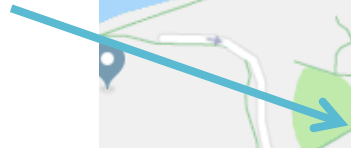
Of the various sites with SMC public Wi-Fi, these two locations were selected because of a combination of a large number of access points and concentrated geographic area. Coyote Point is a 670 acre outdoor site, and has a large number of visitors but the wi-fi coverage isn't park-wide. Pescadero has coverage throughout its "downtown" but it doesn't have a lot of visitors. An ideal test site would have been Millbrae downtown but the wi-fi network was not operation at the time of the pilot.

Access Point locations at Coyote Point (11 access)



Magic Mountain Playground

- One access point



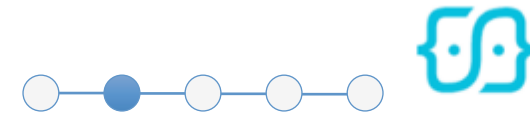
Golf Course Maintenance Shed

One access point



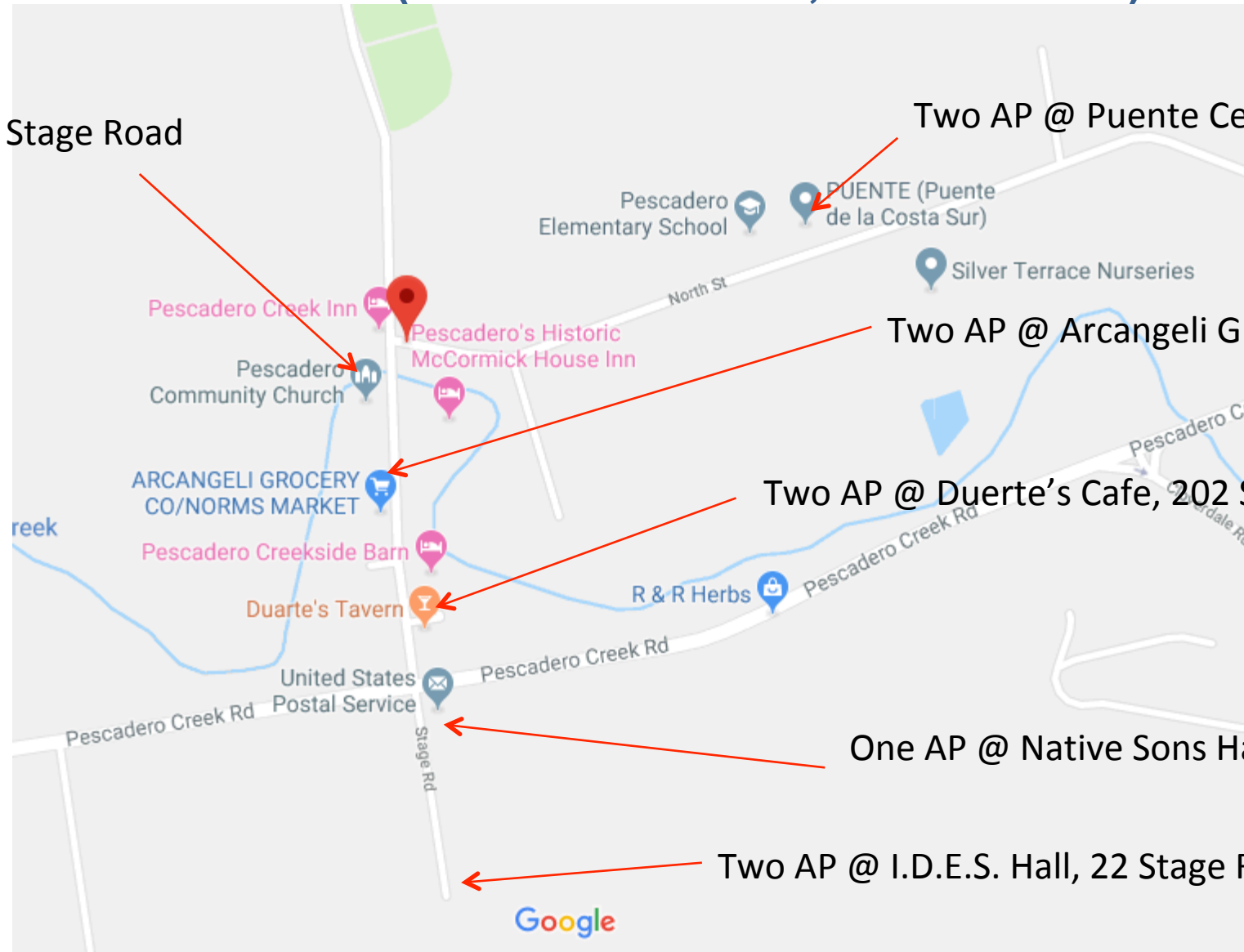
Coyote Point Marina
9 access points

Pescadero AP locations (8 Pescadero, 2 Puente)



One AP @ Church, 363 Stage Road

Two AP @ Puente Center, 620 North Road



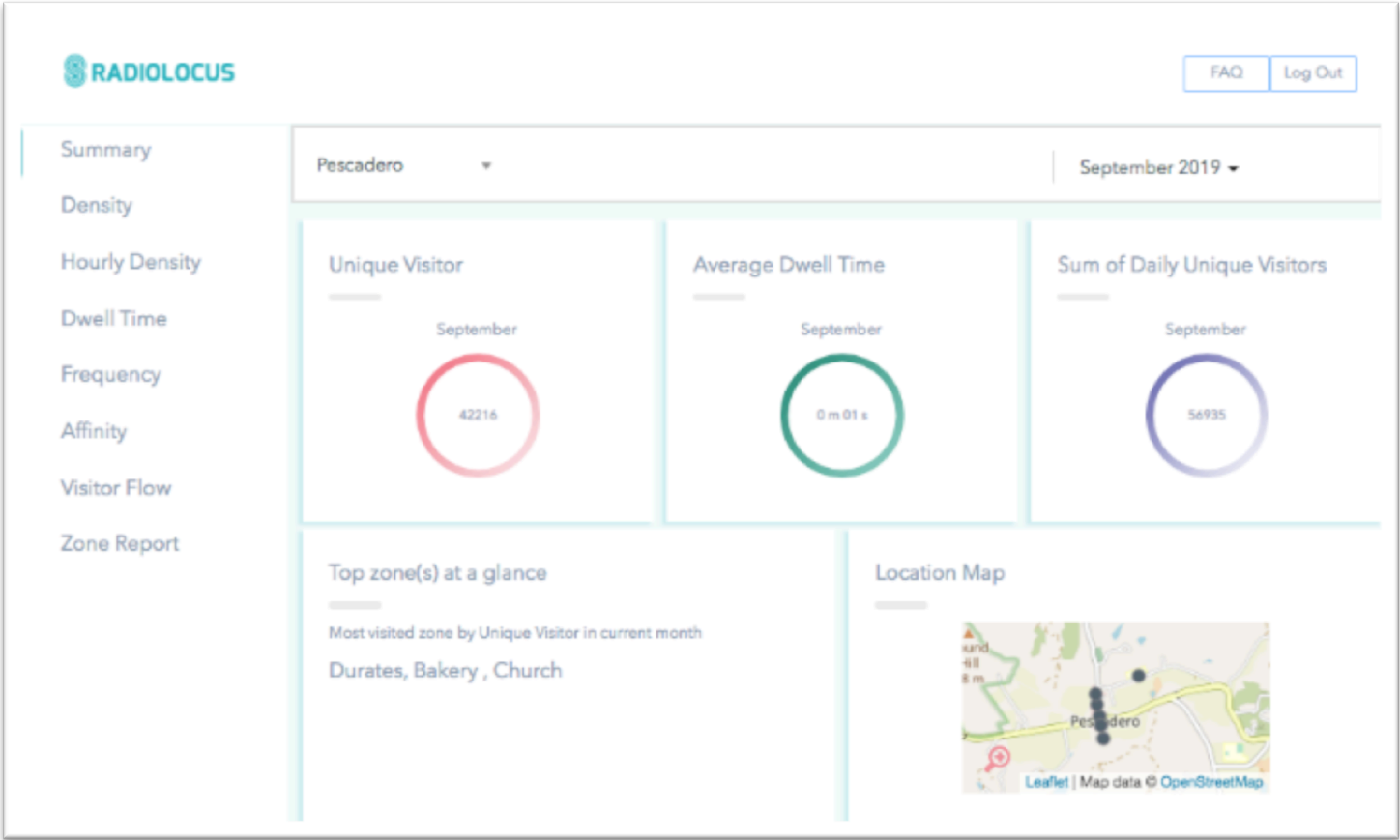
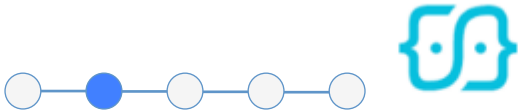
Two AP @ Arcangeli Grocery, 287 Stage Road

Two AP @ Duarte's Cafe, 202 Stage Road

One AP @ Native Sons Hall, 112 Stage Road

Two AP @ I.D.E.S. Hall, 22 Stage Road

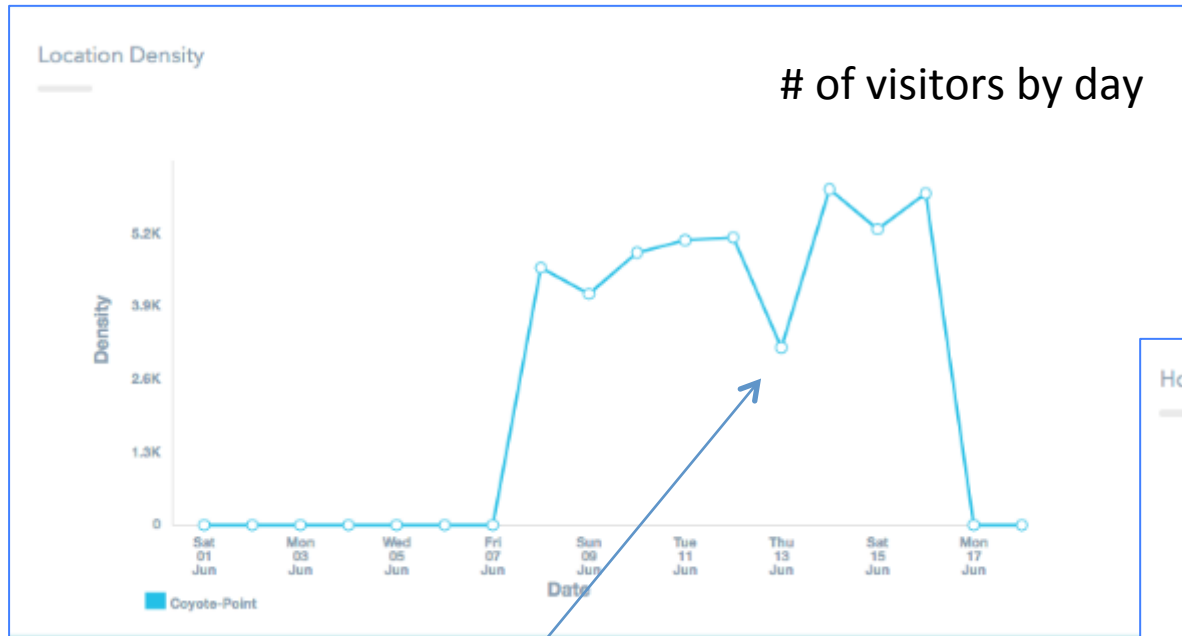
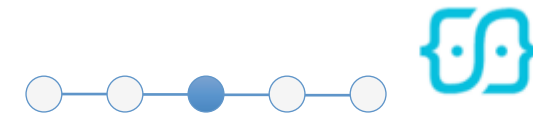
RadioLocus Dashboard





Testing

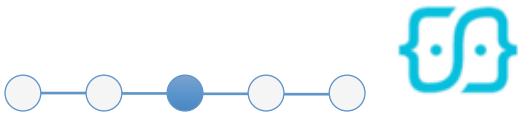
How many people visited overall site?



Dip due to Wi-fi infrastructure outage for 8 hours



How many people visited a specific zone inside a site?

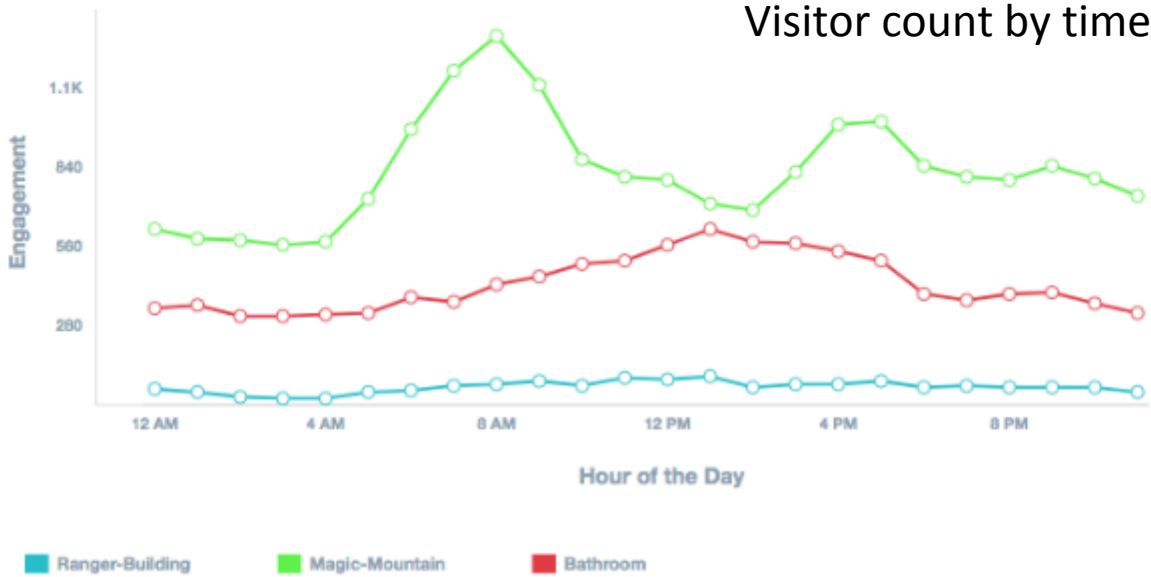


Comparison of Top and Bottom Hours for Location(s) Selected



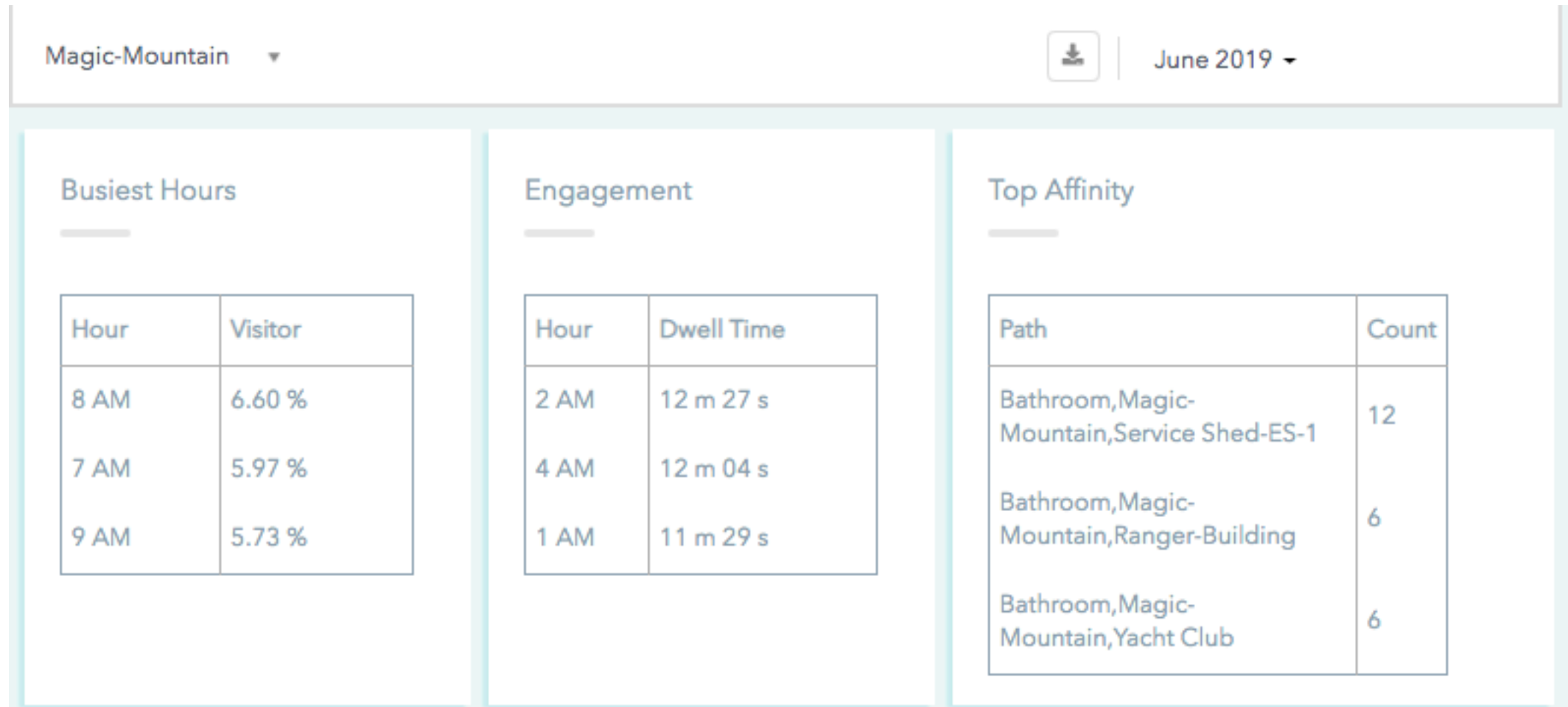
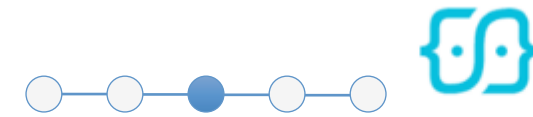
Busiest and least busiest times

Hourly Density Comparison For Location(s)

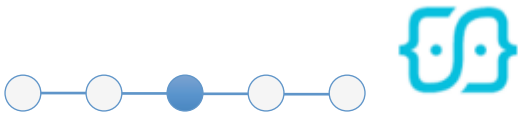


Visitor count by time of day at specific zones

How many people visited a specific zone at the site?



How long did visitors stay in the zones?

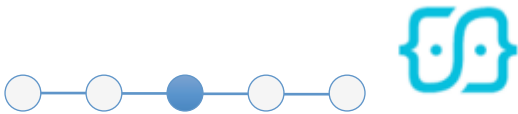


Dwell Time

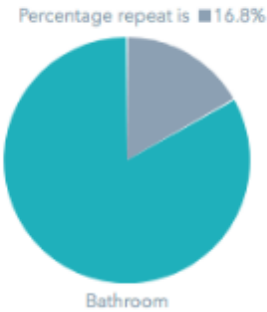
Count

Time Range	Location	Total Visitors	Dwell Time (Ranges in minutes)					
			0 - 20	20 - 30	30 - 90	90 - 180	180 - 360	360 - 480
Sun 16 Jun 19	Magic-Mountain	1736	1468	72	128	49	16	3
	Bathroom	2186	1938	72	124	30	20	2
Sat 15 Jun 19	Magic-Mountain	1941	1665	95	124	39	16	2
	Bathroom	2113	1904	62	102	28	13	4
Fri 14 Jun 19	Magic-Mountain	2324	2063	80	118	41	20	2
	Bathroom	1523	1334	49	101	27	9	3

How many were repeat visitors?



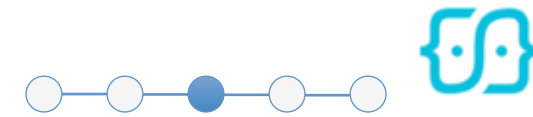
Percentage Repeat Distribution



Frequency

Frequency	Magic-Mountain	Bathroom
1	4427 [81.66%]	1256 [83.23%]
2	563 [10.39%]	106 [7.02%]
3	186 [3.43%]	53 [3.51%]
4	89 [1.64%]	35 [2.32%]
5	57 [1.05%]	15 [0.99%]
6	41 [0.76%]	9 [0.60%]
7	58 [1.07%]	35 [2.32%]

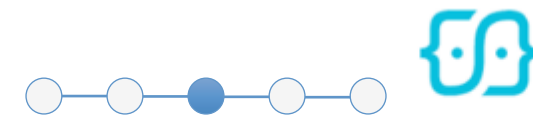
What were the most common zones visited?



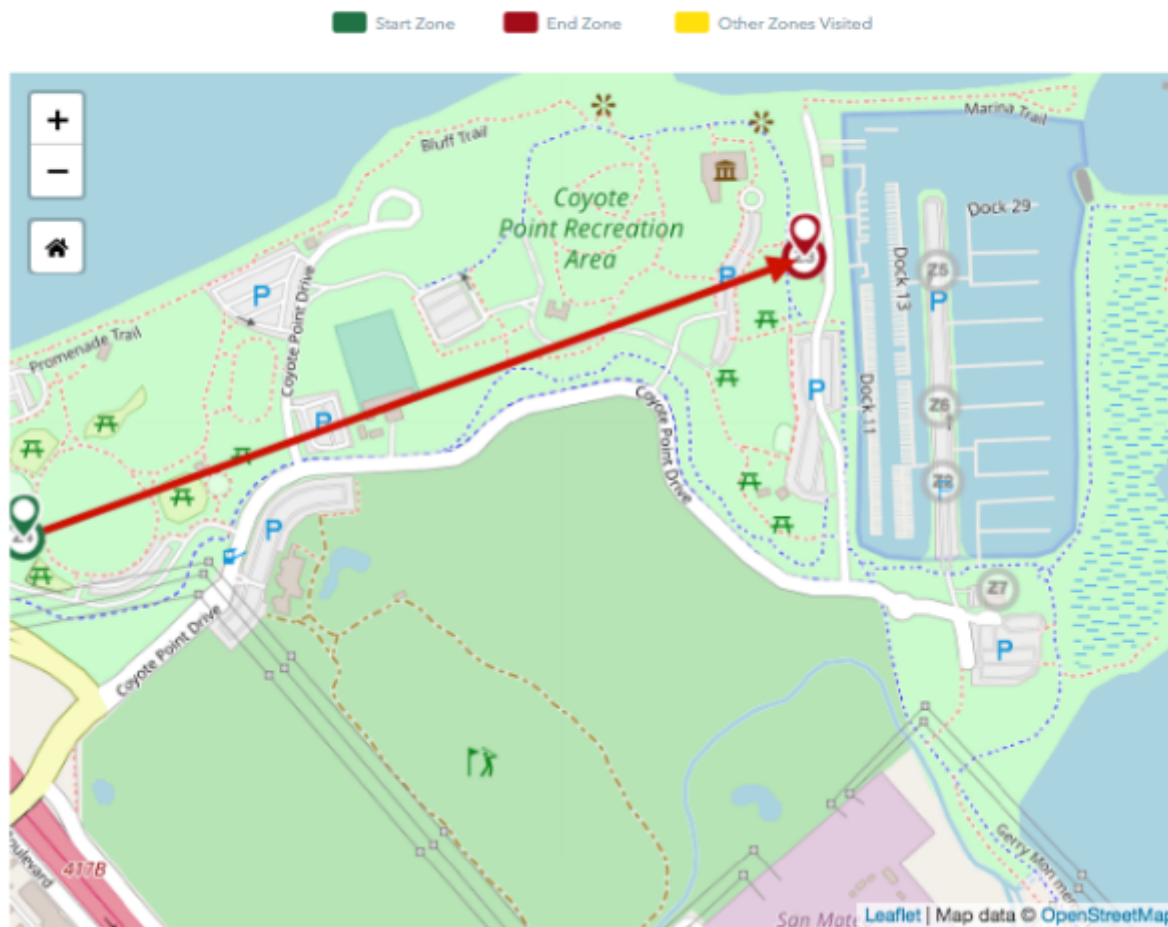
Common Zones

Zones Visited	Affinity
Bathroom,Service Shed-ES-1	448 <div></div>
Bathroom,Ranger-Building	326 <div></div>
Bathroom,Service Shed-ES-3	290 <div></div>
Bathroom,Yacht Club	276 <div></div>
Service Shed-ES-1,Yacht Club	192 <div></div>

How many visitors went from one specific zone to another specific zone inside the site?



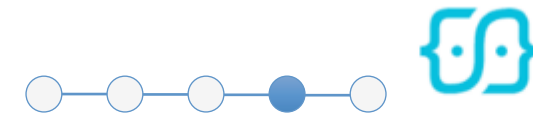
Visitor Flow Path





Correlation with Air Quality Sensor pilot

What was the air quality and how many people were impacted at the site?

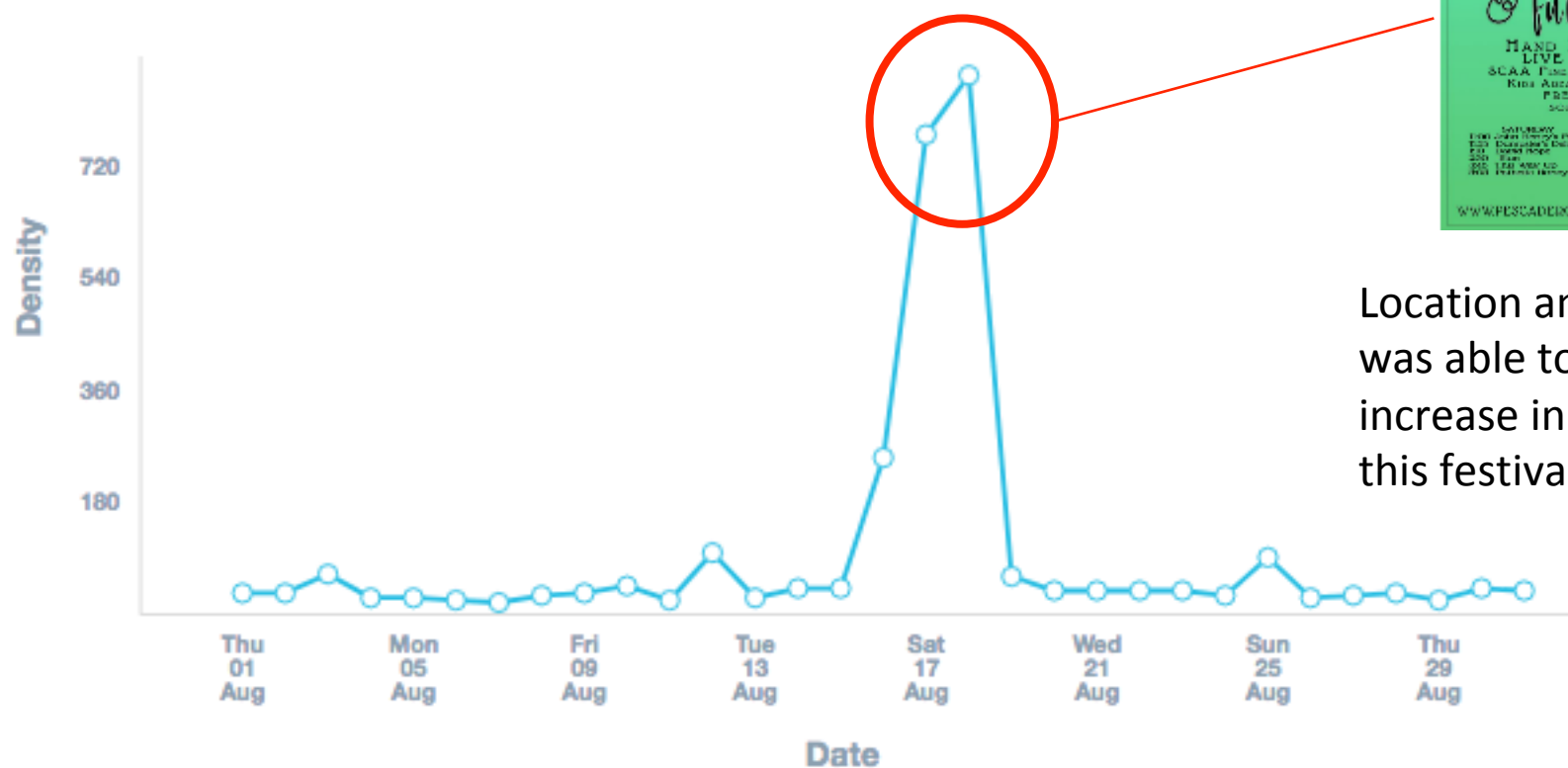


Results: Pescadero Arts and Fun Festival



Zone Density

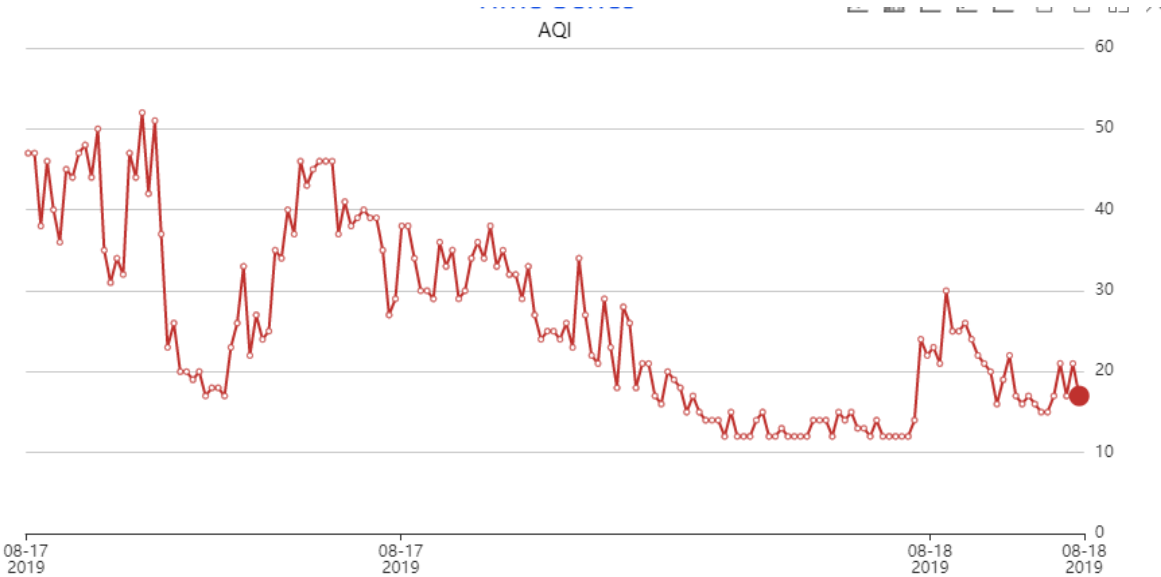
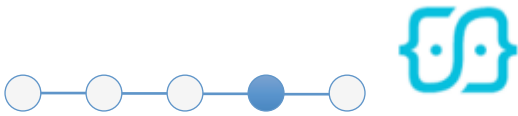
—



Location analytics pilot was able to detect the increase in visitors for this festival

IDES-Hall

Results: Pescadero Arts and Fun Festival

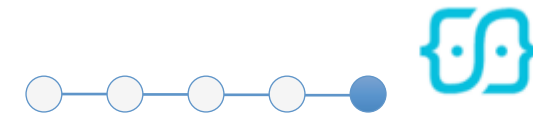


AQ sensor location – intersection of Pescadero Creek and Stage Road (in front of gas station)



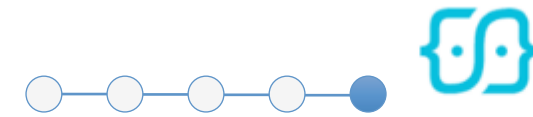
Evaluation

Results: Overall



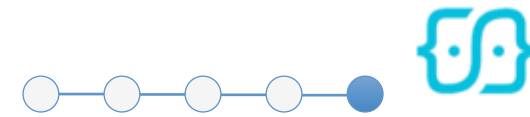
- Pilot completed with three months of data collected.
- Technology worked as expected, and saw interesting behaviors and patterns. We learned that the number of devices detected vs number of connections logged into SMC Public WiFi was about 10:1. That is, 10x more visitors detected in the area than number of people connected to the wi-fi network.
- We were able to record a big spike in people count in Pescadero on August 17-18, 2019. This is the weekend of the Pescadero Arts and Fun Festival, and draws in a lot of traffic. This gave us confidence that the technology was working.
- Number of people and patterns in the test areas corresponded with what we expected (during the day, the number of people increases, while in the evenings, decreases, weekends increase). We were surprised at Coyote Point that there were still quite a number of people after midnight.
- The sensitivity of the data can be changed to reflect changes in the counts. For example, the algorithm can be changed to determine what is a “valid” detection (for example, device must be detected twice during a specified time period). We did not play with that optimization, but should do it against a “calibration” test in the future.
- We observed the dwell time counts. We are not sure this metric is accurate, and will need to understand how that works, and to do some validation. A quick check using the IDES hall statistics at the Pescadero Arts and Fun festival yielded results that didn’t make sense, and it would seem the dwell time calculation is undercounting.
- We were able to correlate the location analytics data with the air quality sensor data at Coyote Point. We used the data from the Magic Mountain access point, and the nearby (< ¼ mile away) Clarity AQ sensor. We were able to pull the two data sets together to show the number of people at Magic Mountain and vicinity and what the AQ levels were at that time period. We did a similar correlation with Pescadero.

Results: Overall



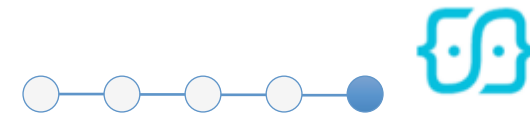
- We were able to get near real time location analytics information. On average, we were able to get the full set of usable and actionable location analytics information within 4 hours from initial data collection.
- We were not able to test the “portable” sniffer unit in this pilot. The portable sniffer device is a standalone travel router reconfigured to collect data in the same way a wi-fi access point does. One of the reasons is the lack of access to power, as well as access to a data line in the locations which we want to install this. Ideally, the portable unit would have its own power source (solar + batteries) and a cellular backhaul. This would allow it to be installed anywhere.
- The Coyote Point test site, despite having 11 access points, was not that great for testing location analytics. 9 of the 11 access points were located in the Marina area, which yielded limited useful mobility information given the way the roads were laid out. In addition, many of the access points were co-located on a few poles (but aimed at different points). The 10th access point was at magic mountain playground, and was relatively far away from the Marina. People either went to the Marina or Magic Mountain – there weren’t much going back and forth between the two locations. The 11th access point, at the golf course maintenance shed at the South-West corner of Coyote Point, was not operational during the pilot.
- While we were able to collect mobility and traffic patterns, we needed to fully characterize the data collected, the algorithms used to create the analytics, as well as compare it against a known accurate benchmark (visual count and observations, etc.).
- Overall, we were able to obtain discernable and useful movement and mobility location analytics from this pilot. The technology appears to work. We were also able to, based on the information collected, see its usefulness to civic applications, and in the next set of slides, identify various use cases and applications.

Learnings: Setup



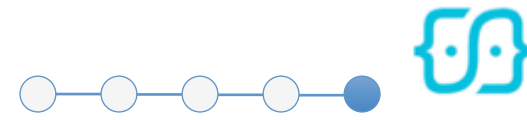
- Set-up was delayed because we could not provide the lat-longs for each access point. Unfortunately, these were not recorded during the initial install of the access points. Any new access points to be installed should have its lat-long information recorded. We had to physically go to each existing wi-fi access point and collect the lat-longs.
- What's good for location analytics is not necessarily the same as what's good for wi-fi coverage. Location analytics require the access points be located in such a way that triangulation of the detected device is possible. Existing access point installs did not take location analytics into consideration (to be fair, this occurred before location analytics using wi-fi became a “thing”).
- This setup used wi-fi access points that did not go through county secured networks. This would have required additional levels of scrutiny and review.
- Being tethered to an access point has some pros and cons. Pros is no hardware required as you are using existing AP and no need to worry about power and backhaul. Cons is that your location is tied physically to the AP. For operational scalability in a city environment, you want a separate “sniffer” device that has its own power source (solar + battery) and its own backhaul (cellular).

Learnings: Operations



- The ability to collect data is only good if the wi-fi is up. Need to monitor the access points to ensure that they are up. Had an incident in which the controller or wi-fi was down and we couldn't get data for around 8 hours. For critical situations, need to have some kind of backup in case network goes down.
- Going in, we knew none of the two test sites were ideal from a test perspective. The ideal site, is one in which we had high traffic, large amounts of wi-fi access points and a small area. Coyote Point was located in a high population area, but the park doesn't have full coverage over the entire area. Pescadero has a high access point coverage in a small "downtown" area, but had low traffic volumes. These were the best sites for the test as the main site, Millbrae downtown, was not available (no wi fi network yet).
- The numbers as reported by the dashboard are based on certain assumptions made by the algorithm. We have to understand how the algorithm determines the visitor counts. This algorithm can be adjusted to determine what is a "valid" count in a given situation. What is a valid count is not a "black and white" – take the case of an intersection with pedestrians and drivers. The system may require a 2 pings over a period of 5 seconds to consider that a real count. If a car drives past an intersection and only one ping gets picked up, it may not be recognized as a valid count. In a pedestrian environment, 2 pings in 5 seconds may work but in a car/driver heavy environment, it may not. In this case, the algorithms need to be adjusted accordingly.

Learnings: Potential use cases



Economic Development

Foot traffic optimization
Retail development
District development



Public Safety

Crowd management
Event routing
Emergency services stations



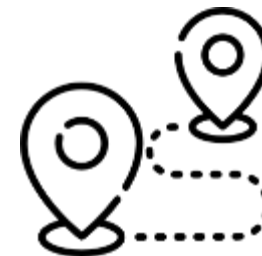
Retail Operations

Location optimization
Shelf planning
Consumer engagement



Urban Planning

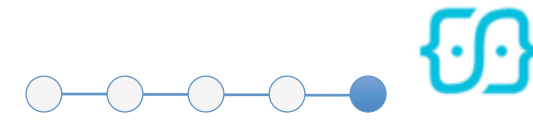
Community development
Redevelopment planning
Services development
Citizen engagement



Mobility

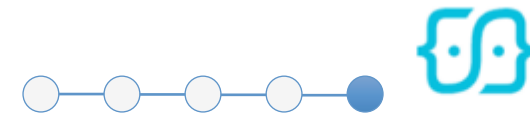
Transportation Planning
Route Optimization
Multimodal Transit

Learnings: Potential civic beneficiaries



Customer	Entity Type	Value Provided	Value Perception
IT Department	Public	<ul style="list-style-type: none"> Metrics - Wi-Fi usage statistics and patterns Additional ROI – reuse of infrastructure for new tasks Potential IT service charge to other agencies 	\$
Economic Development	Public	<ul style="list-style-type: none"> Metrics – visibility into visitor and people patterns New insights to develop & validate new programs 	\$\$
Transportation	Public	<ul style="list-style-type: none"> Metrics – visitor and people mobility patterns New insights to develop Transportation services Ability to measure pilot and planning effectiveness 	\$\$
Public Safety	Public	<ul style="list-style-type: none"> Metrics – visitor and people mobility patterns Public safety services planning Near real time services planning for events 	\$\$
Chambers of Commerce	Private	<ul style="list-style-type: none"> Metrics – visibility into visitor and people patterns Services planning and programs to drive growth 	\$\$\$
Downtown Merchants Assn	Private	<ul style="list-style-type: none"> Metrics – visibility into visitor and people patterns Services planning and programs to drive growth 	\$\$\$
Merchants	Private	<ul style="list-style-type: none"> Metrics – visibility into shopper patterns Targeted promotions and campaigns 	\$\$\$

Recommendations



- Privacy policies be developed and notices be placed in test sites prior to the launch of the next pilot. With the California Consumer Privacy Act (AB 375) going into effect on January 1, 2020, we recommend that the pilot be designed taking this law into account in order to reduce or minimize any liability for the county.
- If a standalone device (wi-fi or bluetooth sniffer) is used to collect data (instead of existing wi-fi access points) in the next pilot, we recommend making sure that the device (including hardware and any software) complies with the California IoT security law (AB 327) in order to minimize or reduce any liability for the county.
- Need to do an accuracy count - count the number of people visually and correlate against what was detected. Also need to look at the dwell time counts. These may not be accurate.
- In conjunction with the accuracy count – should examine the algorithm settings to define what is considered a valid detection event and count. This is more for optimization. The data collected will still be there, but how the algorithms counts is another matter.
- Test the system (or any other location analytics system) in a high traffic density, compact area (like a busy downtown). This will showcase the true operational and functional capability of this system. Our test sites proved out the viability of the technology but we weren't able to exercise its true capabilities.
- Co-locate use cases together with the location analytics pilot (e.g. air quality, etc.) to maximize impact of the data collection and analysis for both use cases.



STRATEGY OF THINGS

Benson Chan

Senior Partner

benson@strategyofthings.io

Mobile/WhatsApp +1-925-699-7562

Renil Paramel

Senior Partner

renil@strategyofthings.io

Mobile/WhatsApp +1-415-846-9448