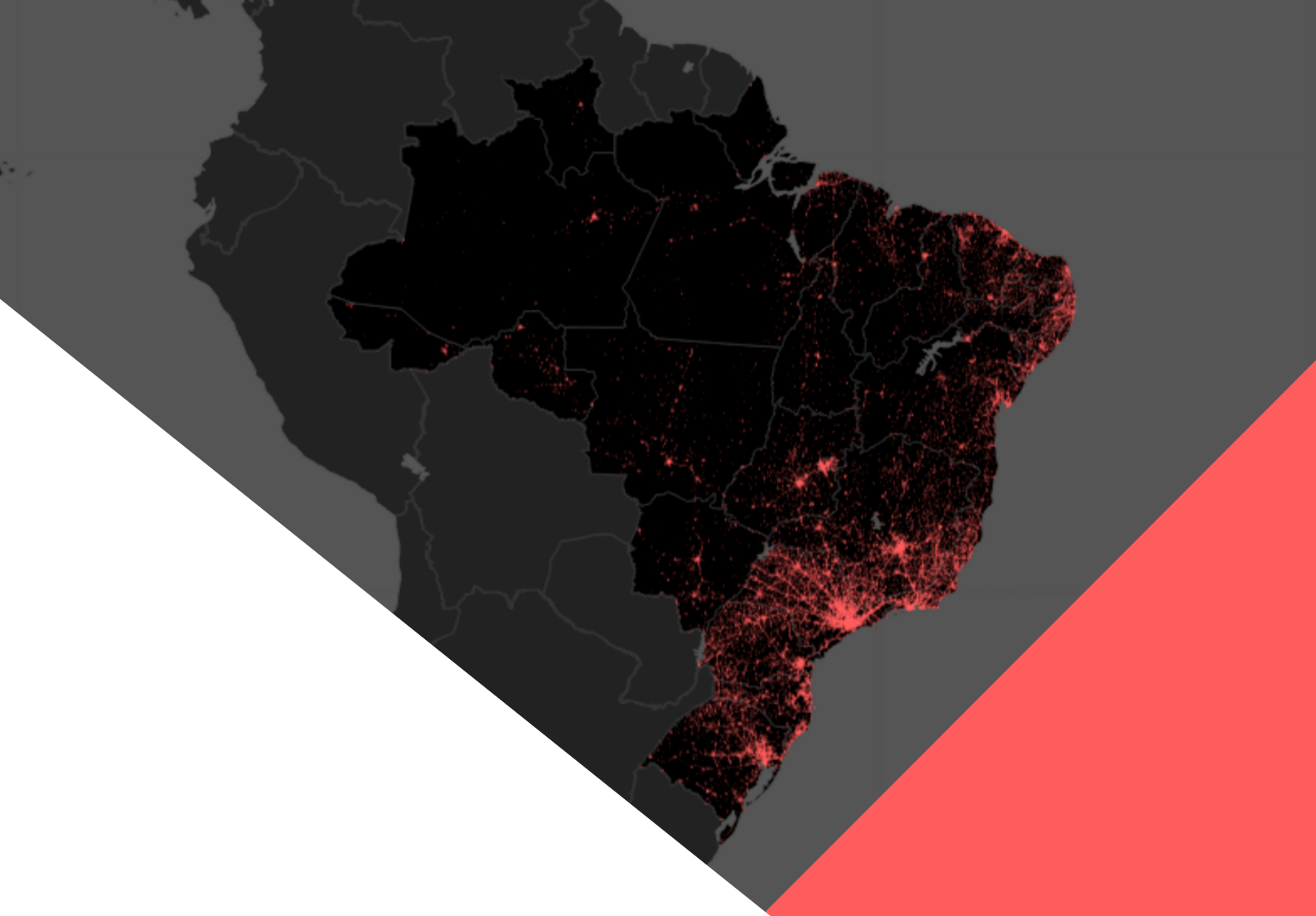


Brazil

State of Mobile Networks

May 2019

Analysis of Tutela crowdsourced data from over 403 billion mobile network measurements.

For further information about the methodology, data and tools used to create this report, please contact analysis@tutela.com.

TUTELA

Introduction

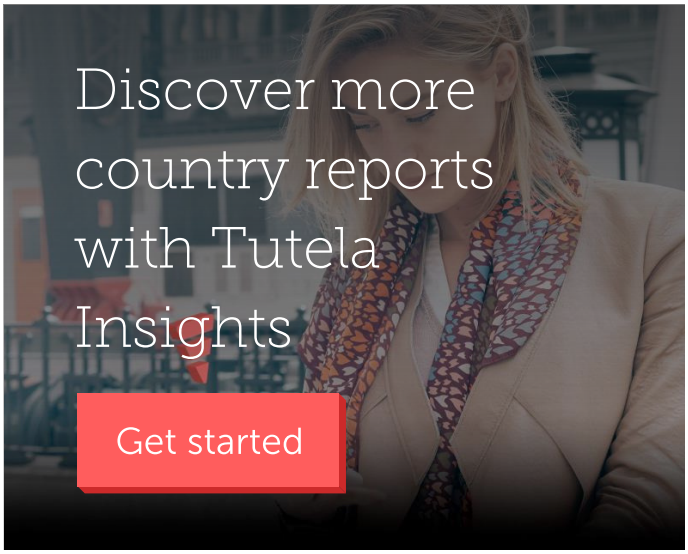
With 236 mobile subscriptions across 143 million unique mobile subscribers(1), Brazil is one of the largest wireless markets in the world. Ensuring a consistent level of service for those subscribers, whilst simultaneously handling an explosion in mobile data volume and ensuring the continuity of legacy services, is no mean feat for Brazil's national operators.

In this report, Tutela has analyzed data collected from over 16 million devices, including 100 million speed tests, 4.73 billion latency tests, and over 11 billion total cellular records. The data includes records taken from January 1st, 2019, to March 31st, 2019.

Key numbers

403 billion measurements
100 million speed tests
4.73 billion latency tests
16 million mobile devices

1st January - 31st March 2019



(1)Digital Agenda for Brazil 2019-2022: Contribution of the GSMA to the Program of Government of the Next President, GSMA, "https://www.gsma.com/newsroom/press-release/digital-agenda-for-brazil-2019-2022-contribution-of-the-gsma-to-the-program/"
Retrieved 7 May 2019

Executive Summary

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Best performing networks – Brazil 2019

Operator	Excellent Consistent Quality	Download speed	Upload speed	Latency
Claro				
TIM				
vivo				
oi				

Key findings

- Claro's strong 3G and 4G networks saw it take first place in a number of tests, including Tutela's excellent consistent quality benchmark, average download speed, and average upload speed
- TIM's users used 4G networks the most, with the greatest proportion of data used on 4G compared to other operators. However, overall Claro users used the most data each on average via a mobile connection
- Despite the additional load on Vivo's network -- it has significantly more subscribers than Claro or TIM -- Vivo's results were similar to Claro and TIM's results in most categories including basic Consistent Quality across Brazil
- Although Oi's 4G network provides users with an adequate experience, the quality of its 3G network -- and lack of 4G utilization compared to other operators -- saw it place last overall in most categories

Consistent Quality

Historically, download speeds have been used as the standard for measuring mobile network performance. For years, the logic has gone like this: the faster the download throughput, the better the network experience for subscribers.

However, as networks (and how subscribers have used them) have evolved, the means used to evaluate them have changed. Adequate download speed is just one of several crucial requirements for a "good" connection, and an over-emphasis on download speeds that are well in excess of what's required for almost all mobile applications has caused other network performance measurements to be overlooked.

To solve this problem, Tutela has developed a metric called consistent quality. It incorporates five network performance measurements: download speed, upload speed, latency, jitter, and packet loss. Every time Tutela collects those measurements on a mobile connection, we compare them against two sets of thresholds, which were selected using the minimum performance requirements of popular mobile applications. There are two sets of thresholds, excellent and basic. If all the network measurements meet or exceed the standards for excellent consistent quality, we conclude that the user can use services like Netflix, Skype, YouTube, or other real-time or streaming video applications (in 720p HD) with no noticeable problems or hiccups, since these will exceed the minimum network requirements set by these services. Connections that don't meet the thresholds may still allow users to use those services, but without the same likelihood of a flawless experience.

Excellent quality

Download speeds > 4 Mbps
Upload speeds > 2 Mbps
Latency < 50 ms
Jitter < 30 ms
Packet loss ~ 0%

Basic quality

Download speeds > 512 Kbps
Upload speeds > 128 Kbps
Latency < 100 ms
Jitter < 50 ms
Packet loss < 5%

The basic consistent quality thresholds follow a similar principle, but for less demanding use-cases. A connection that meets the basic consistent quality thresholds will be sufficient for things like web browsing, email, or a VOIP voice call on a service like WhatsApp or Viber. Tutela set these thresholds based on the network requirements set by the applications (where available). You can read more about how Tutela chose these thresholds and what they represent here(2).

In the reports, Tutela represents each operators' consistent quality with a percentage score; this number represents what percentage of tested network connections met or exceeded the excellent or basic consistent quality thresholds. Every connection that meets the excellent consistent quality threshold also exceeds the requirements for basic consistent quality.

(2) Introducing Consistent Quality - measuring more than just speed
https://www.tutela.com/blog/introducing-consistent-quality-measuring-more-than-speed
Retrieved 7 May 2019

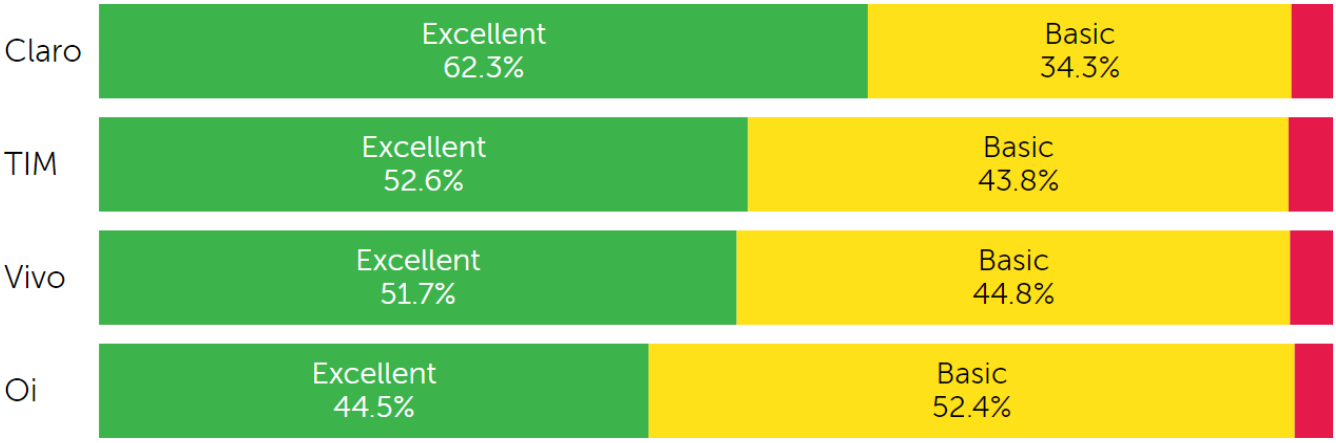
Consistent Quality

Claro has a commanding lead over other operators with regards to excellent consistent quality. 62.3% of its tests met Tutela's threshold for excellent consistent quality, a nearly-10% lead over the next-placed operator.

TIM and Vivo were a close second and third place for excellent consistent quality, with scores of 52.6% and 51.7% respectively, not quite a one percent difference. Oi was in fourth place by a more considerable margin, with an excellent consistent quality score of 44.5%. In practical terms, the difference between first and last place means that in places where a Claro user gets a signal, it is good enough for the user to do the vast majority of mobile use-cases such as HD video streaming or group video calling six out of ten times; for an Oi user, the same is true just four-and-a-half times out of ten.

When it comes to basic consistent quality, the gap between operators is much smaller. Tests from all four operators met the thresholds for basic consistent quality 96% of the time, demonstrating that Brazil's networks are almost always adequate for less-demanding use-cases like browsing the web or making VOIP calls.

Consistent Quality: Percentage of Tests that Meet or Exceed the Thresholds



Discover Tutela Explorer

Tutela Explorer is a powerful cloud-based solution for real-time analysis of crowdsourced data. Using the platform, mobile operators can:

- Create coverage and quality maps
- Benchmark network quality and coverage across all operators
- Drill down to any KPI at city, street or even building level
- Analyse spectrum utilisation, performance and more

Visit www.tutela.com/explorer to learn more

Learn more

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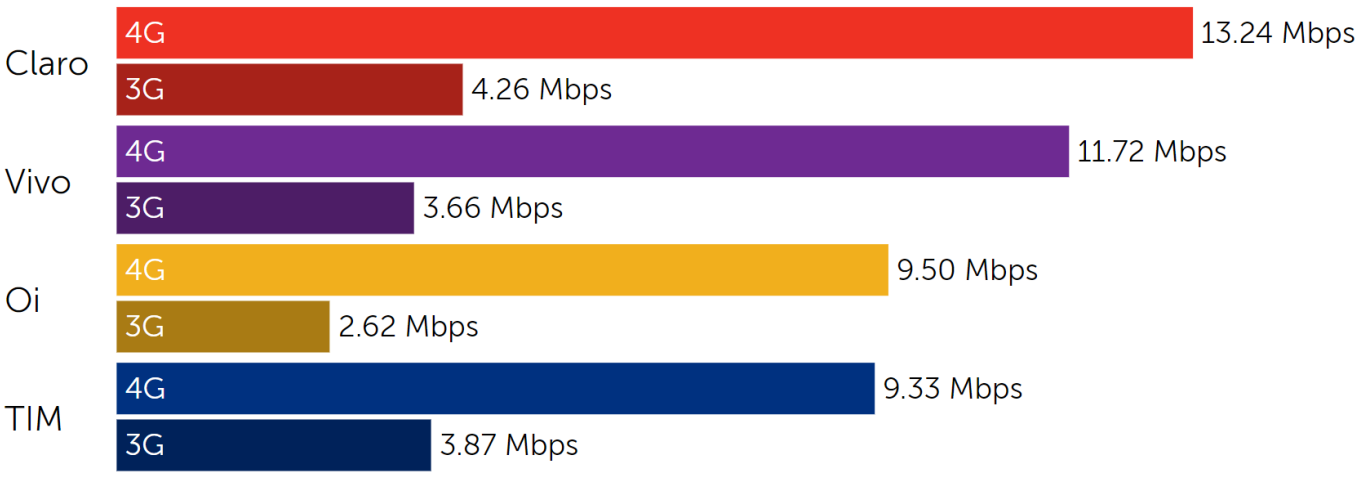
Download Speed

Although Claro remains on top when measuring combined download speed, the rankings of the other operators shift a little compared to consistent quality. Vivo is in second place for 4G-only speed and combined 3G-4G speeds, just less than 2 Mbps behind Claro.

Although TIM has one of the fastest 3G networks, its 4G speeds are the lowest of all four operators, resulting in a third-place finish for combined download throughput speed. Oi takes third place for 4G download throughput, beating TIM by less than 200 Kbps; however, its 3G download throughput is notably slower than all the other networks, and since Oi relies on its 3G network more than other operators, its combined download throughput is in last place overall.

Download Throughput (4G & 3G Combined)

Download Throughput (4G & 3G Seperate)

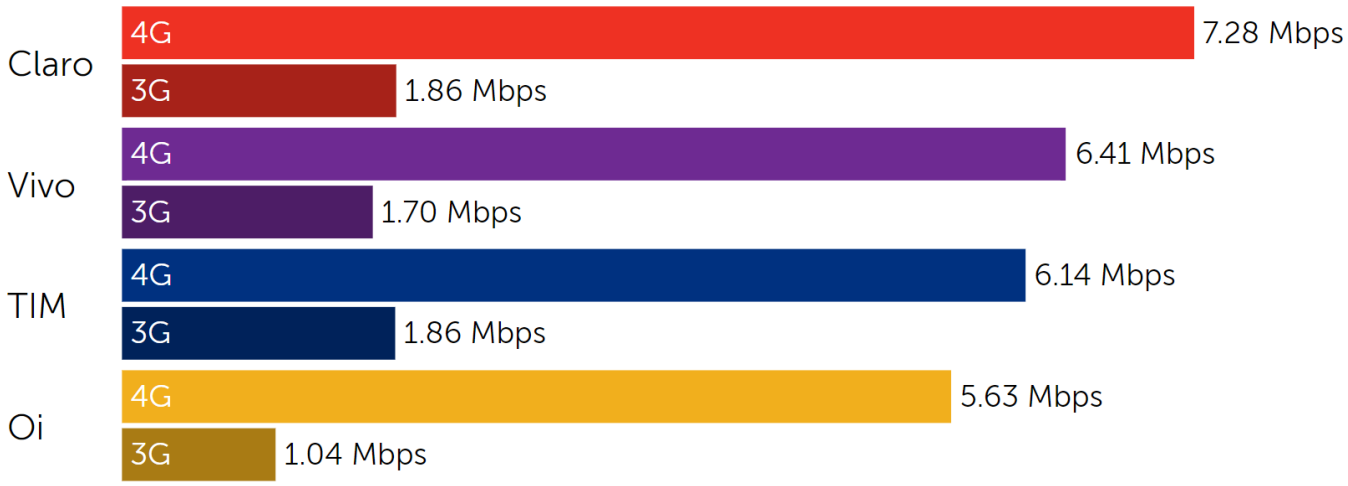


Upload Speed

The results were closer for upload speed, with less than 2 Mbps separating first-place Claro from last-place Oi. Claro took first place for combined upload speed, and also had the fastest 4G upload speed and the joint-fastest 3G upload speed, along with TIM. Vivo took second place for 4G upload speed, but slipped to third place overall for combined upload speed, thanks largely to TIM's greater usage of 4G and superior 3G upload speed. Oi was in last place for upload speed, and its 3G upload -- barely better than 1 Mbps -- was significantly behind that of other operators.

Upload Throughput (4G & 3G Combined)

Upload Throughput (4G & 3G Seperate)

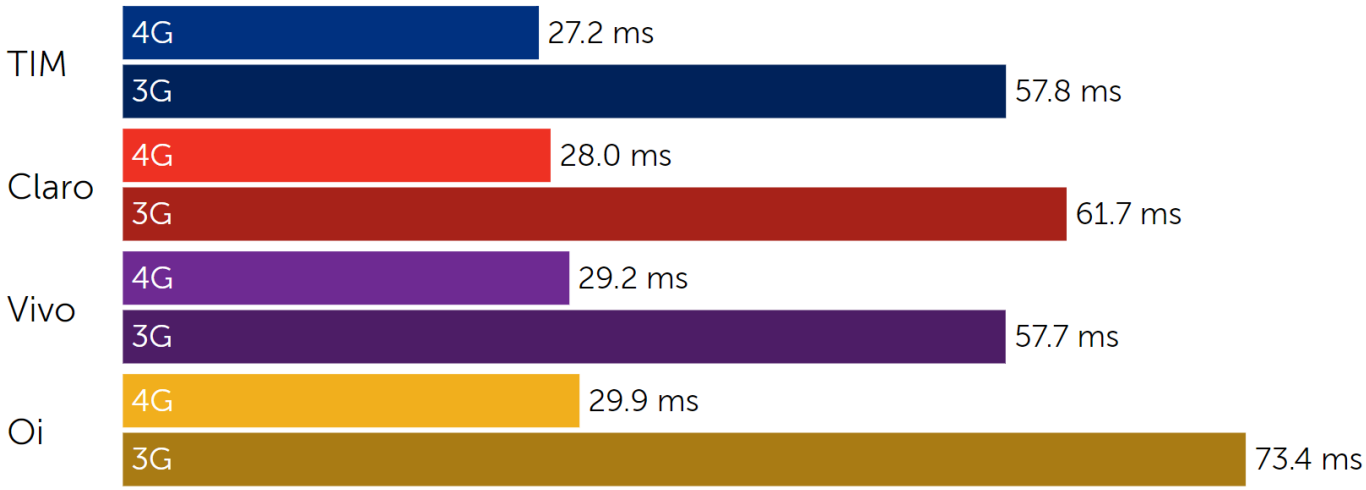


Latency

TIM took a commanding first place for latency, with its combined 3G and 4G average of 35.9 ms over four milliseconds faster than the next-placed operator. Claro and Vivo were second and third respectively for combined latency, at 40.4 ms and 42.5 ms. Oi was in fourth place by a greater margin, and it was the only operator to have a combined latency (51.7 ms) greater than Tutela's standard for excellent consistent quality. When looking at 3G latency, the gaps between the operators were less pronounced. Vivo was in first place, with TIM second and Claro third; however, just four milliseconds separated first and third place. Oi was in fourth with an average of 73.4 ms.

Latency (4G & 3G Combined)

Latency (4G & 3G Seperate)

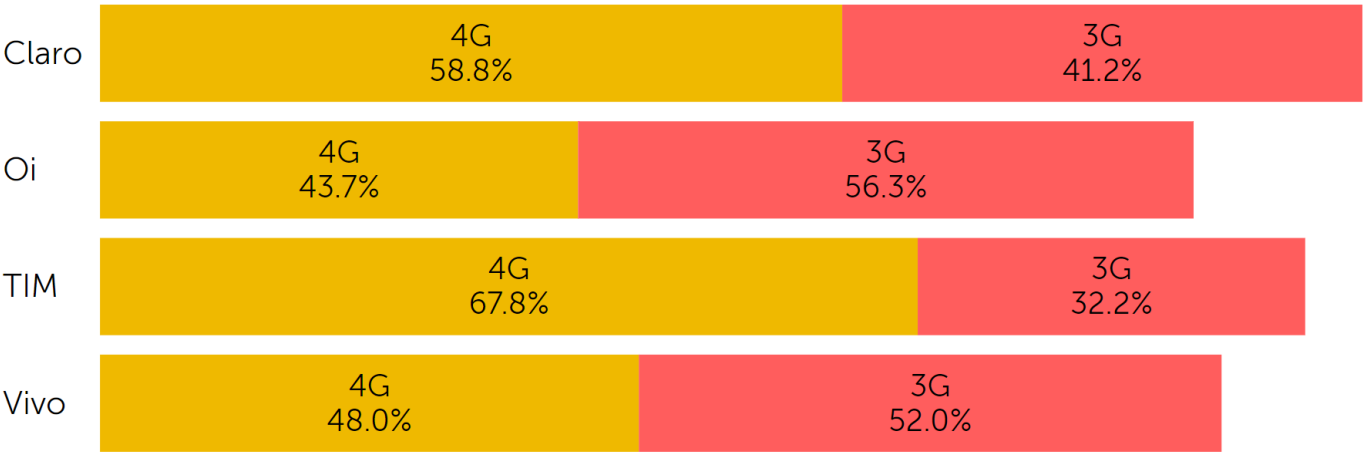


Technology Usage

For this report, Tutela examined the utilization of 3G and 4G networks using the volume of data transferred over these networks, broken down by operators.

TIM was in first place for 4G utilization, with 67.8% of data usage over 4G. Claro was in second place, with 58.8% of data usage on a 4G network. Vivo was over 10% behind Claro for the percentage of data usage over 4G, while Oi users recorded the lowest levels of 4G data usage -- 43.7% of data usage per user was on 4G and 56.3% on 3G.

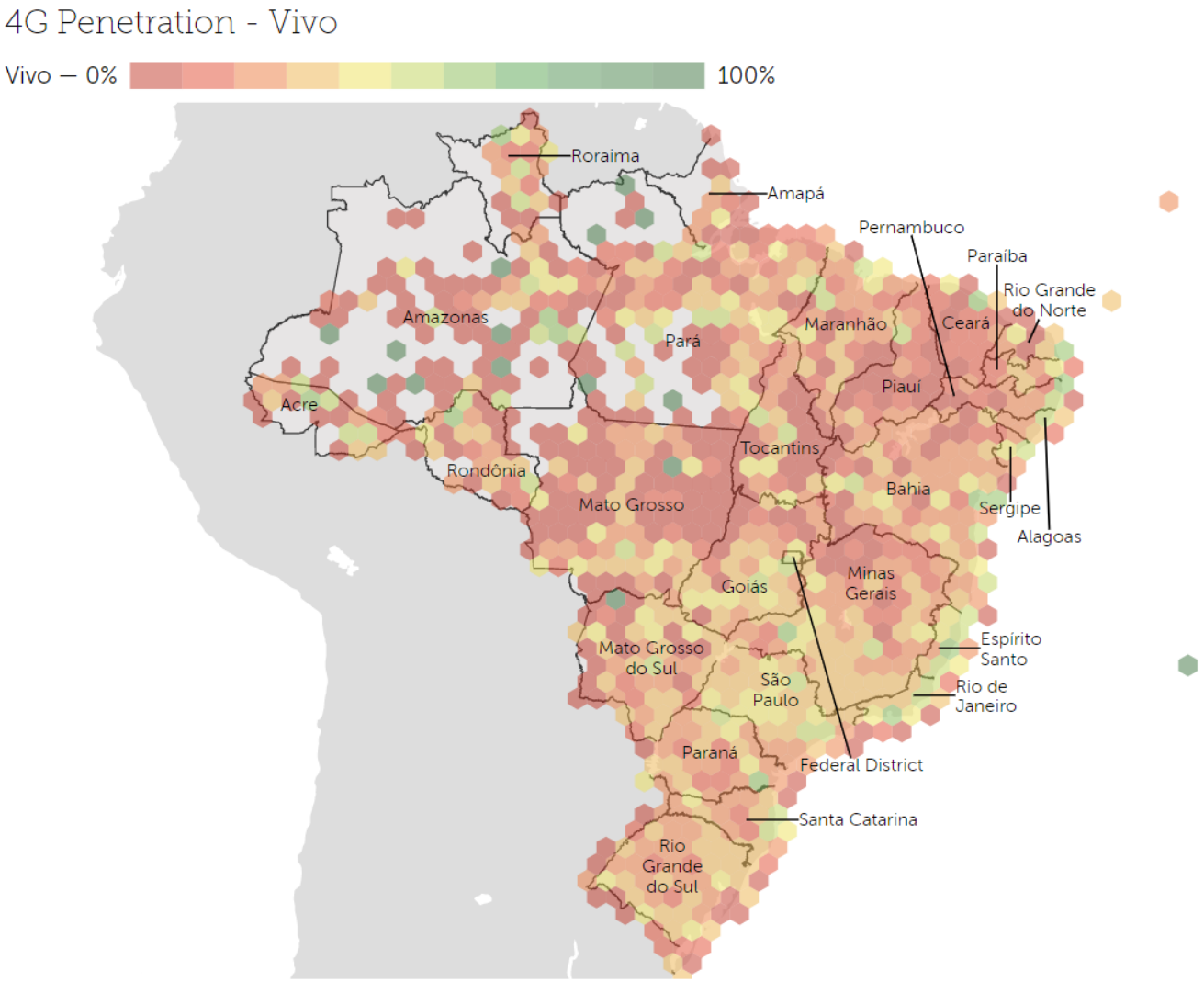
Percentage of Data Usage per User per Mobile Technology



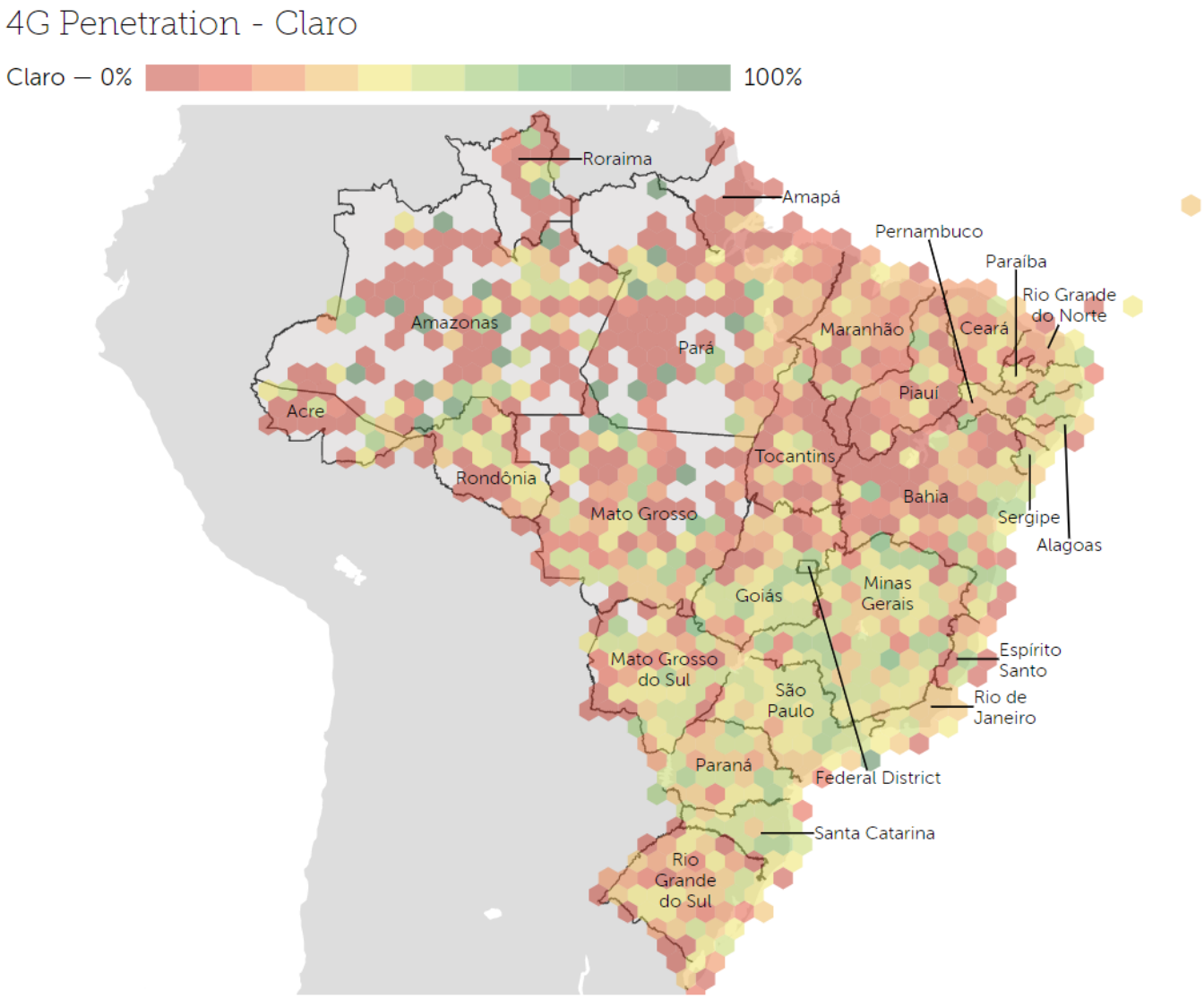
4G Penetration by Region

When looking at 4G availability by region, a similar picture emerges when looking at the national average. TIM's coverage is 4G-heavy, with a substantial number of regions having majority 4G coverage, including numerous areas outside of urban areas. Claro's 4G coverage is strong in the south of the country and along the coast, but falls off towards the north-east.

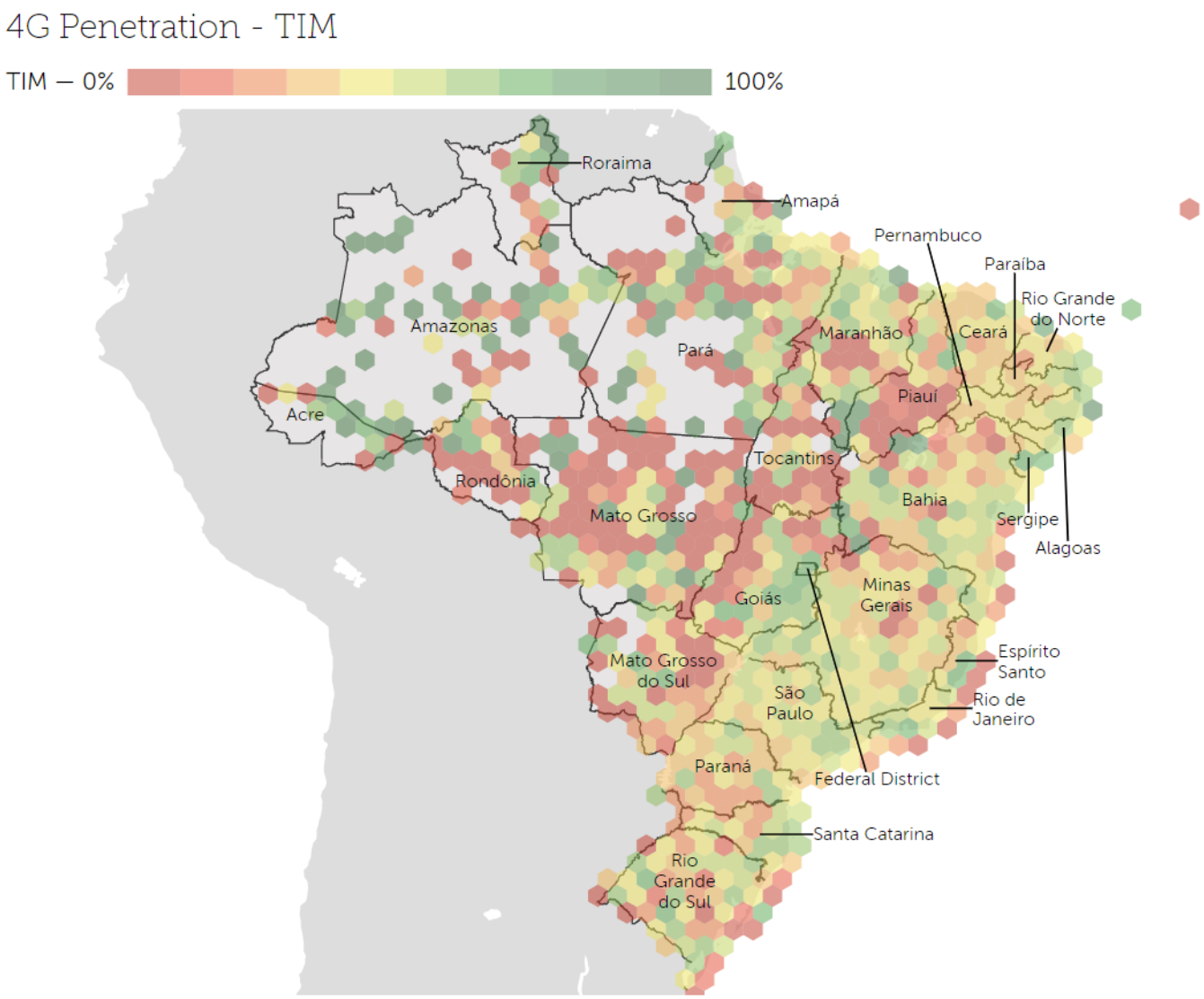
Vivo and Oi, meanwhile, have visually sparser 4G coverage, with its faster network concentrated in more densely populated urban areas.



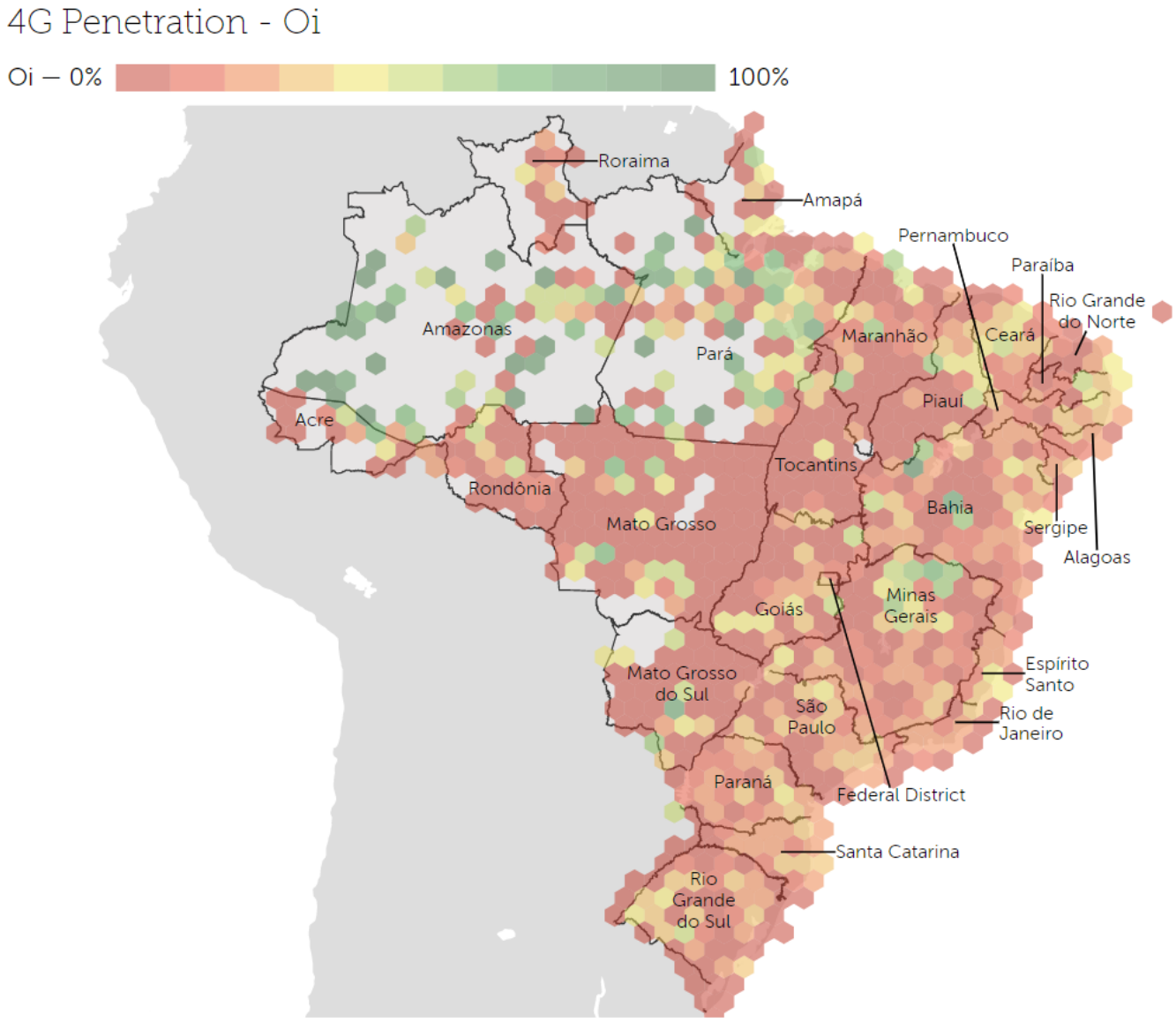
4G Penetration by Region



4G Penetration by Region



4G Penetration by Region



Methodology

Tutela measures network quality based on the real-world experience of millions of users. We employ software installed in more than 3,000 partner apps to actively test network performance, conducting download, upload, and server response tests against Tutela-configured servers. The tests are conducted randomly and in the background to avoid sampling bias, with a testing configuration designed to emulate and measure real-world user activity, not maximum network throughput.

At the heart of Tutela's throughput testing is our use of small, lightweight files (2MB for download and 1MB for upload), which are designed to mimic the way that people actually use their devices. The most common smartphone uses include things like web browsing, using weather apps, written communication with friends and colleagues, playing games, or reading the news(3) -- all of which involve sending and receiving small data packets. How a network performs depends on the size and type of data packets being sent and received, which is why Tutela uses a small, fixed file size to test how the network handles typical traffic -- rather than huge files of several hundred megabytes, which are representative of downloading huge apps, entire movies to watch offline, and little else.

Unlike traditional methods of benchmarking mobile network performance, the crowdsourcing techniques employed by Tutela don't inherently offer a head-to-head comparison of operators in exactly the same location. Crowdsourcing is complementary to drive-test techniques and measures network performance wherever users are actually using the network -- which, if you're seeking to examine the real-world experience of subscribers using their own devices on the network, is exactly what you'd be after.

In addition to working in the background (to eliminate user-initiation bias) and testing using representative packet sizes, Tutela also employs the largest crowdsourced population in the world for mobile network testing. Our software is present on over 250 million Android and iPhone devices globally, and our network collects over 10 billion mobile data measurements every day. Our data scientists analyze results for countries on a monthly basis and tabulate the results into reports. Our custom analytics solution, Tutela Explorer, updates with new measurements on a daily basis, and enables operators to chart, map, and filter over 80 key performance indicators into customized dashboards to help them better understand network performance, enhance customer Quality of Experience, and benchmark their network against competitors.

(3)Something for everyone, Why the growth of mobile apps is good news for brands, IPSOS "https://www.ipsos.com/sites/default/files/2017-08/Google-mobile-apps-report-2017.pdf" Retrieved 7 May 2019

Join Tutela Insights

Tutela Insights is our exclusive online portal which hosts all of our complimentary and premium reports and data products.

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- Powerful tools to analyse and drill-down into our data
- Raw data with direct database access and data extracts
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Visit insights.tutela.com/register to sign up.

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About Tutela

Tutela is a mobile data and analytics company serving the mobile and telecommunications industry with software is embedded in over 3000 diverse mobile applications installed on over 250 million mobile Android and iOS handsets. Tutela continuously monitors network quality of experience all across the world. We collect more than 10 billion measurements every single day, and through our interactive toolset, enable our customers to turn those numbers into actionable intelligence for their businesses.

For more information, visit www.tutela.com or contact us at info@tutela.com

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