

The Takeover by the Big 5 Tech Companies

Bo Brandt, Neha Mittal and Anuj Ramakrishnan

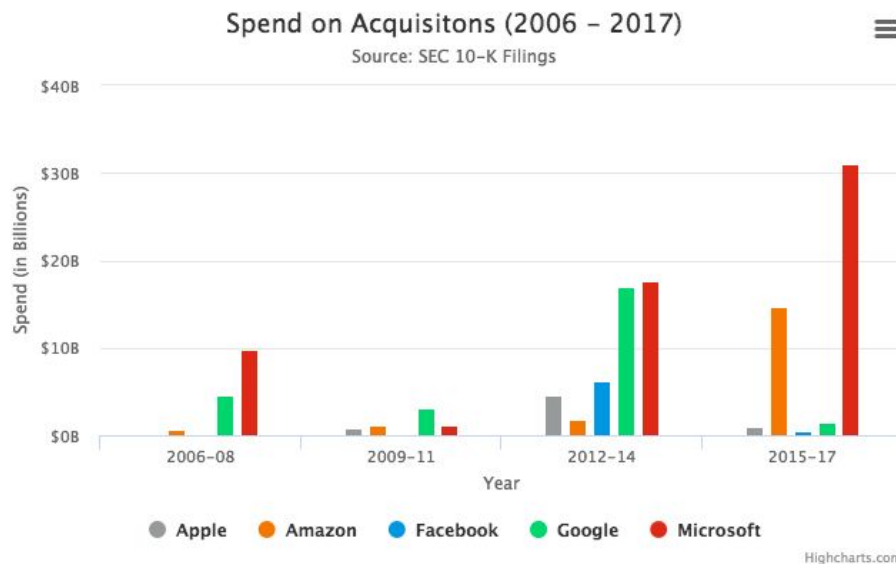
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Project goals

Our goal was to explore the acquisitions by the Big 5 tech companies, namely Amazon, Apple, Facebook, Google, and Microsoft. We were interested in this topic because there seemed to be a lot of contention around the consolidation occurring in the tech industry, and the concentration of power by these tech giants. For instance, headlines in the press on this topic included, “The ‘Big Five’ Could Destroy the Tech Ecosystem”¹, “Tech’s ‘Frightful 5’ Will Dominate Digital Life for Foreseeable Future”², and “The Upside of Being Ruled by the Five Tech Giants”³. When investigating these articles though, we could not find a lot of useful detail. The articles predominantly focused on the market valuation and the acquisition spend by the Big 5 tech companies. Therefore, while there was a lot written about the Big 5 tech companies, many articles stated very similar things such as market spend, ignoring insights like areas of acquisition that hint toward the strategies of the Big 5 in near future... Clearly people were intrigued by the consolidation going on in the tech industry, given the amount of articles, but from our point of view, not a lot of valuable information was communicated. As a result, we felt there was an opportunity for us to create a compelling information visualization on this topic.

Before delving into our data collection, we decided to see if this readily available information was useful. The chart below is the aggregate acquisition spend by the Big 5 tech companies. The information is from the respective company annual filings.



¹ <https://www.bloomberg.com/view/articles/2017-11-15/the-big-five-could-destroy-the-tech-ecosystem>

² <https://www.nytimes.com/2016/01/21/technology/techs-frightful-5-will-dominate-digital-life-for-foreseeable-future>

³ <https://www.nytimes.com/2017/11/01/technology/five-tech-giants-upside.html>

As you can see the chart shows an upward trend from around 2006 to 2017. The limited acquisitions in 2009-2011 was likely a result of the Great Recession. While the trend is interesting to note, we did not find this chart very useful. First, acquisitions are lumpy, meaning companies make acquisitions, particularly large acquisitions, infrequently and not consistently. Second, while the trend increases, we have no idea how to contextualize this information besides concluding that more money is being spent by the these companies. This limited information stems from the lack of disclosure by companies making acquisitions. Not disclosing how much an acquisition costs is a widespread practice, not just a Big 5 tech company decision. Only the largest acquisition amounts are disclosed. Therefore, since the disclosed aggregate amounts of acquisition spend did not provide much use, and specific acquisition amounts are not disclosed, we thought the most interesting piece of the acquisition puzzle was to look at not how much money was spent by the Big 5 but what specifically was the money spent on.

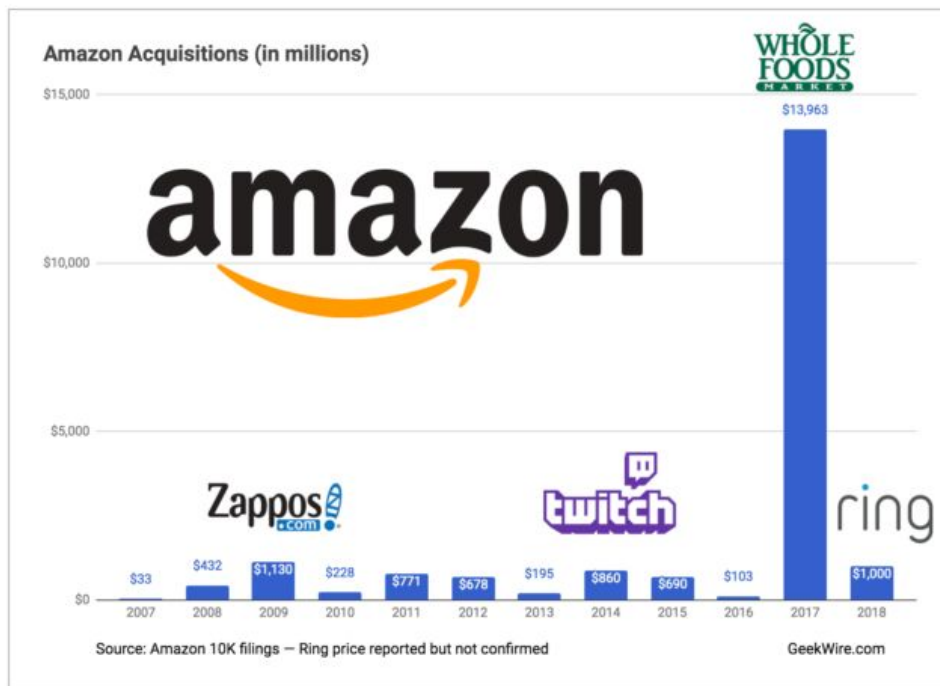
Not surprisingly, given the redundant information in the articles mentioned above, the available information on each acquisition was sparse. We found lists of previous acquisitions by the Big 5 tech companies, but not much else as some acquisitions contained significantly more information than others. However, when we dug deeper we found significantly more pieces of information on each acquisition target. The issue was that the information was contained on other sites. No one had connected and aggregated the information. This missing link between the disparate pieces of information was the main hurdle that press and media outlets did not seem to cross in their analysis. Instead they pulled easily available information from stock charts or company filings regarding current market valuations and annual acquisition spend. To us, while the process of aggregating the data and connecting the missing links would be both manual and tedious, we saw a big opportunity to create a compelling visualization using a unique dataset we built ourselves (details on our data collection and aggregation are in a below section).

Therefore, our goal was to provide an original analysis on the acquisition activity by the Big 5 tech companies looking at the type of categories acquired. We hoped to uncover acquisition trends within certain categories, as well as find interesting insights that potentially have not been detailed or shown previously. Further we wanted to see if certain categories were overhyped or underhyped, overinvested or underinvested based on the acquisition activity. Finally, we wanted to make our visualization not just engaging but clear. We felt our dataset would provide a huge asset, given its originality, but we did not want to show everything that we found. We wanted to provide enough exploration opportunities for the user to engage them, but also craft the story in a specific direction so we could communicate the message that we thought was most important to the user.

Discussion of related work

Bo

1. GeekWire posted an [article](#) highlighting Amazon's recent acquisition activity. The article showed a nice-looking visualization detailing the price Amazon paid for its recent acquisitions (see below).

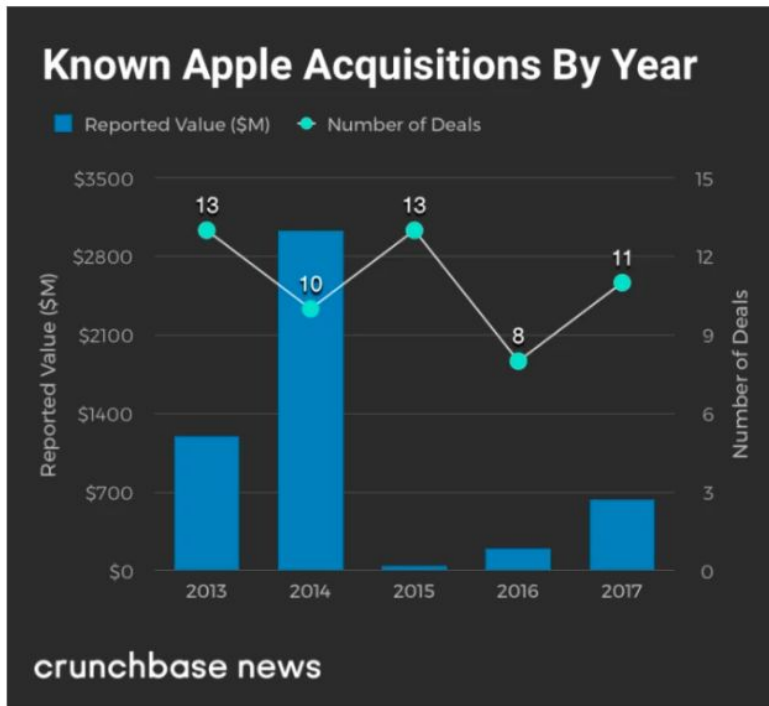


However, I did not find this visualization very useful. To me, you cannot make inferences that Amazon is on a buying spree because it spent \$15 billion last year, given that \$13.2 consisted of the Whole Foods acquisition. Instead, the Whole Foods acquisition looks more like an aberration than the norm. Further, the article does not detail the valuation of the Whole Foods acquisition. Perhaps Whole Foods was at such a significant discount that Amazon felt it could achieve a higher ROI investing in the grocery store than invest \$13 billion in its own business.

As a result, these types of visualizations helped to give us confidence that we should focus not on the acquisition price, but instead on the number and types of companies acquired.

2. I found TechCrunch's [article](#) on Apple's acquisitions over the last 5 years very informative. It matched our data which also showed that Apple made a lot of small

acquisition. While our data used headcount as a proxy for size, the TechCrunch article showed both the number of acquisitions and the total acquisition value over the last 5 years.

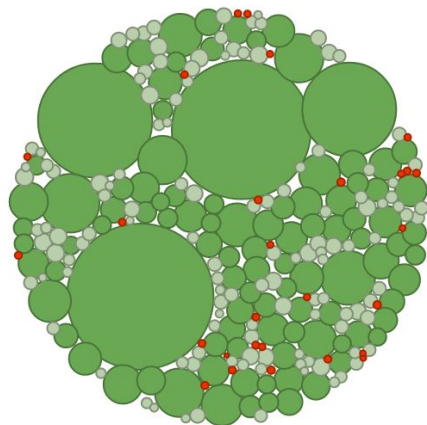


Although this chart is not very engaging, it is nonetheless informative. As a result we tried to capture this information in our bubble chart, which we felt would engage the user and inform them of the size of the acquisitions.

3. Jim Vallandingham's [blog post](#) influenced me to use the bubble chart in our visualization. While the code was tricky, the visualization was so engaging that it seemed to propel the user to discover new information.

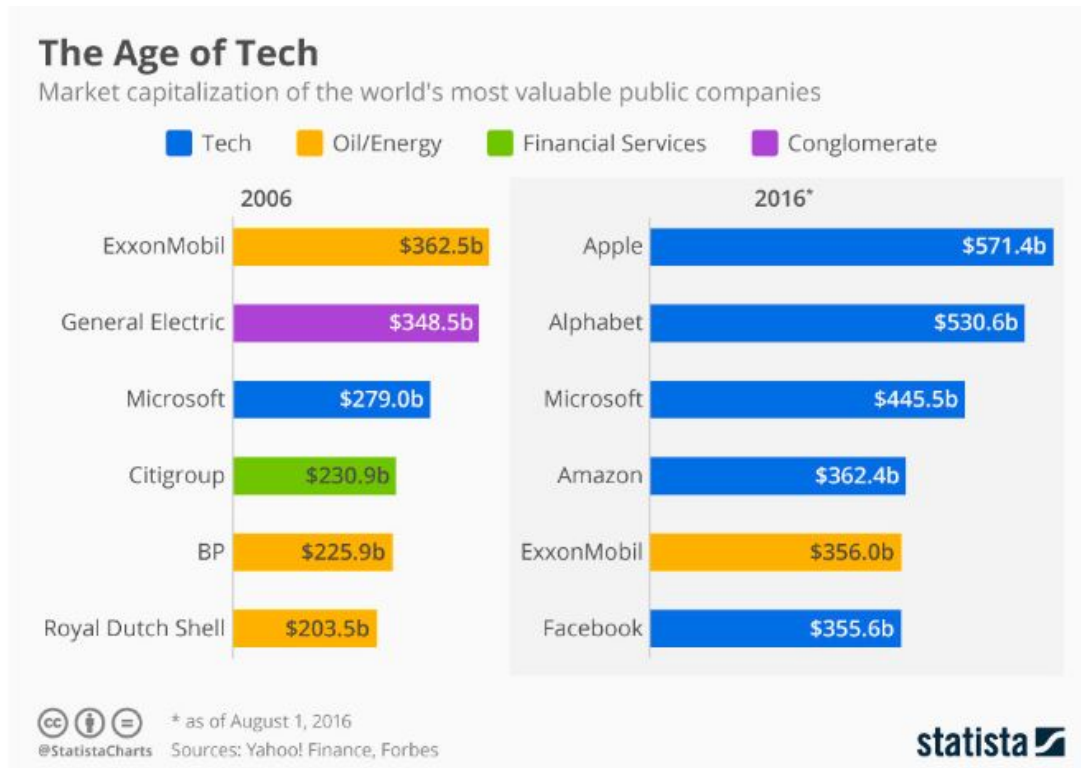
Gates Foundation Educational Spending

All Grants Grants By Year



As a result I felt it was perfect to add, particularly towards the beginning of our visualization because it brought the user in and got them interested to learn more about the data. After bringing the user in, we could then show them more detailed data and information in Tableau.

4. The World Economic Forum's [article](#) showcased the incredible dominance of the Big 5 tech companies.



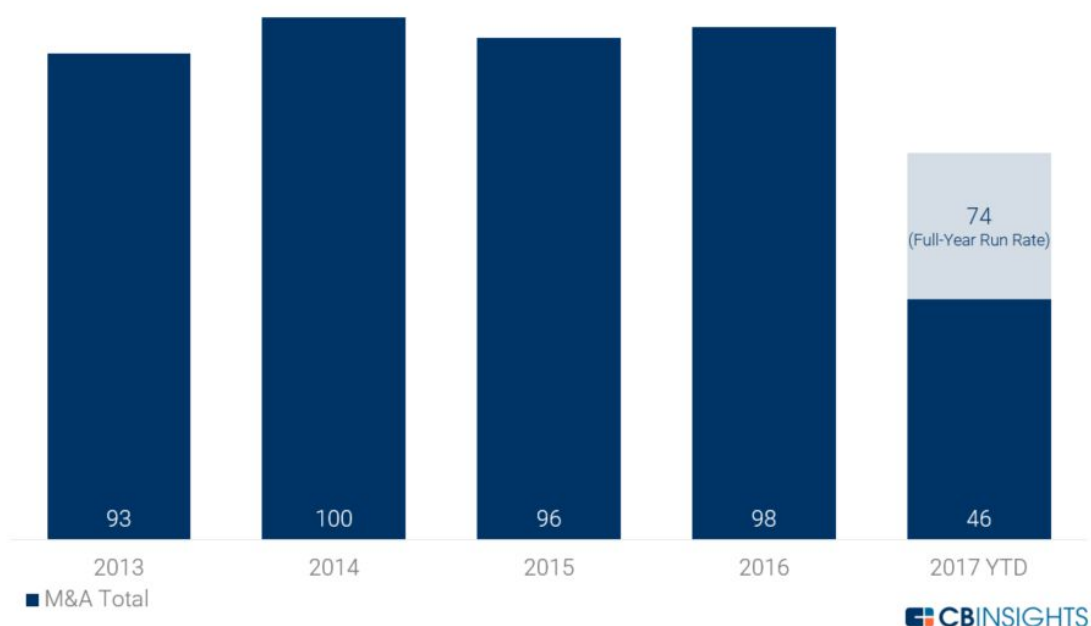
While we decided against using a chart similar to the one used in the article, it nonetheless highlighted to us the importance of our visualization. Clearly, the magnitude of the Big 5 tech companies is at unprecedented levels. Our visualization if done will could provide very valuable information that many people might find useful and interesting.

Neha

5. The [CBInsights article](#) gives hints that most of the big companies (even beyond) are making their biggest acquisitions in Artificial Intelligence and Data Analytics, with the largest deal being Intel's \$15B+ acquisition of Mobileye. Similarly, Apple has been acquiring companies in AI space starting with Siri's acquisition in 2010. These insights motivated us to get the complete truth behind acquisitions in different areas by different companies, i.e., we were curious to analyse if it's true that most companies' strategy is to

focus on AI products or is it more of a hype but companies continue to spend rather uniformly if most of the key growth areas like security and software. Another micro-trend that was offered by this article is that even though the number of acquisitions has been on the rise in general, the estimated 2017 number was lower than 2016 which means that companies have decided to slow down their activity and watch the reality take shape before making heavy investments.

M&A ACTIVITY OF LARGE TECH PLAYERS 2013 - 2017 YTD (8/15/2017)

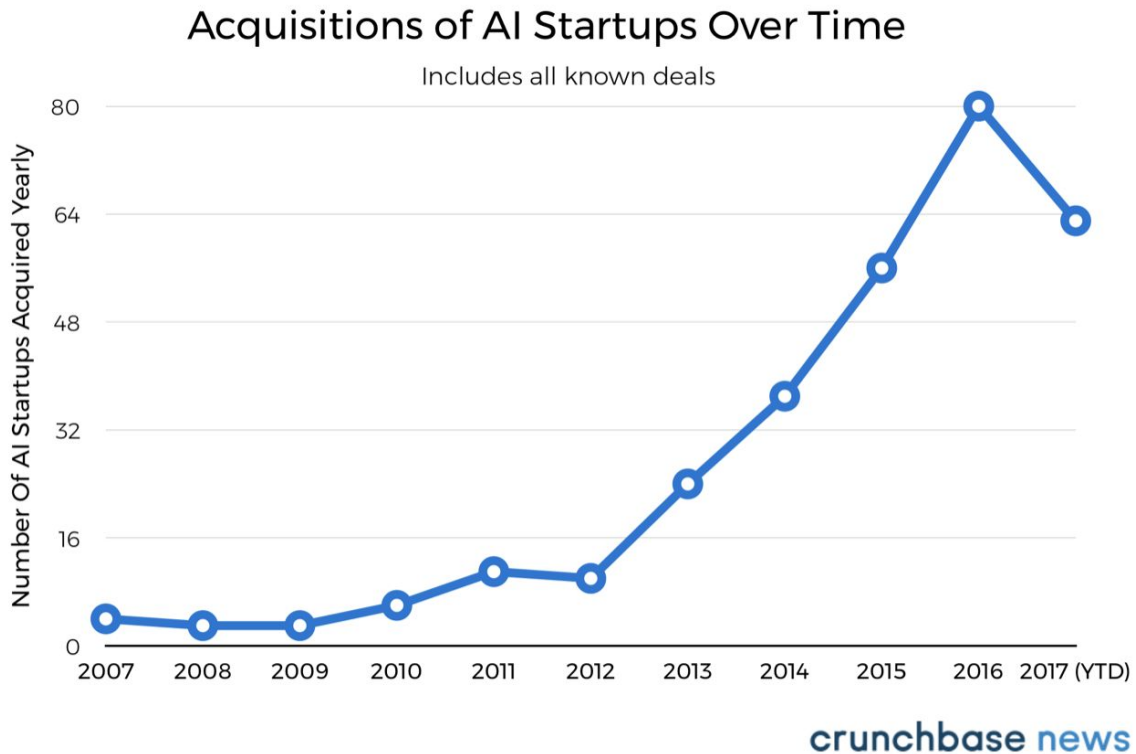


- [This paper](#) gives an interesting take on potential acquisition strategies used by the Big 5- something that we would like to validate through our data as well. It suggests that while Google looks for talented teams, core business enhancement and strategic technologies of the future, Facebook follows the ‘shepherd mode’ in that when it “when it sees somebody that could erode either its growth or could take away a part of their audience, it’s are aggressive about trying to acquire the asset”, classic evidence being Whatsapp and Instagram. The article further highlights that while Microsoft and Apple on the other hand do not seem to have fixed strategies, Microsoft has made as many acquisitions as has Google but Apple seems to be on the conservative side (as shown by our data).
- [This article](#) gives interesting facts on the Big 5’s acquisition year over year in different fields. Even though all 5 are chasing AI, Google is beating the rest with 22 acquisitions so far. With Oculus’ take over, Facebook is leading the AR/VR space. The article also brings into light the overall power of these five companies in terms of the cash flow and market cap. They collectively have \$573 Bn of free cash flows which means there will be

an enormous concentration of Tech IPs among these 5 and with their financial muscle, they might be able to crush any competition in their market comparatively easily.

Anuj

8. During our initial research, we were under the assumption that Artificial Intelligence and Machine Learning related company acquisitions were on a rise and that would be the trend for the coming years. But this [article](#) published in Crunchbase suggested otherwise. It predicted that growth in acquisitions in the AI/ML space was declining.



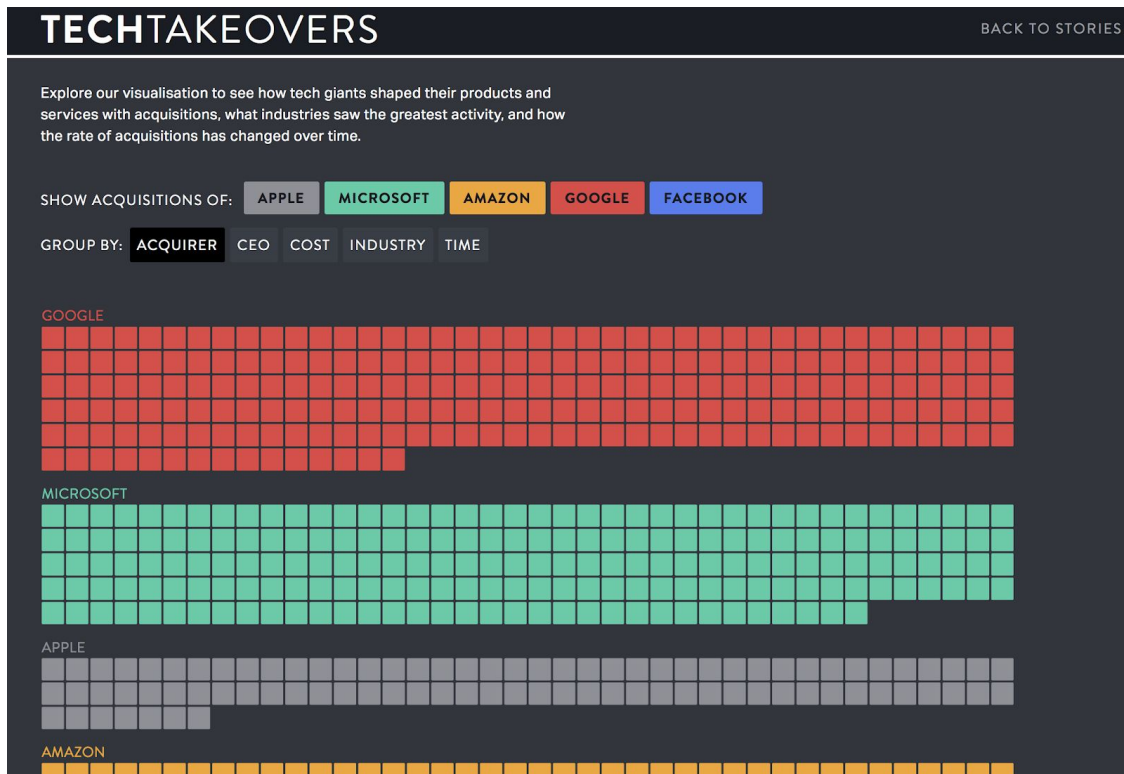
This piece was intriguing, as it was against our expectations. We noted that the numbers in this article were only till August. The article suggests that the compounded annual growth of the forecasted values for 2017 would be less than what it has been in the previous years. We were interested to find out if that actually was the case.

9. This research [article](#) by cbinsights gives a detailed account on the acquisition strategy of Amazon. They managed to gather a large amount of detailed data on the company's acquisition strategy. This article inspired us to look at this topic from different viewpoints (like growth %, number of companies, areas of investment, size of company etc.) and not just the acquisition amount. The level of detail in this article was beyond the scope of our project. Nonetheless, reading about the Amazon strategy was essential for us to think about the overall story for our information visualization project. It gave us the required perspective and direction to proceed.

This article also had a really good infographic (screenshot attached) around the major acquisitions of Amazon across time. I would have loved to incorporate a similar view in our website had time permitted. The website also used donut charts and stacked column charts to convey information, which wasn't the clearest way to do so. We decided not to use such charts in our visualization.



10. Geckoboard.com has previously visualized the acquisitions of these 5 tech giants from 1985 to 2016. Their visualization allows the user to slice the data by the acquirer, CEO who made the acquisition, time, cost and industry. The visualizations in this [article](#) also have a story element to it. But all the visualizations are only slicing of the overall data by one of the above mentioned filters. As inspiring as this article was in making us choose this topic, I felt that there were certain weaknesses in the visualization presented in this article which made it difficult to comprehend and retain the information. There were more than 15 categories of companies which were presented in this article. We decided to group them into 6 broad categories to aid retention and comprehension of the data. The article also used the same visualization (animation with blocks) to show all the data. I felt this was very repetitive and hence we tried to visualize various dimensions of data using different visualization methods.



Description of Visualizations

Pacman animation

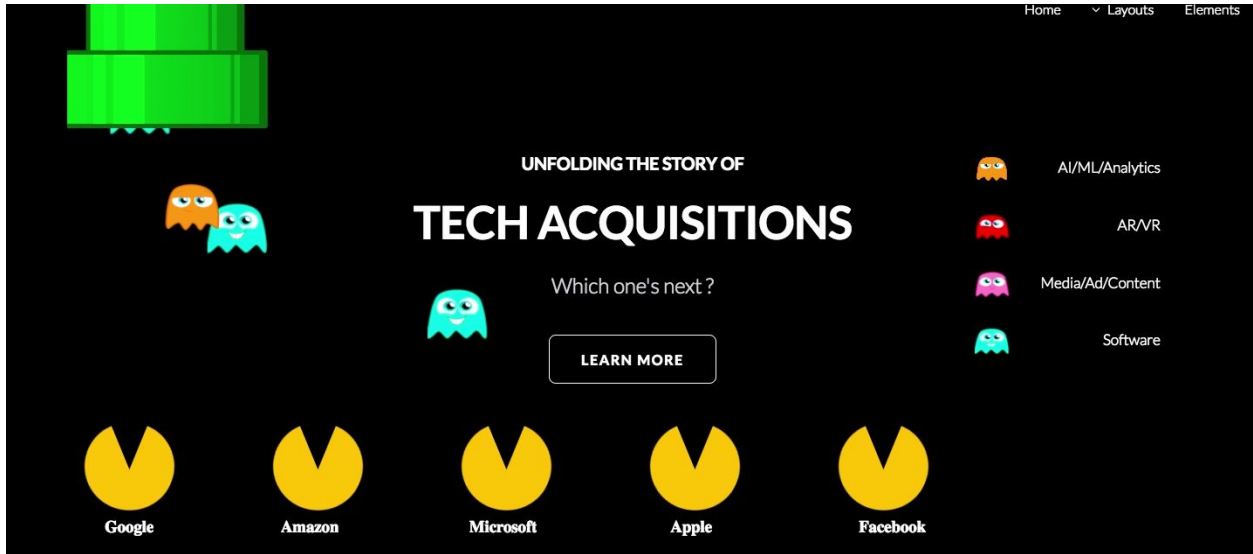
Iteration 1: The goal of adding a pacman themed animation in the first iteration was to highlight the birth and acquisition of each and every company that has been acquired by the Big 5 until 2017.

Acquisitions by Big 5 tech companies



Iteration 1: (1) Appearance of ghosts on conveyor belt was based on when the company was born (2) The cloud represented the ecosystem in which the company sustained before being acquired (3) The pacmans are the Big 5 that acquire the companies by eating the ghost in the acquisition year (4) The colors of the ghosts indicated the area of specialisation of each company, eg: AI, Security etc

Iteration 2: Soon enough, we realized that it was difficult to prevent clutter and chaos because of the large number of companies being born and acquired in the hot years, like 2014. Based on user feedback, it was difficult for people to grasp information because of “too much going on” in the animation at the same time. So, we decided to dumb it down to few important companies (eg: LinkedIn, Whatsapp) that were game changers for the Big 5 so that we could still convey the gist of our idea through the pacman theme without creating chaos on the screen. Other design improvements included better colors scheme, pacman themed props (green pipe) and switching 3d pacman images to 2D ones to stay consistent.



Iteration 2: Have only 10 ghosts in total (2 per company) highlighting the major acquisitions. The colors indicate the area of specialisation

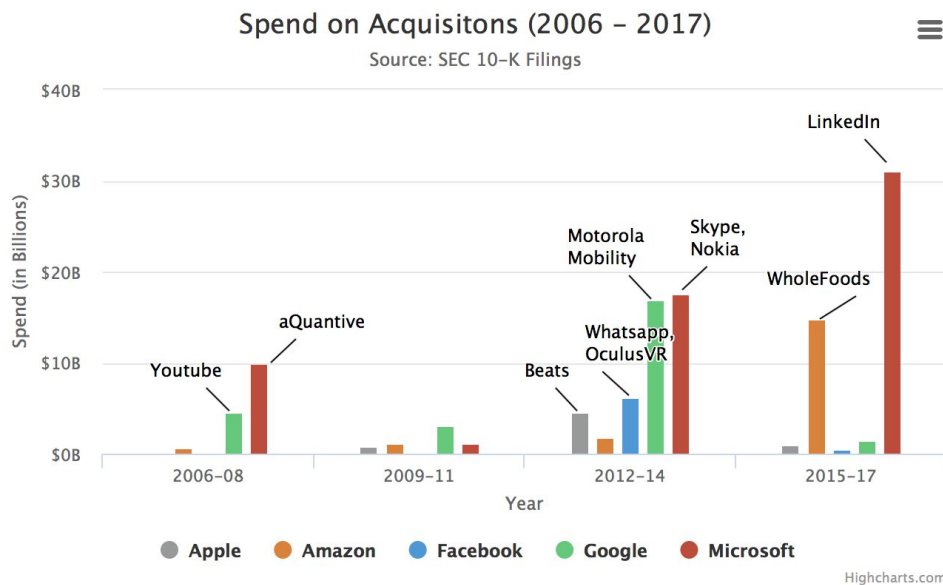
Iteration 3: Based on more feedback and by judging the colors and information conveyed by the rest of the website (highchart and bubble chart), we decided to remove specialization color legend on the right and labeled the names on the pacman. Most people looked at the animation as an engaging start and quickly scrolled to the charts below. So, we concluded that the animation served to be more of an interesting introduction to the website and less of an information exploration graphic. So, we decided to make it cleaner on the content side by removing the color legend.



Iteration 3: Simplified graphic with labeled ghosts and no color legend

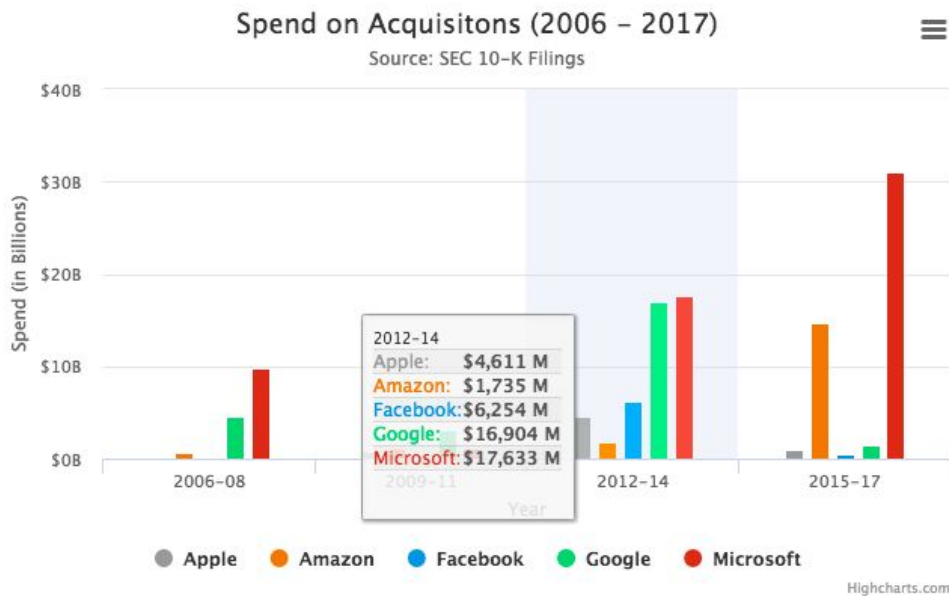
Spend on Acquisitions using HighCharts.js

Our story had to start with the obvious way of looking at acquisitions - through spend across years. For this, we decided to use Highcharts to implement a simple column chart which showed the spend on acquisitions by the Big 5 across time. Highcharts graphs look very clean and simple and their interactive nature makes them very user friendly on a web site. The initial version of the Highchart had annotations regarding the major acquisitions made by each company in the given time period.



Iteration 1: With the annotations of major acquisitions

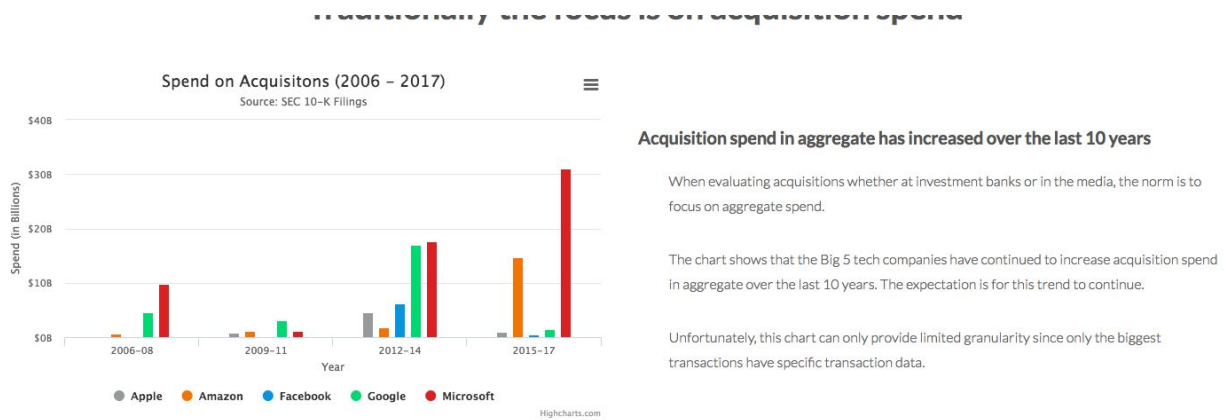
On showing the visualization to a couple of users in our initial user testing, we realized that viewers of the visualization were interpreting the annotations differently than how we envisioned it. They thought that the annotation meant that the column value corresponded to the acquisition spend on the particular annotation. We decided to get rid of the annotations from the chart as it was more confusing than informative. The information regarding the major acquisitions was subsequently captured in the highlights scroll.



Iteration 2: Removing the Annotations for a cleaner view

Acquisition highlights scroll

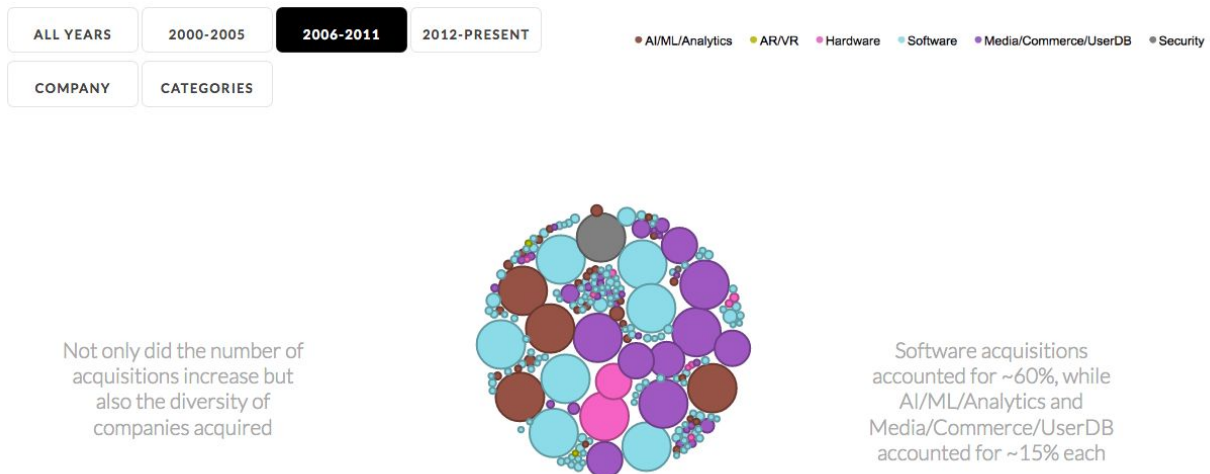
The motivation to add the ticker like scroll under the Acquisition spend highchart was to supplement some of the information that wasn't clearly available by just looking at the highchart. The highchart succeeded in showing the general increase in spend of different companies but wasn't able to account for the reasons of this spend, i.e., what were the major acquisitions that caused this increase in spend. The ticker subtly shows those major acquisitions in an engaging manner, for example, "Microsoft acquires LinkedIn for \$26B!!". This visualization was also meant to give a feel of the stock exchange tickers on Wall Street.



Microsoft acquires LinkedIn for \$26B!! Facebook buys Whatsapp Inc. for \$19B. Google acquires

Bubble chart

As mentioned previously, we did not feel that acquisition spend provided useful information, so we focused instead on what types of companies the Big 5 were acquiring. The bubble chart provided the first look into our original dataset. We wanted this visualization to be both engaging and informative. We felt the d3 animation would make the exploration fun for the person interacting with our visualization. They could click on the various buttons to see the collection of companies acquired for the entire time frame (2000 onwards) or in 6 year increments, such as from 2006-2011 (see below screenshot).



The person could then split the various collection of acquisitions by company and by category. By splitting the acquisitions by company, the user could see the acquisition makeup by company. For instance, they could visually see how the majority of acquisitions by Microsoft were in software, or how Amazon made many Media/Commerce/UserDB acquisition. When splitting by category, the user could also see how certain categories were dominated by certain companies. Again the user would see that Google and Microsoft made the majority of the software acquisitions, while Google specifically made the majority of acquisitions in AI/ML/Analytics.

Acquisitions split by company



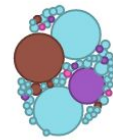
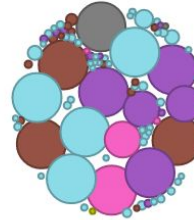
Amazon

Apple

Facebook

Google

Microsoft



Amazon during this time frame began consolidating its competitors from Zappos to Audible, acquiring 12

Google began investing outside of its traditional software background, making big acquisitions in

Acquisitions split by category



AI/ML/Analytics

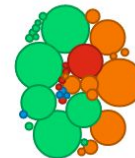
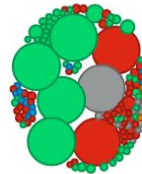
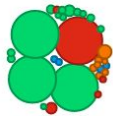
AR/VR

Hardware

Software

Media/Commerce/UserDB

Security



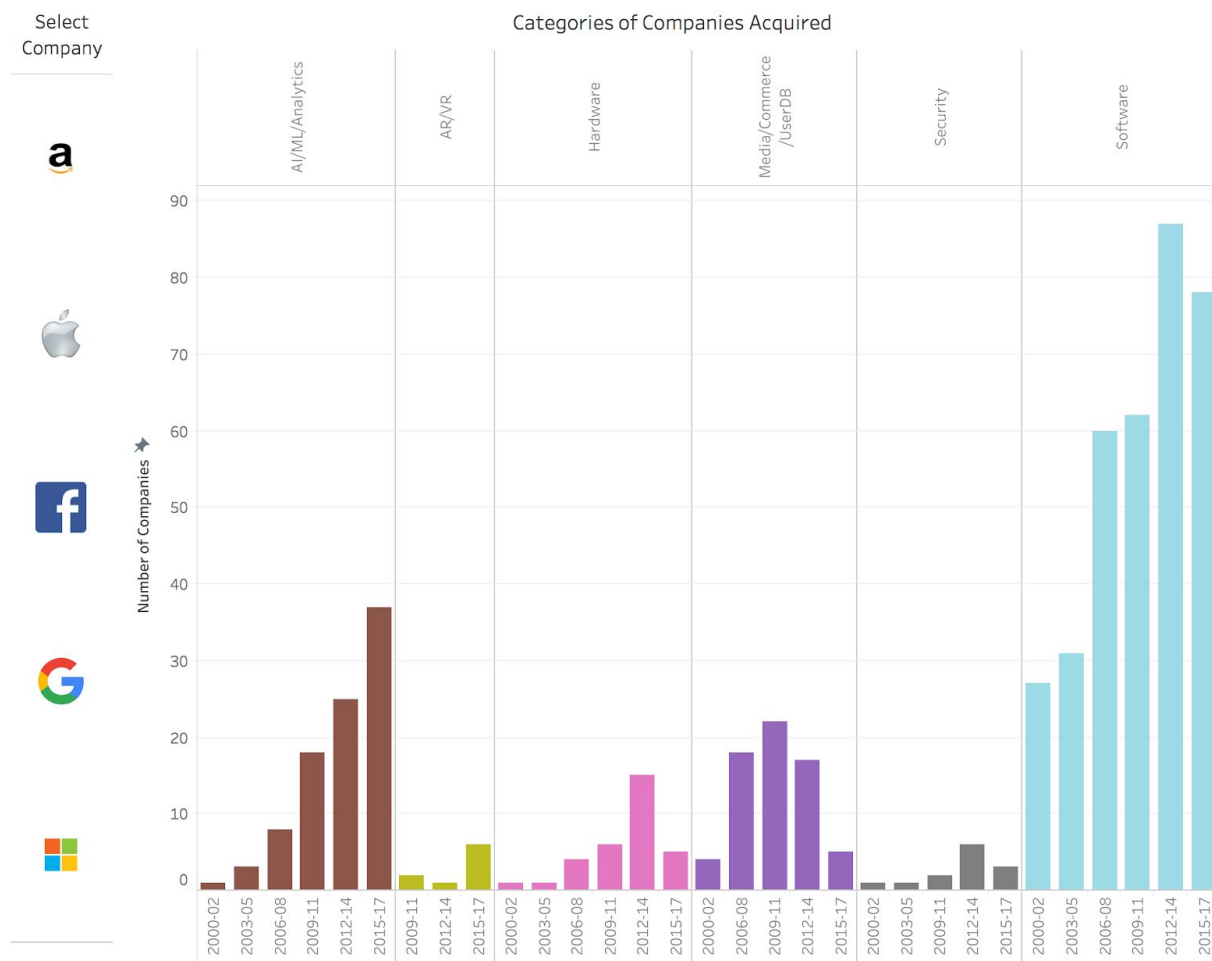
Google made large acquisitions in every category except AR/VR during this time period from reMail to YouTube and to

The chart also clearly show Amazon buying up commerce companies from Zappos to Audible and to Woot

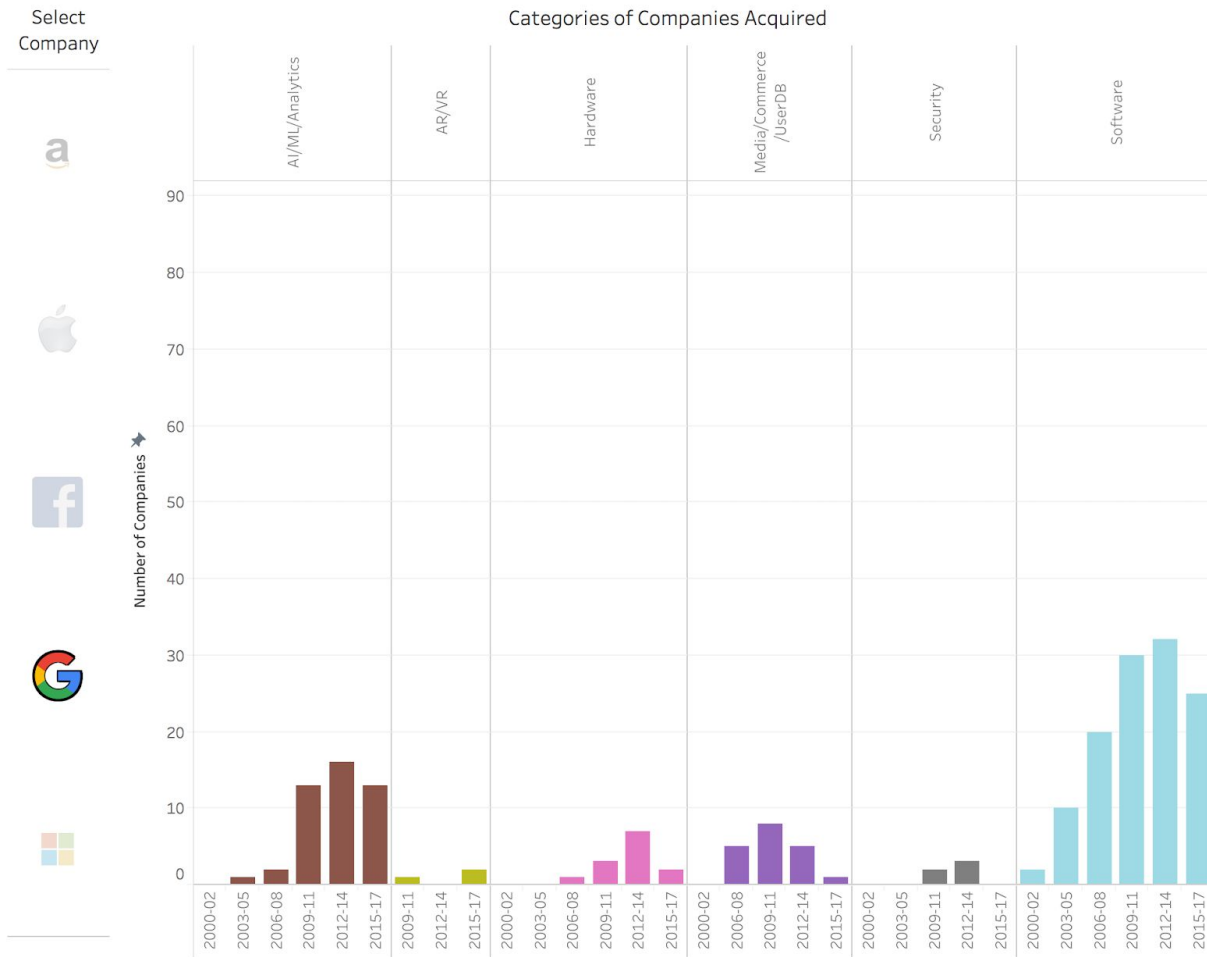
Finally, we added text to each separate view in the bubble chart to add both context and provide our insights. In all there are 12 individual views: 4 aggregate bubble views, 4 split bubble views by company, and 4 split bubble views by category.

Tableau Exploratory Workbook

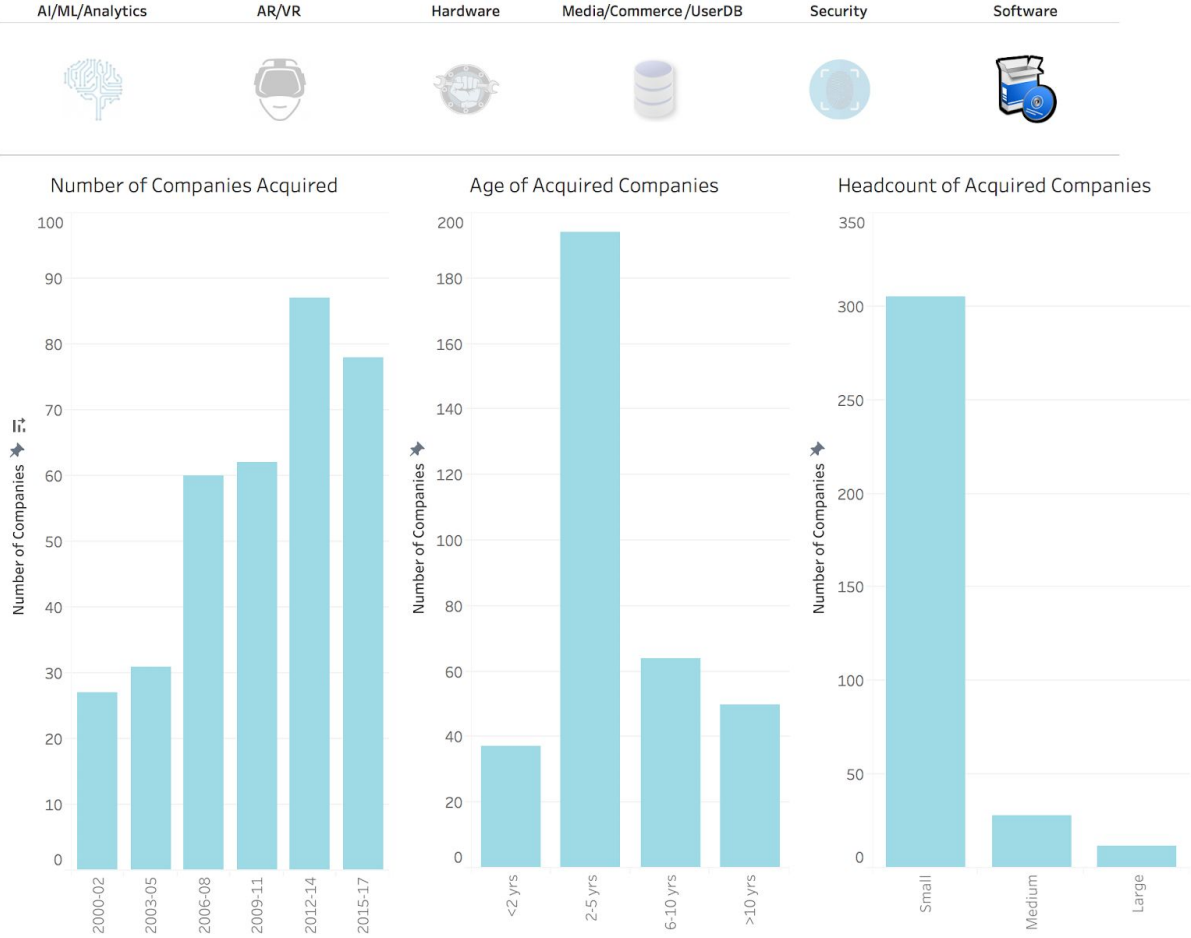
We hoped this exploration using Bubble charts would entice the user to seek more specific data. Therefore, we decided to add our Tableau charts below our engaging bubble chart. While the Tableau chart provided an interface where the user could obtain more specific and granular data, it was nonetheless interactive. The user could still click on different company icons to parse different information. To us this chart provided a good transition from engaging to static charts, which followed the Tableau chart.



Here we wanted to draw the users attention to the number of companies acquired by the Big 5 across different categories. To filter by company, we used the logos of the companies instead of the default drop down menus present in Tableau as it added a better visual feel to the chart. The user could click on one of the logos to filter the information for a particular company (as shown below):



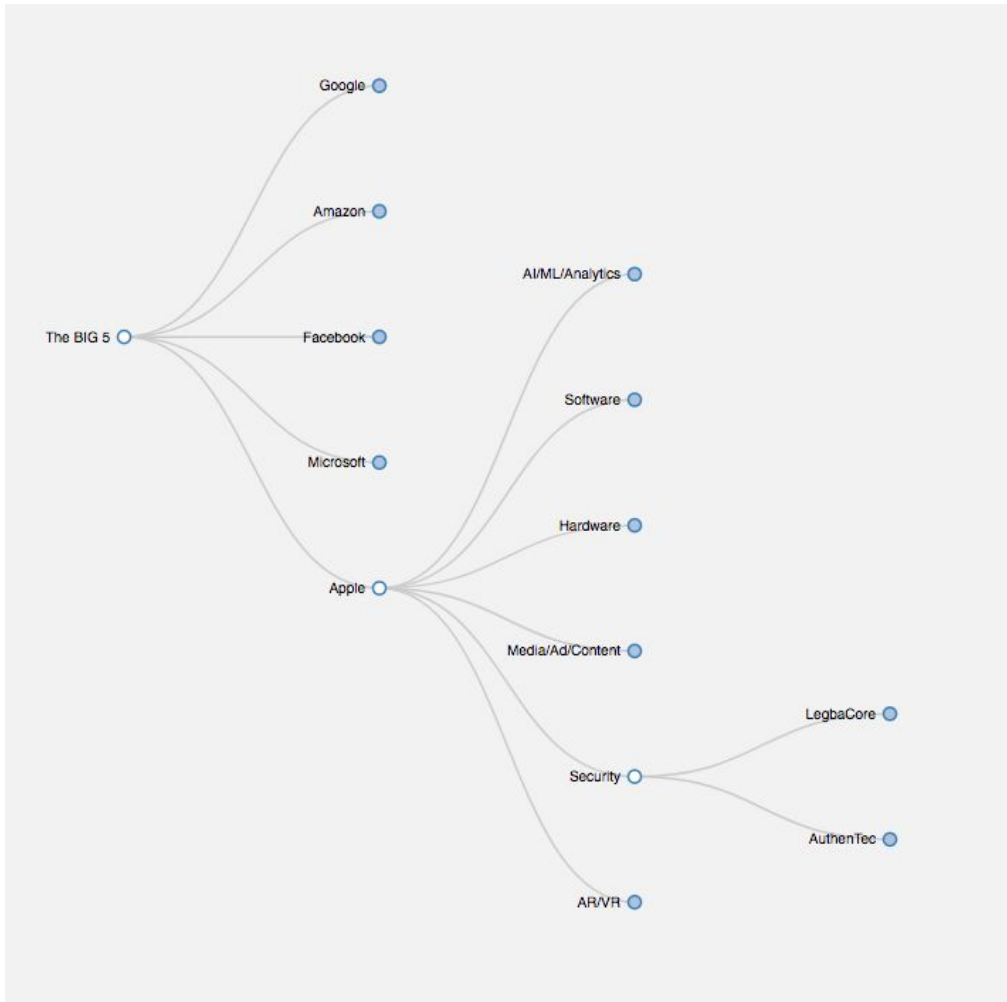
We also created another dashboard view where the user could additionally see metrics like number of companies acquired, headcount of companies acquired and age of companies acquired by the different broad categories so as to provide a deep dive for the user. This view (below) is present in the workbook but not on the website. We wanted dynamic text to show for the different category selections and hence decided to place screenshots of the different Tableau charts on the website which would be toggled by a javascript button which also toggled the callouts for the different charts.



**This view is not present on the website (but is in the Tableau Workbook)*

Collapsible tree

We wanted our users to have an interactive way to search our entire hand annotated database with ease. For example, if a user wanted to look at details of all the companies acquired by apple in the area of 'Security', they should be able to do so quickly through an interactive d3 and collapsible tree seemed like the perfect way to do so.



Data Used

The data collection was a very manual process, since we could not find any other sources that contained our specifically desired information. First, we found the specific lists of acquisitions made by each of the Big 5 tech companies. These lists contained some of the information, such as name of the acquired company, the industry/category of the acquired company, date of acquisition, and if available acquisition value. However, each list was very different. For instance, the detail within the list of acquisitions for Google was far superior than in the list of acquisitions for Amazon.

Sample of list of acquisitions for Google

List of mergers and acquisitions [\[edit \]](#)

Acquisition date ▾	Google company ⇅	Business ⇅	Country list ⇅	Price ⇅	Used as or integrated with ⇅	Refs ⇅
October 9, 2017	Relay Media	AMP converter	USA	—	Accelerated Mobile Pages	[252]
October 11, 2017	60db	Podcasts	USA	—	Google Play Music	[253]
November 5, 2016	LeapDroid	Android Emulator	USA	—	Android	[236]
May 10, 2017	Owlchemy Labs	Virtual reality studio	USA	—	Google VR	[243]
March 9, 2017	AppBridge	Productivity suite	USA	—	Google Docs	[242]
March 27, 2018	Tenor	GIF image search	USA	—	Google Images	[254]
July 12, 2017	Hall Labs	Artificial intelligence	IND	—		[244]
January 5, 2017	Limes Audio	Voice communication	SWE	—	Google Duo, Google Hangouts	[239]
January 19, 2017	Fabric	Crash analytics	USA	—	Firebase	[240]
September 26, 2017	Bitium	Single sign-on and identity management	USA	—	Google Cloud Platform	[251]
September 21, 2017	HTC (portions)	Talent and intellectual property licenses	TWN	\$1,100,000,000	Google Pixel	[248][249][250]

Sample of list of acquisitions for Amazon

2017 [\[edit \]](#)

- [Harvest.ai](#)^[83]
- [Thinkbox Software](#)^[84]
- [Do.com](#)^[85]
- [Souq.com](#)^[86]
- [Whole Foods Market](#)^[87]
- [GameSparks](#)^{[88][89]}
- [Graphiq](#)^{[90][91]}
- [Wing.ae](#)^[92]
- [Body Labs](#)^[93]
- [Goo Technologies](#) (assets acquired, became Amazon Sumerian)^[94]
- [Blink Home](#)^[95]

2018 [\[edit \]](#)

- [Ring](#)^[96]

As evident from the above screenshot, the only really consistent pieces of information were name of acquisition and date of acquisition. Later on when we clean the data, we used the year as the acquisition date, rather than the specific day/month/year.

After pulling together the list of acquisitions for each of the Big 5 tech companies, we in total now had over 600 listed acquisitions. However, we were still missing a lot of data that we wanted to collect. So we split the dataset into three separate parts where each of us would find specific data for around 200 companies each. This process entailed searching for the target acquisition on crunchbase and pulling 3 specific company attributes, namely, description, headcount, founding, and category. Below is a screenshot of an example page.

The screenshot shows the 'Overview' page for Ring on Crunchbase. At the top, it indicates the company was 'Acquired by Amazon' and has '1' acquisition. Below this, the Ring logo is displayed next to the company name 'Ring'. A description states: 'Ring is an outdoor home security company that provides homeowners a line of preventative outdoor security doorbells and cameras.' The location is listed as 'Santa Monica, California, United States' and 'Western United States'. A list of categories includes 'Consumer Electronics, Security, Smart Home'. Other details include: 'Founded Date: 2012', 'Founders: James Siminoff', 'Operating Status: Active', 'Funding Status: M&A', 'Last Funding Type: Series D', 'Number of Employees: 501-1000', and 'Also Known As: Doorbot'.

On Ring's company crunchbase page, we pulled:




- Description: Ring is an outdoor home security company that provides homeowners a line of preventative outdoor security doorbells and cameras.
- Categories: Consumer Electronics, Security, Smart Home
- Founded Date: 2012
- Number of Employees: 501-1000

As mentioned previously, we pulled this information for 600 individual companies to form our comprehensive database. However, after pulling this information, we still had a lot to do to standardize the data. First, for the acquisition dates, we took the year it was acquired, rather

than the specific data, since not all of the acquisitions contained this specific information. Second, we took the larger of the two number for the headcount size. As an example, in the screenshot above, we used 1,000 as the headcount for Ring. We decided to take the larger of the two because in crunchbase many company headcounts were listed as 1-10. We thought 10 was a more likely proxy than 1 for the actual size of the company. Further, we felt if we were just consistent, the relative size of the company would still be captured. Finally, we needed to group and categorize the categories. Crunchbase provided a lot of valuable detail for the categories of the companies, but the labeling was too specific. We our visualization would be more valuable and easier to interpret if the categories were bucketed into around 5 or 6 groups. The groupings we ultimately decided on were:

- Artificial Intelligence / Machine Learning / Analytics (or AI/ML/Analytics)
- Augmented Reality / Virtual Reality (or AR/VR)
- Hardware
- Media / Content / User Databases (or Media/Content/UserDB)
- Security
- Software

We felt each of these higher-level groupings were mutually exclusive and collectively exhaustive, separating the acquisitions into appropriate and relevant buckets. We wrote a Python script to appropriately place the companies in the right categories. A sample of our code from the script is below:

```
44 lines (36 sloc) | 2.23 KB | Raw | Blame | History |   
1 import csv
2
3 # open the file in universal line ending mode
4 with open('AcquisitionDatabaseFinal.csv', encoding="ISO-8859-1") as infile:
5     # read the file as a dictionary for each row ((header : value))
6     reader = csv.DictReader(infile)
7     data = {}
8     for row in reader:
9         for header, value in row.items():
10            try:
11                data[header].append(value)
12            except KeyError:
13                data[header] = [value]
14
15 # extract the variables you want
16 Categories = data['Categories']
17
18 newdata = []
19 for i, element in enumerate(Categories):
20     if 'AI' in element.upper() or 'artificial intelligence' in element.lower() or 'robotics' in element.lower() or 'machine learning' in el
21         newdata.append('AI/ML/Analytics')
22     elif 'augmented' in element.lower() or 'virtual reality' in element.lower() or 'augmented reality' in element.lower():
23         newdata.append('AR/VR')
24     elif 'digital' in element.lower() or 'internet' in element.lower() or 'app' in element.lower() or 'information' in element.lower() or '
25         newdata.append('Software')
26     elif 'hardware' in element.lower() or 'wireless' in element.lower() or 'developer' in element.lower() or 'manufacturing' in element.low
27         newdata.append('Hardware')
28     elif 'commerce' in element.lower() or 'music' in element.lower() or 'media' in element.lower() or 'ad' in element.lower() or 'content'
29         newdata.append('Media/Ad/Content')
30     elif 'security' in element.lower() or 'cyber' in element.lower():
31         newdata.append('Security')
32     else:
33         print('picking from manually annotated records', data['Broad Category'][i])
34         newdata.append(data['Broad Category'][i])
35
```


After running the script we then spot checked the categorization to make sure each company was placed in the right group. We also went through the various descriptions of the companies to try make sure the description was a short concise sentence describing each company. Finally the data was ready to explore and conduct an exploratory data analysis.

Tools Used

We used highcharts.js, javascript, CSS, Tableau, and d3.js.

Highcharts.js was used in our first chart. We thought a straightforward barchart was the best use for a highcharts visualization. The simple yet effective design, incorporating a dynamic tooltip, provided a clear visualization.

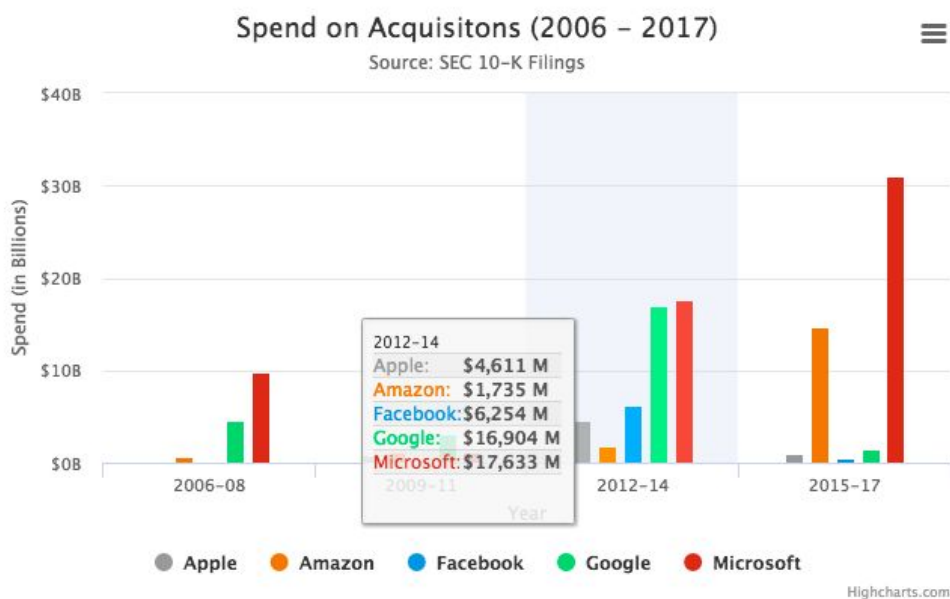
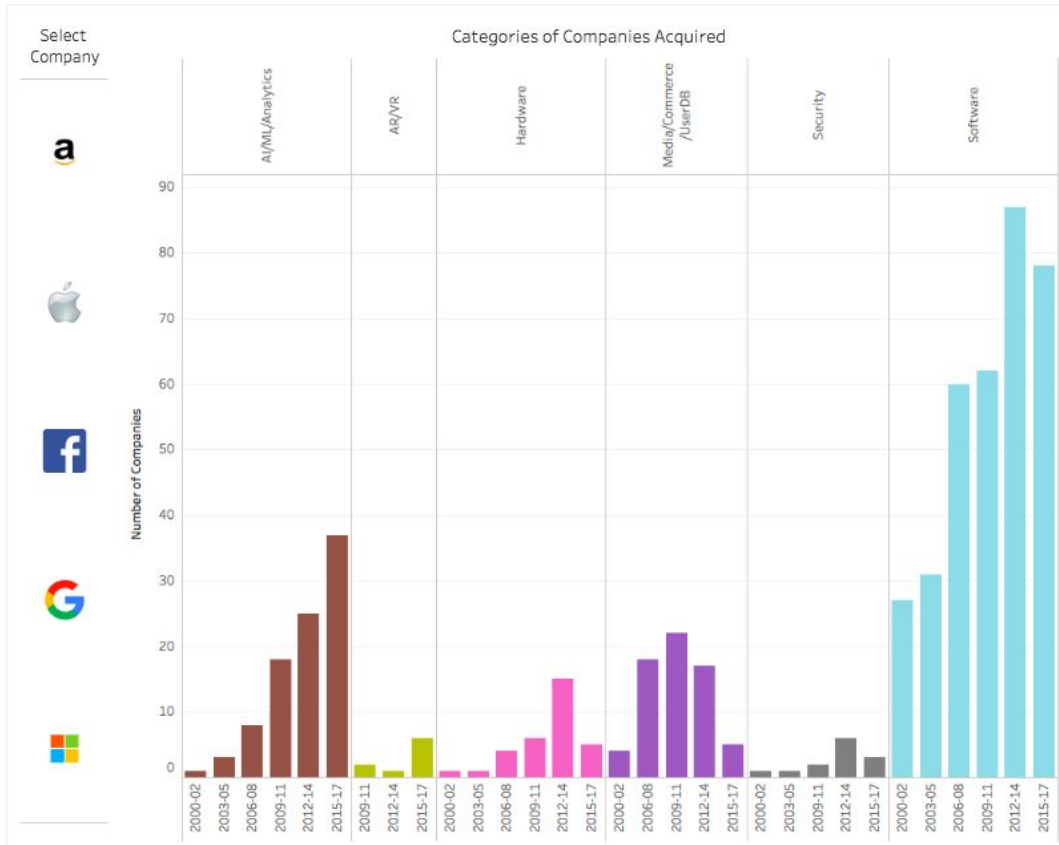


Tableau was implemented throughout the back half of our visualization. We felt Tableau provided the appropriate exploratory tools that would allow people to interact with our data. However while we wanted people to explore our data we also wanted to refined the specifics of what they could explore. Therefore, only one chart was truly exploratory, where people could click on the relevant company logos to refine and adjust the visualization (see the below visualization).



The other Tableau visualizations were individual static images. Depending on the visualization, some of these Tableau charts would only get displayed if a specific button was clicked. Others though were shown throughout.

Tableau charts shown throughout:

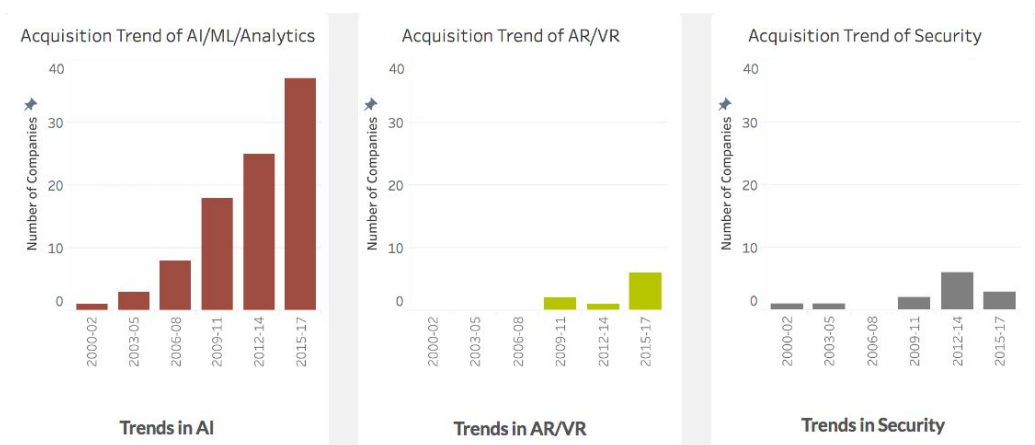
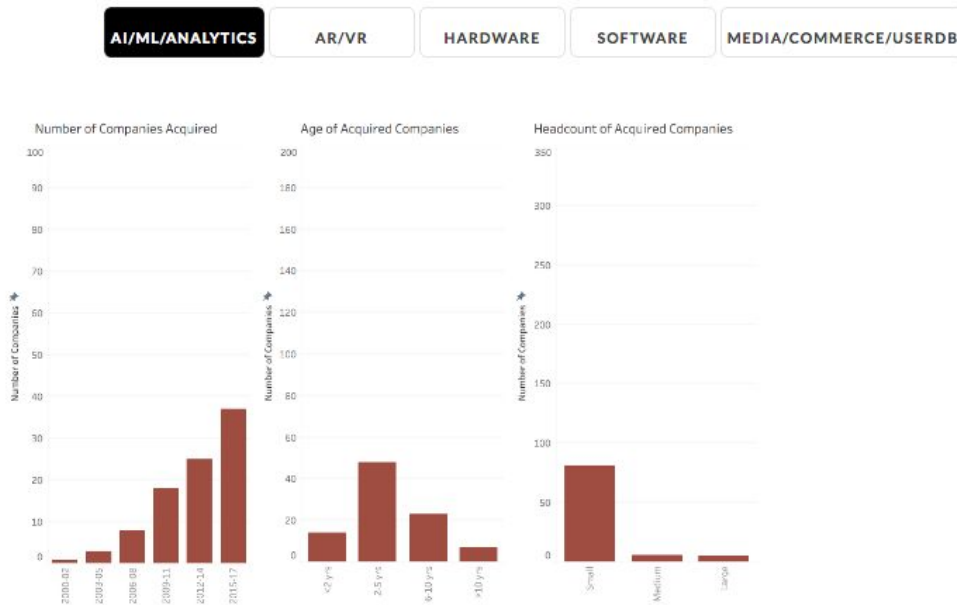


Tableau charts show depending on button click:



We implemented d3.js throughout our visualization, spending a significant amount of time to get these working right.

Pacman animation

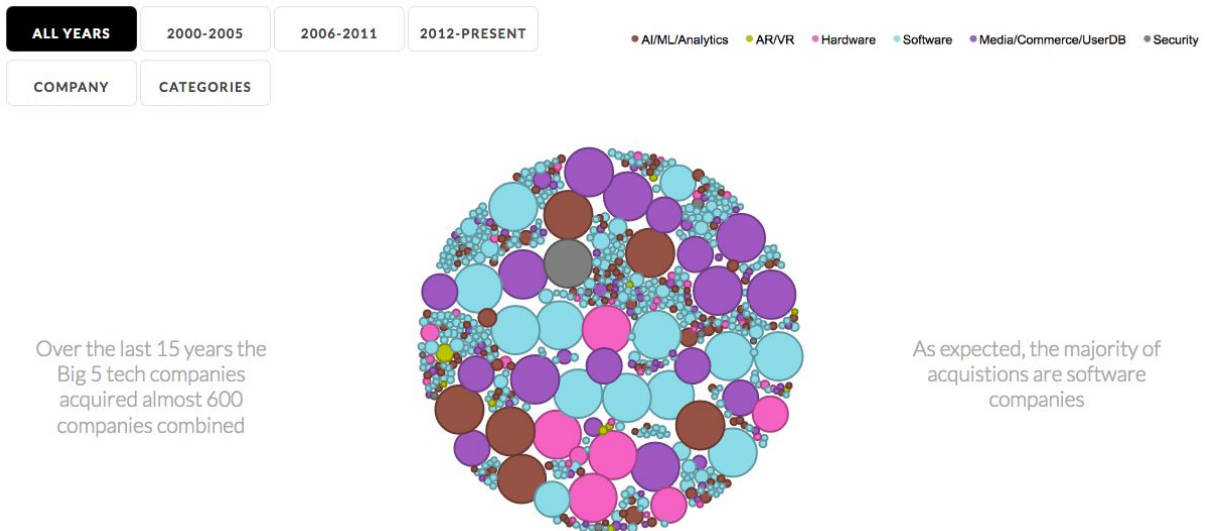
Given that we built this d3 animation from scratch as opposed to using an already sophisticated example online, some of the key challenges that we faced while building this d3 animation were (1) Mapping pixels to coordinates that the ghosts should follow to obtain a smooth trajectory, there was a deep learning curve to understand how animation works in d3 at a primitive level (2) While ghosts were animated using D3, pacman animation was added using pure javascript which made the coordination of the positioning of pacman such that the ghosts fall exactly into the pacman's mouth became tricky, especially with dynamic screen sizing. A lot of CSS modifications had to be applied to achieve proper positioning and spacing.

Acquisition scroll

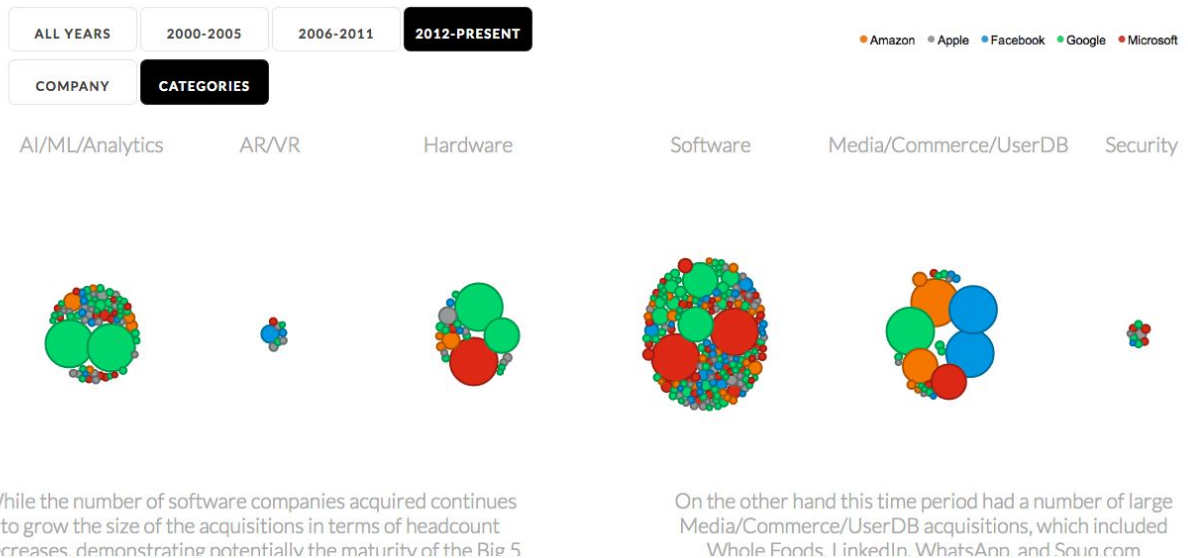
The acquisition ticker like scroll has been designed using pure CSS and HTML elements. The basic inspiration of the design has been taken from this example on code pen: <https://codepen.io/ugly/pen/ZaaOWr?page=2>. Some design enhancements were made such changing text color, font and content.

Bubble chart

We also added a bubble chart using d3.js. The basic structure and foundation of this design was taken from Jim Vallandingham (http://vallandingham.me/bubble_chart/#).



However, like anything we had to make a tremendous amount of adjustments to specifically tailor this visualization for our data and what we wanted. Specifically, we needed to parse through the dataset to group the appropriate information to display. This subset of data then needed to display on a button click. Further the data needed to split into both company and categories, while also recoloring itself. Finally, we had to add the appropriate headings and text below the bubbles to add important contextual information. This involved learning how to wrap text and position text and bubble to line up based on individual button clicks.



Collapsible Tree

The inspiration for collapsible tree was taken from <https://bl.ocks.org/mbostock/4339083>

The major challenge to implement it was to parse our csv file and convert it into the json format expected by the code as an input. Specifically, the code expects the json to contain only 'name' and 'children' as keys (and values can be variable). This was not straightforward when we wanted to include metadata about companies such as 'Description', 'Headcount' and 'Acquisition Year'. Since we could not add these tags as keys, we decided to use a workaround and added them along with the actual value. For example, in the figure below, every metric in the metadata of the company '60db' is stored as value of key 'name'.

```
{
  "name": "The BIG 5",
  "children": [
    {
      "name": "Google",
      "children": [
        {
          "name": "AI/ML/Analytics",
          "children": [
            {
              "name": "60db",
              "children": [
                {
                  "name": "Headcount: 50"
                },
                {
                  "name": "Founded: 2016"
                },
                {
                  "name": "Description: Podcasts"
                },
                {
                  "name": "Acquired: 2017"
                }
              ]
            }
          ]
        }
      ]
    }
  ]
}
```

Results from User Testing and Survey Feedback

We aimed to incorporate user feedback throughout our design and development cycle. We sought feedback from MIMS students (both who have taken INFO247 and those who haven't) to get a better sense of our progress. We received valuable feedback during the initial versions of our design which led to improvements in the highchart (removal of the annotations from the column chart) and addition of the acquisition ticker. The feedback also helped us iterate through the pac-man animation in terms of design and functionality. We initially wanted the pac-man animation to be the central visualization of our story but realized that it was very time consuming to show all the data through the animation.

We also collected feedback on "Demo Day" from the attendees through a short [survey](#) which was presented to them after interacting with our visualization. We wanted to get a general sense of what they liked and disliked about our visualization. We also added two multiple choice questions to understand if the user could retain the major callouts from the visualization. The questions we asked in the survey are as follows:

- What are some of the things you liked about our visualization?
- What are some of the things you feel that can be improved in the visualization?
- Which company has been most dominant making acquisitions - overall?
- Which new category of companies has been on the rise in terms of growth in companies acquired?

We got a total of 5 responses to the survey. The results of the survey are given below:

Question	Response (unedited)
What are some of the things you liked about our visualization?	<ul style="list-style-type: none">• Great mix of many types of effective visualizations! Technically so impressive.• The insights and the bubble chart animation• great use of D3, narrative flows smoothly• The visualizations were really cool. The Pac-man animation in the beginning was a lot of fun and would have required a great amount of coding. The bubble chart was visually very impressive.

	<ul style="list-style-type: none"> • The bubble chart was really fascinating. The use of company logos as filters in the Tableau charts looked really good (How did you do that?). The overall story was clear with the clear and concise text
<p>What are some of the things you feel that can be improved in the visualization?</p>	<ul style="list-style-type: none"> • Some visualizations had legends/keys that were a bit too small and located in an unnatural place. From a working memory perspective, I had to keep looking up to the legend, then back down. For the d3 bubbles one, the colors kept shifting so the legends would change, so it was hard to keep track of what was what. Also, in that visualization, the categories could have been better served being on the bottom of the bubbles and not the top, or maybe borders to show the separation of columns. Lastly, for that one, there were overlaps between bubbles and the text which made it hard to read. • Dynamic filtering in the bubble chart animation • maybe have more explanatory text and the motivation for your viz • The filtering in the bubble charts can be made more intuitive. • The filtering in the bubble chart can be made more user friendly. I don't know why there were screenshots of Tableau charts on the website, but it looked very good.
<p>Which company has been most dominant making acquisitions - overall?</p>	<p>80% (4/5) got the right answer - Google</p>
<p>Which new category of companies has been on the rise in terms of growth in companies acquired?</p>	<p>80% (4/5) got the right answer - AI/ML/Analytics</p>

Links to Visualization

Item	Link
Website	Link (http://people.ischool.berkeley.edu/~neha01mittal/infviz/dashboard/)
Animation Demos (All Iterations)	Link (https://drive.google.com/drive/folders/1k49eUPXiM23yUjHhJekfily_paE9IFrT?usp=sharing)
Code and Dataset	Link (https://github.com/neha01mittal/acquisitions-analysis/) Link to Dataset (https://github.com/neha01mittal/acquisitions-analysis/blob/master/Tableau/AcquisitionData baseFinalFixed.csv)

Contributions towards the project

Description of visualization task	Contributors	% allocation
Research, data aggregation and preprocessing	Bo, Anuj, Neha	24%
Highcharts	Anuj	6%
Tableau	Anuj	12%
Web implementation and design	Bo, Neha	6%
Bubble chart - d3	Bo	18%
Pacman animation - d3	Neha	18%
Acquisition scroll bar	Neha	4%
Collapsible Tree	Bo, Neha	4%
Informative text next to our charts	Bo, Anuj	8%
Total		100%
Individual Contributions		
	Anuj	30%
	Bo	35%
	Neha	35%