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Teaching Case

Online Maps and Route-Finding – Lots of Ways to Fail, Yet Still a Great Success!

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Hook

Leverage students' real-world experiences in the use of online maps and routes to discuss fundamental IT and business principles including maps, routing, multi-factor decisions, as well as gathering, evaluating, and using information.

Abstract

Technological tools continue to permeate modern life, to the extent that they can supplant previously fundamental skills. Maps and route-finding are no exception. This complex function, driven by huge volumes of data, makes modern transportation easier, more resilient, and at the same time riskier and more dependent on a sometimes-opaque technology and revenue model. This case study explores a variety of instances of online mapping and route-finding, and invites the student to consider how these routes are identified and influenced.

Keywords: Teaching Case, Online Maps, Route-finding, Route optimization, Route tuning, Rerouting, Traveling salesman.

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1. OPENING STORY

Helen was on a seemingly straightforward, 5-hour drive northeast from Los Angeles to Las Vegas to pick up her son at the airport, en route to Utah for Thanksgiving. But what started as a time-saving detour ended for her in a 2-hour delay, only to get back to where she started the detour.

Early morning on Monday before Thanksgiving 2023, Google Maps had said the route was in good shape – north on Interstate 15 (I15) from Victorville to Las Vegas. All was well until she approached the Nevada border. At about 2 p.m., authorities had issued a closure notice for that section of the freeway due to dust storms.

She did not know about the closure at the time. She had only relied on the visual map updates to re-route around issues. Google Maps said she should get off at an isolated desert gas station exit and take an excursion several miles to the north of I15 (see Figure 1), for about 40 miles total. This would (per Google Maps) save her 56 minutes of travel time.

More details will follow in Scenario 1, below – but in short, the detour was impassable. She spent two hours on that diversion – 5 minutes going away from the highway, and the rest of the time moving very slowly to get back to the highway once she was alerted to the impassable route. News reports the next day confirmed that Google had indeed been recommending an impassable detour.

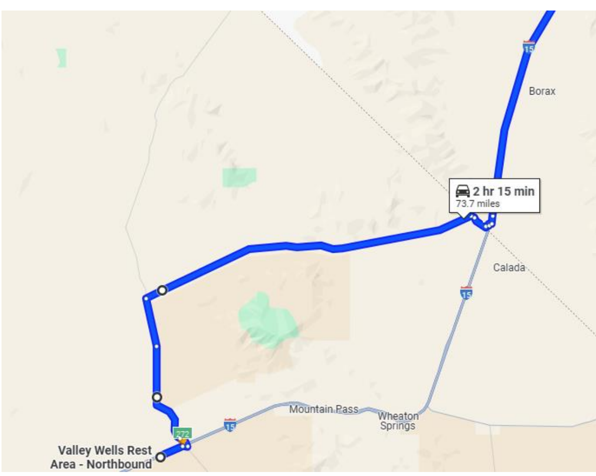

Figure 1: Google Maps and its Nov 2023 proposed diversion around a dust storm (Source: Google Maps)

Google Maps later issued an apology for this issue and indicated that they would "no longer recommend" (DuBose, 2023) this detour.

We hope that this set of real-world cases will help students understand and analyze these situations from several fundamental perspectives. Note that all references to people by first name only are real people unless stated otherwise.

2. TECHNICAL BACKGROUND

There are a number of technical concepts that apply to various aspects of this case, and we identify and describe them briefly here.

Theoretical Underpinnings of Online Maps and Routing

The fundamental principle behind route-finding treats a map as a series of road "segments", of varying length. The map services capture static data about those segments (endpoints, length, shape, speed limit, slope, etc.). They also capture and can respond to dynamic (live) data, including actual speeds, reported issues, and details about actual driver behavior in those areas. Each segment (known in graph mathematics as an "edge") is connected to its "neighbor" segments by a node, which could be a road continuation or an intersection of some sort, with or without traffic controls.

Choosing a route is a function of many parameters. One of these functions examines the desired start and end points of the requested route, and then lays out alternative graph paths that will accomplish the desired end points. Multiple routes are tested to find the "best" one, based on a range of criteria (Gregory, 2011). While this is not a treatise on the complexity of the problem, we outline the challenges to help better understand the root causes of mapping and routing issues.

The fundamental algorithm for doing that step is called A* (Luxen & Vetter, 2011), and its primary function is to find the "best" path between two points on a graph. There is metadata about each "edge" (the connection between nodes) that describe that edge's speed limit, energy cost, tolls, traffic, etc. The combination of this metadata aggregated across each potential route is used to find the "best" route(s).

As a visual example, consider the 4x4 graph below, with its 16 segments or edges and its 16 nodes. Getting from A to P could be done hundreds of ways, many of which would be illogical to a human traveler. We have outlined three of them below, in Figure 2.

- Fewest turns
- Zig-zagging diagonally across

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- A more circuitous route that involves some apparent backtracking

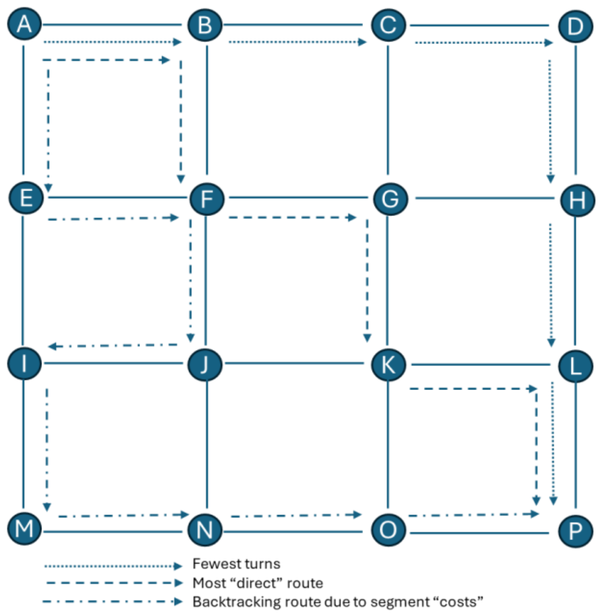

Figure 2: Example graph traversals (adapted from (Gregory, 2011))

That said, it is not obvious from the information in Figure 2 which route is "best." We do not know speed or cost in any units, and we do not know what any specific user would call "best". These route options also may result in apparent "irrational" routes, such as the one with backtracking in Figure 2.

The algorithm can also quickly become computationally expensive, comparing vast numbers of potential routes even for short distances. The map-routing variants of this algorithm narrow the scope of the potential routes, reducing memory and computation requirements.

Map data can change for many reasons, so map data used for routing must be maintained and updated, usually by the company that shows the maps. The map maintainers also keep track of the "Functional Classification" of each road segment, with slight variations in definitions at the lower levels:

- FC1 – Interstate or other major highways
- FC2 – Other arterial highways
- FC3 – Collector roads (US Department of Transportation, 2000)
- FC4 – Local roads – higher volume
- FC5 – Local roads – residential and lower volume (Gregory, 2011)

The objective of this information is to try to move smoothly from lower-volume (capacity) and lower-speed roads to higher-volume roads, so as not to overload the lower-volume roads. This also helps choose routes more or less appropriate for other vehicles such as bicycles.

Route Finding Parameters and Constraints

As noted previously, the definition of "best" route will vary amongst users, and will depend on time, weather, preferences, and many other factors. Parameters used in assessing "best" route before presenting options to the user include shortest distance, shortest travel time, most cost-efficient, most environmentally friendly, etc. (Intellias, 2022).

Among the many fine-grained details, thorough route-finding requires knowing exactly where the user wants to start and finish. A university campus, for example, may have dozens of buildings and many parking or drop-off locations, and just knowing the address of a building may not be enough to get to the right place for visitors, students, or staff to park.

Road information also includes other dynamic data, collected from a number of sources, but often from the users' communications back to the mapping service. These include actual speed at a particular point, road conditions, weather, accidents, and the like. Services like Google's Waze invite users to submit information about traffic situations to allow more responsive route adjustments.

Other data (both static and dynamic) that may be captured and used by map routing algorithms include a variety of items, as noted in Table 1, below.

Business Use of Online Maps and Routing

While billions of individuals use online mapping and route finding apps world-wide, there is ample business use as well (Wylie, 2024). For example…

<u>Logistics and Transportation</u>

Route optimization is the process of finding the fastest and most cost-effective way to deliver products to customers. Cost savings are generated by shorter distances and travel times, with corresponding reductions in fuel consumption, wear and tear on vehicles and associated maintenance. Optimized delivery routes lead to on-time delivery, resulting in improved customer satisfaction.

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Category	Examples
Type of transit	car, public transit, two-wheel motorized, bicycle, walking
Weather	Sandstorms Floods Snow, ice
Road work	Planned Emergency
New roads and routes	Planned Emergency or temporary
Changes to speed limits	Temporary Permanent
Accidents	Severe, causing lane or route closures Moderate, causing delays
Traffic	At route planning As the trip progresses Live data Historical data
Viability of road vs. vehicle	Dirt roads, wet conditions, etc.
Side effects of routes	Environmental impact Scenery Tolls Fuel costs Business traffic impact – pro or con Neighborhood traffic impact
Avoiding things	Highways Tolls Ferries Mountain passes

Table 1: Additional parameters to consider (Google Inc., 2022)

<u>Ride-Hailing Services</u>
Real-time navigation combines historical travel times for routes with real-time traffic conditions leading to a reduction in travel time and fuel savings, benefiting both drivers and passengers. Online mapping and route-finding apps that use real-time navigation can provide precise estimated times of arrival (ETA) of drivers as well as the final destination. Similarly, identifying the best driver for a passenger – the one closest who can arrive quickest – can be achieved in the very same way.

<u>Public Transportation</u>
Many transit agencies leverage online mapping and route-finding systems – sometimes embedded within their own apps – to aid customers as they plan the best routes for where they want to go.

<u>Travel and Tourism</u>
The common features of online mapping and route-finding apps provide tourists valuable tools. Directions can be provided for driving, walking, public transportation, and cycling. Underlying search engines help users locate nearby restaurants, hotels, etc. Different views like street, landscape, and earth give travelers an introduction to unfamiliar locations.

<u>Delivery Services</u>
Delivery services require the same degree of efficiency and effectiveness of route planning/optimization that other industries do (above). In this case, successful deliveries lead to cost savings and increased customer satisfaction.

<u>Retail and E-commerce</u>
Store locators are a critical component of retail and E-commerce companies' web and app presence. They provide important information to existing and potential customers, such as location(s) and directions leading to an increase in website traffic and customers in stores.

<u>Event Planning</u>
Event planners frequently publish client events online and they often enhance event websites with dynamic mapping and direction capabilities facilitating guest navigation.

<u>Service Call Businesses</u>
Organizations that provide on-site services to businesses or consumers may utilize mapping and route optimization to deal with their unique challenges. This includes the logistical and routing complexities of getting the right people, with the right tools and supplies, to the right place at the time promised. It may also involve alerting the customer to changes in schedule based on traffic, prior job completion time, etc.

<u>Customized optimizations</u>
Various map vendors provide tools to allow businesses to customize their route planning. This may include route restrictions for certain vehicle lengths, number of axles, vehicle weight, and other factors, such as avoiding left turns. Some of these are simply consumer tools, whereas others are commercially-focused tools, with specialized capabilities aimed at the business market.

Online Maps as a product
Like many other "free" services, users would be wise to recognize that maps and routes are products in and of themselves. As such, the map provider needs to consider ways to monetize their map presentations. Such mechanisms may include advertising to prioritize what appears on

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user map displays, as well as fees for the use of mapping services to find office or store locations, plan travel routes, or other activities appropriate to a business' operation.

3. DISCUSSION SCENARIOS

The following scenarios may be assigned by your instructor as individual or group exercises. Each is designed to be self-contained, so you could analyze any one scenario on its own, and from either a technical level or an organizational level.

Scenario 1 – Off the highway and into the desert!

Picking up from the Opening Story above, Barbara was assessing the online map routing suggestion to go off into the desert. As she approached the exit, she had the good fortune to be able to see ahead. I15 was still moving, but slowly. The exit onto the detour was moving well. However, there was a long line of cars coming slowly down to the I15 from that same detour – why? She had only about 30 seconds to decide. She thought those cars coming off of the detour could be a queue of vehicles coming southeast from Las Vegas.

Google Maps had saved her time before, so she decided to risk it. As she motored north away from I15, she passed a solidly packed, barely moving line of vehicles coming south. About 1.5 miles off I15, a southbound driver flagged her down, suggested she turn around, and reported that "the road is closed up there; you will either get stuck or have to join the line further back."

She promptly headed back to I15. The entire time she was returning from the detour to I15, she continued to see groups of cars coming up from I15. She does not know what prompted those folks to try the detour, or when or even if Google Maps stopped recommending that detour in that time period.

Others were not as lucky. News reports from the following days indicated that thousands of vehicles had taken these routes, and some of the earliest to try the detour drove well past their vehicle capabilities, with at least one needing to call a tow-service to recover their broken vehicle, and reporting that for part of the detour they were driving only 2-3 mph due to the dirt road's poor condition.
Questions

- What data would you expect Google Maps to have available that might have enabled them to detect this problem and stop sending people over this detour?
- What are the risks of using this information to disqualify or downrate alternative routes?
- Where could Google or other map vendors obtain such data?
- What were the key factors that led Helen to take the detour despite potential risks?
- What role could social media play in providing timely updates to travelers during emergencies like this?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 2 – A Winter Wonder Land?

Issues that arise while using online maps and navigation apps can be irritating, causing unnecessary delays. Winter storms can make these challenges much more problematic and dangerous.

Consider the following headlines and the summaries of their associated articles.

"Drivers Say Google Maps Failed Them in Snowstorm"
Drivers complained that when highways were closed due to record-breaking snowfall, services like Google Maps and Waze sent them on hazardous detours through mountain passes. Crystal Kolden tweeted about one such route, saying "This is an abject failure. You are sending people up a poorly maintained forest road to their death in a severe blizzard." No deaths were reported, though one family from Southern California was stranded for two hours when their vehicle got stuck on a snow-covered dirt road. They had ignored illuminated warnings signs and followed GPS instructions instead. Caltrans spokeswoman Raquel Borrayo said that people using mapping apps to dodge closures can face "precarious and dangerous situations with unplowed roads, heavy amounts of snow, and zero cellphone service." (Quinn, 2021).

"Google Maps Sending Drivers To Unmaintained Dirt Roads During Blizzards"
Every winter, the Sweetwater County Sheriff's Office regularly rescues people stuck on unmaintained seasonal dirt roads. "The drivers did not intentionally seek them out, they were guided there," said Jason Mower, Sweetwater County's public affairs director. "Each was mistakenly misled to the same remote roads thanks to their in-car GPS navigation systems." It

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has gotten so bad that the county had to close roads, build fences and make signs that say, “Your GPS is wrong. This road is closed!!” (Orr, 2023).

"Washington police urge caution against using Google, Apple Maps detours onto remote forest roads"
With all main highways across the Washington Cascades closed due to heavy snow and dangerous travel conditions, Washington State Patrol troopers are warning drivers not to attempt to find their own way over the mountains on forest roads. Sgt. Darren Wright said that asking popular GPS navigation mapping programs to plan a route could send you on a dangerous detour to seldom-traveled forest roads that are not designed for regular vehicular traffic. "We really discourage this idea for safety reasons." (Sistek, 2022).

Questions

- Given these criticisms of two different map and navigation apps, what recommendations for improvement might you suggest to their product owners? Consider technological approaches as well as internal-to-the-company processes.
- What additional steps might the various agencies take – both technological and procedural – to prevent travelers from endangering themselves under these sorts of circumstances?
- What strategies can be employed to improve road infrastructure and signage to prevent drivers from relying on potentially dangerous routes suggested by online map providers?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 3 – A Letter from Pakistan

Ayla is an undergraduate student in Lahore, Pakistan. She writes, sharing her experience with online map and navigation apps.

But first, a bit of background. Lahore is the capital and largest city in the Punjab province. It is the second largest city in Pakistan, with a population of over 13 million people (Government of Pakistan, 2023).
Like many metropolises, Lahore struggles with traffic challenges. Congestion is a major problem, particularly during peak hours. Numerous reasons have been identified, key among them:

- Rapid economic growth causing increased migration
- Insufficient public transportation
- Ineffective urban management
- Inefficient road engineering, e.g., choke points where three and four lane roads collapse into a single lane
- Increased traffic accidents

In her letter, Ayla highlighted two traffic issues unique to Lahore:

VIP Movement
It is very common for government parties to travel in multiple cars, followed by security in separate cars, leading to road closures, traffic jams and blocked vehicles rerouted. Ayla has first-hand experience in this regard. Many of the gates to her housing complex are closed when a VIP’s family visits another house in the same complex. She often has to take a longer route to exit the complex and get on the main road.

Sinkholes
Rain frequently causes sinkholes to appear, often underneath important and well-travelled roads (Our Correspondent, 2023).

While there are many online map and navigation apps available in Pakistan, Google Maps is the go-to app, as it is world-wide (Anonymous, N.D.). And, as elsewhere, there are the common benefits along with various challenges, such as:

- Maps outdated in various locations
- GPS connectivity issues
- Traffic information not up to date
- Inaccurate directions due to road closures, construction, etc.

Ayla and her friends regularly use GPS systems like Google Maps. It is not uncommon for them to find that new locations or road renovations are not updated on the app, causing them to drive over unpaved roads, be blocked by construction sites, and get stuck in traffic for 2-3 hours when the trip could have been 15 minutes.

Questions

- What additional factors might make Pakistan's roads more subject to this type of congestion and delays?
- What additional information, or perhaps information delivered in a timelier fashion, could improve route-finding in the presence of VIP convoys?
- Beyond their use of map and navigation apps, what information systems might Ayla and her friends use to avoid the “pop up” / unplanned traffic challenges?

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- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 4 – Business impacts of online mapping

Brian, a seasoned transporter of edible oil, embarked on a crucial delivery from Uganda to Nairobi. This was a return trip from the manufacturing plant to the distribution center. Before he embarked on his journey, he received a permit from the Kenya Revenue Authority, the national body responsible for collecting taxes as well as providing a GPS tracking device for his cargo.

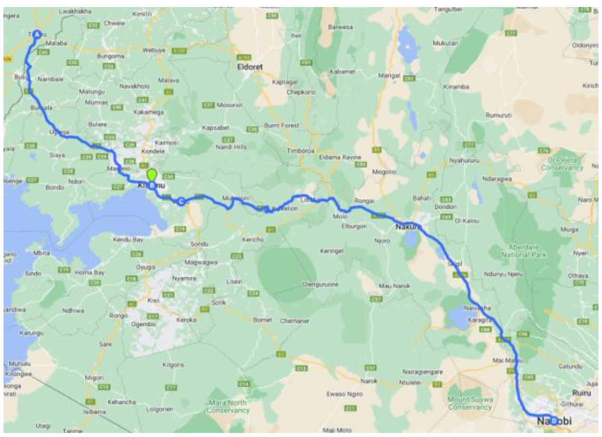

Figure 3: Uganda to Nairobi

The journey began early in the morning with Brian leaving Uganda with a tanker full of edible oil bound for Nairobi. His route, passing through the lush landscapes of Uganda, across the border, and through Kisumu (see Figure 3 – letter B, green pointer), was well-trodden and familiar. Brian's GPS indicated clear roads ahead, and he was on schedule to make a timely delivery.

However, as he approached Ahero (Figure 4, letter C), a small town near Kisumu, Brian encountered an unforeseen challenge: the Ahero bridge was heavily flooded due to recent torrential rains causing the River Nyando to break its banks. Local authorities had closed the bridge to all traffic, and a long line of vehicles had already formed on either side (Obiero, 2024). The flooded bridge was a critical point on Brian's route, and its closure posed a significant dilemma.

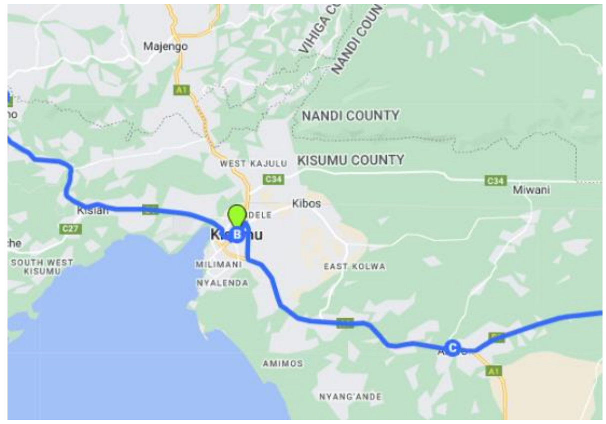

Figure 4: Bridge outage at Ahero (C) above


Figure 5: alternate route (in green) running north of the original route

Faced with this obstacle, Brian had two options. He could wait at the bridge until the floodwaters receded, and the bridge reopened, but there was no clear indication of when this might happen. Delaying his journey could disrupt his delivery schedule, potentially causing financial losses and damaging his reputation. The other option was to take an official detour (see Figure 5, green route), a route that would bypass the flooded bridge but attract a substantial fine of KES 10,000 (about US$80, or between 15 and 30% of his monthly salary) for deviating from the main route. Given that he was on a tight budget since he had spent most of his earnings to repair the chassis of the lorry, the second option was daunting.

Questions

- How could Brian possibly have avoided running into this dilemma? Is there other information that might have helped him or the map services make better choices?
- Why is it hard to forecast bridge closures amid weather issues?
- How might the processes for issuing permits and managing transport routes be improved to account for unexpected events such as natural disasters?
- What strategies can be implemented to support transporters financially when

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they face penalties or additional costs due to unavoidable detours or route changes?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 5 – GPS Spoofing

At a coffee shop in Beirut, Maya (not her real name) was reviewing possible matches on Bumble. Usually matches were located in Beirut. But in the recent past, since the onset of the Israel-Hamas war, most matches were far away – in Israel (Arraf, 2024).

Taxi drivers throughout Lebanon have not been able to trust directions on their smartphones because their online map apps are indicating that they're located in the Beirut airport or Cairo, Egypt (Bulos, 2024).

In flight in 2024 from Qatar to Madrid, cruising at 36,000 feet, Víctor (a commercial pilot) received an alert from the cockpit's GPS system, telling him that he was 1,800 feet from the ground. He knew this was incorrect, but he had never experienced such an alert in his 33 years of flying (Inal, 2024).

The common thread? They are all being affected by the Israel Defense Force's use of GPS "spoofing" to counter missile strikes from Hamas and its Lebanese ally Hezbollah who possess GPS-guided weapons, including drones. In an April news conference, Israeli military spokesman Rear Admiral Daniel Hagari said "we are aware that these disruptions cause inconveniences, but it is a vital and necessary tool in our defensive capabilities." (Bulos, 2024).

GPS spoofing exploits vulnerabilities in GPS infrastructure; in particular, the weak signal strength of GPS satellites. The Global Positioning System sends signals from satellites to GPS receivers, such as smart phones and commercial airliners. Receivers calculate their position based on the time it takes for the signals to arrive. Due to the weak signal strength of the GPS satellites, their signals can easily be overwhelmed by fake signals, leading to inaccurate location data on the receiving devices (McAfee Inc, N.D.).

While incorrect locations in a dating app are a nuisance and delays for taxi drivers can lead to customer dissatisfaction as well as a reduction in fares as they take time to figure out directions, the risks to commercial airlines are more serious. Researchers at the University of Texas have estimated that more than 50,000 flights have been spoofed in the Middle East in 2024 (Gebrekidan, 2024).

When pilots realize that their GPS receivers are being spoofed, they are often instructed to shut down their plane's GPS receiver and dependent components like the terrain warning system. In these circumstances, pilots will resort to other means for navigation, such as referring to location points on the ground. This frequently causes pilots to ask air traffic control for assistance, which can prove challenging for already stressed air traffic controllers.

With this in mind, Todd Humphreys, an aerospace engineering professor at the University of Texas said "There's no question that safety has been reduced in flights in the eastern Mediterranean because airlines are instructing their pilots to shut off GPS" (Bulos, 2024).

Questions
- Separate from the politics of the situations, what steps could be taken to prepare for such a scenario?
- What are the potential impacts of a breakdown of GPS service?
- What are the ethical considerations surrounding the use of GPS spoofing for military purposes, and how can these be balanced with the need for national security?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 6 – What's in a name?

The goal was simple. Barbara and Paul were in Germany, and Barbara wanted to see the small town where her mother's family had lived during the Second World War.

They were in Nuremberg when they began their search. They had a couple of clues. The name of the town is Jettingen, and many of Barbara's extended family – her mother, aunts, uncles and cousins – had stayed at one point during the war at an old castle that has since been converted to a hotel named Sindlingen.

Paul searched Google Maps for Sindlingen and initially found a neighborhood by that name near Frankfurt, but no hotel. Paul found it easier to use a German travel app – DB (Deutsche Bahn, German Rail) Navigator; in particular because

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Google Maps does not cover long-distance train travel as thoroughly as DB Navigator does. Paul searched for Jettingen on DB Navigator and found a match. They booked two tickets for the 2+ hour train ride and headed out.

When they arrived, they found themselves at Jettingen-Scheppach (the yellow map markers at bottom center of Figure A), and soon discovered that this was not where they wanted to be. It turns out that the DB Navigator app displays this location simply as Jettingen. They happened upon two immigrant Polish workers who explained that same-named towns are frequently distinguished by the addition of a modifier such as a state name or postal code. These good Samaritans further explained that Barbara and Paul were about 150 kilometers away from where they wanted to be in Unter Jettingen (B, with green map markers, lower left in Figure 6), which is about 45 kilometers outside Stuttgart.

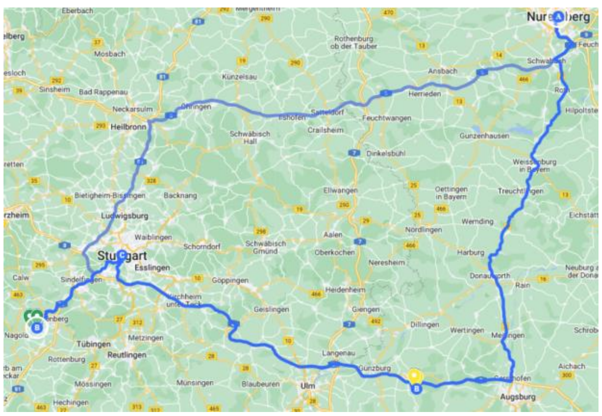

Figure 6: Routing errors in finding a German castle/hotel

Paul tried to book this leg of the trip with Uber and Bolt (a European Union ride-hailing company); both companies responded with "sorry, an error has occurred," meaning that no drivers would take the ride. So, onto a train for the ride to Stuttgart, and an Uber ride to Unter Jettingen. They made it to the Hotel Schloss Sindlingen in the evening. Goal accomplished, all in one eventful day.

Questions

- What value or additional information could a user get by comparing results from two independent mapping services?
- How can one best distinguish between two similarly- or identically-named places?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

4. ADDITIONAL RESEARCH QUESTIONS

Please feel free to use these prompts as you and your instructor see fit, to conduct additional research and analysis on online mapping and route-finding issues.

<u>Added Risks in Autonomous Vehicles</u>
Autonomous vehicles are already in limited service in various parts of the world. Considering your own experience as a driver, what do you anticipate might be new problem areas to explore and resolve if the rider in the vehicle has no means to control route decisions? What data might be used to resolve those?

<u>Side effects of GPS and routing systems' impact on traffic</u>
Personal experiences and numerous media reports indicate sometimes-significant impacts on traffic in certain areas. Quiet neighborhoods can suddenly become an alternate route for a major nearby road, or autonomous vehicles can suddenly divert onto a side street, and then have to turn around (Macfarlane, 2019).

Research some incidents of this type of impact. What were the underlying causes of the impact? What additional information could have been used (or better used) to mitigate this effect?

<u>Impacts of the Technology Acceptance Model for online maps</u>
Revisit Scenario 2 above and assemble your product team to further discuss these recent events and assess the impact. Please use the conceptual Technology Acceptance Model below to first assess and discuss the impact – how will this event affect those directly and indirectly impacted in terms of their intention to use Google (or perhaps other) online mapping services going forward? Be sure to consider each variable as well as the interrelation with the other variables.

A premise of this model is that the more functionality available, the more likely the user will be to use and adopt online mapping software (Marzuki et al., 2016). Given this, what specific recommendations would you make to enhance the functionality and features from a product perspective. Consider technology options, crisis communication features, and the other Ps in relation to the product enhancements (Price, Place/Distribution, and Promotion). Be prepared to present your recommendations to senior management with a high-level timeframe for implementation.

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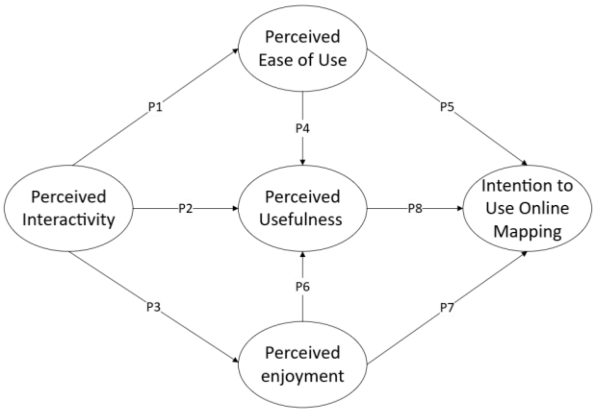

Figure 7: Technology Acceptance Model (TAM) Conceptual Framework Adding Perceived Enjoyment Variable (Marzuki et al., 2016)

Testing Map Services by Manipulating the Environment
A performance artist in Berlin, Germany, borrowed mobile phones from 99 friends, and set them all up to be running Google Maps directions. He then loaded them into a wagon that he pulled behind him as he walked through Berlin and across a bridge. This had the effect of convincing Google Maps that there was a terrible traffic jam there, and it showed that on the live map and re-routed other (real) traffic to other bridges (Barrett, 2020).

- Can you think of other ways to "test" an online mapping system to see if you can trigger or exploit certain online mapping or route-finding behaviors?
- What are the legal and ethical concerns to be considered before actually conducting such an exercise?

5. CONCLUSIONS

We hope that this case provides significant opportunities for students to consider how online maps and routing decisions work, and the data required to make the "best" decisions. Information is fundamental to making good decisions in any situation, and especially so in routing decisions, with a wide range of potential considerations and consequences.

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