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Demand for indoor connectivity driving the need for enhanced performance

Extract from the Ericsson Mobility Report

November 2023

Demand for indoor connectivity driving the need for enhanced performance

To achieve expected indoor performance, both coverage and capacity must be enhanced in key venues through optimal network deployment scenarios.

Key insights

- Indoor traffic patterns are different compared to outdoor – 1.5–2 times more traffic per user, with large variations across venue types.
- Indoor small cells provide significant throughput improvements over distributed antenna systems (DAS), especially in uplink, paving the way for XR services.
- Current 4G indoor deployments often experience high load and limited user performance. 5G mid-band should be deployed to deliver the full 5G experience.

So far, 5G mid-band time division duplex (TDD) has mostly been deployed at outdoor macro sites to provide coverage and capacity for mobile broadband and Fixed Wireless Access (FWA) services. However, the majority of traffic is generated indoors where people tend to spend most of their time; we spend 90 percent of our time indoors, and up to 80 percent of our data is consumed there.[1]

The importance of indoor performance

With so much of our lives spent inside, it makes sense to focus on providing 5G performance at indoor venues, especially where there are high user concentrations. Indoor environments often have difficult propagation characteristics due to the fabric of buildings containing steel frames and solid walls. Venues typically facing these challenges include train stations, shopping malls, stadiums and airports.

To address these challenges, tailored 5G solutions for indoor deployments are preferred as they can deliver superior user experience.

A recent ConsumerLab study shows the correlation between network performance in key locations and service provider churn. The research found that users who encounter connectivity problems at event venues and airports are three times more likely to churn in the next six months.[2] This highlights the need to invest in improving performance in key locations for today's services to drive up customer satisfaction. It will also be fundamental for new and emerging services such as cloud gaming and XR that have demanding network performance requirements.

Methodology

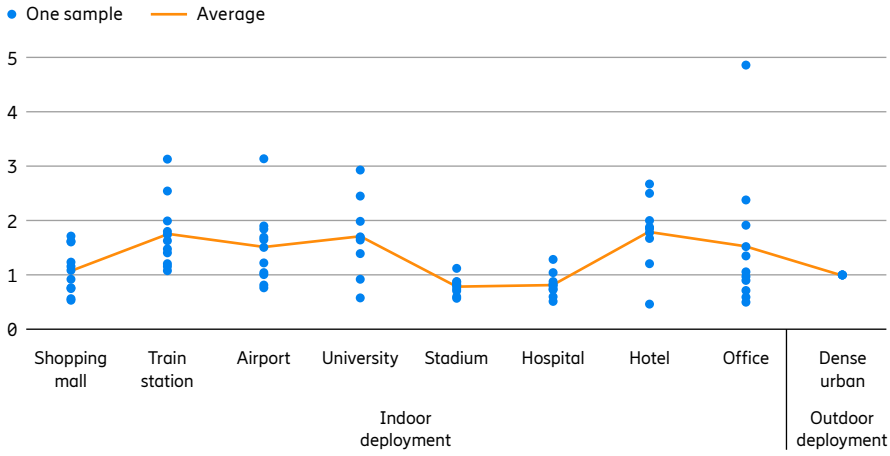
In North America, data was retrieved from nine different venue types, with 30 samples of mobile traffic data taken per venue type, from across three different networks in Q1 2023.

Indoor traffic behavior analysis

Understanding user behavior is important for selecting the best indoor solution to meet user experience and capacity needs. Mobile data usage patterns will be different across venue types depending on the services that users are running on the mobile network. Indoor venues typically have many users concentrated in a limited area, making capacity demands extremely high during peak times.

In many cases, average traffic consumption is also significantly higher in the indoor venues compared to when being served by the outdoor network. Figure 29 shows the relative average traffic per user in indoor venues, normalized with outdoor dense urban traffic. The results show that in busy venues peak traffic per user is 1.5 times higher on average, with one airport in the sample seeing over three times higher traffic. This illustrates that not only is there a difference by venue type but often a large spread within the same venue type.

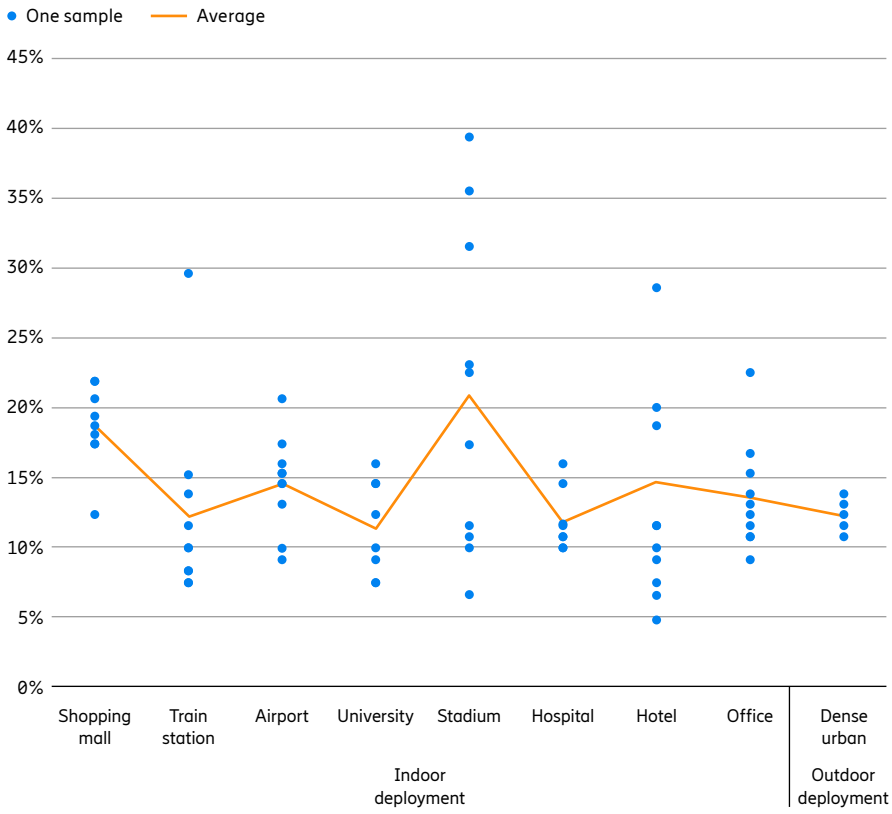
Figure 29: Relative average traffic per user for busy hour



[1] Ericsson Blog, "5 ways indoor 5G will change your life (and mine)" (July 2023).
[2] Ericsson ConsumerLab, 5G value: Turning performance into loyalty (October 2023).

Further analysis of the traffic shows that the share of uplink traffic is significantly higher at many indoor venues, compared to the dense urban benchmark (see Figure 30). There is considerable variation in the share of uplink traffic at stadiums and hotels. Social media sharing from live events could explain the high uplink traffic in stadiums, as highlighted by a major sporting event within a stadium where 35 percent of traffic was uplink. Hotels are likely to have the biggest variation based on their venue, guests, and time of the week. The most-used services here range from uplink services such as uploading of work-related material, video calls and social media, compared to heavy downlink traffic from services like video streaming. Altogether, these results exemplify the need for a good understanding of traffic behavior when planning and deploying an indoor 5G solution.

Figure 30: Share of uplink traffic out of total traffic



Bringing 5G to enhance the fan experience

For the recent major women's football tournament in Australia, Optus upgraded three stadiums, introducing 5G bands (non-standalone and standalone) to enhance the fan experience. The event saw games sell out and stadiums reach full capacity, totaling an excess of 0.75 million live spectators. To analyze the fan experience during the live events, over 1,100 cells were monitored, including within the stadiums, corporate boxes, nearby public transport and the immediate vicinity around the stadiums.

During the event over 29 TB of mobile traffic was generated, of which 37 percent was carried over 5G, with the 5G share peaking at 51 percent.

On average, 40 percent of devices in the stadiums were 5G capable, making it critical to have 5G at such events to meet traffic demands and enhance the fan experience. Of the traffic generated during the tournament, around 25 percent was uplink driven by social and sharing applications, illustrating the importance of considering both uplink and downlink performance when dimensioning deployments in such venues to give fans the complete experience.

When measuring the success of bringing 5G bands to the stadiums for this event, the key performance indicator was reaching greater than 99 percent accessibility. This was achieved across all stadiums for both 4G and 5G.

This success was partly enabled through 7,000 live changes optimizing the cell sites. This resulted in an improvement in uplink throughput that ranged from 5–53 percent compared to matches with similar traffic prior to the improvements made for this tournament.

Optus is working to further enhance two major stadiums with the latest high-capacity design, products, and network performance. One of the key objectives is to monetize the superior network performance through service offerings such as new immersive experiences.

OPTUS

Figure 31: Optus' reported women's football tournament network statistics, 2023

Over 0.75 million live spectators attended the games in total.

>0.75m

Over 29 TB of mobile data traffic was generated, of which 37 percent was over 5G and 25 percent was uplink.

>29 TB

4G and 5G reached over 99 percent accessibility during the tournament.

>99%

Resource utilization is nearing capacity

Deeper analysis of the 4G radio resource utilization in the busy hour has been examined for many venues. When resource utilization is below 50 percent a good user experience can be delivered, with over 95 percent of users experiencing an acceptable time-to-content for web browsing. When utilization reaches a high level, above 50 percent, and a high density of users are requesting services at the same time, this will lead to a degraded user experience. Many users are fighting to share limited resources. Figure 32 shows that resource utilization is very high in many deployments across different venues. Typically, stadiums perform better, having seen more investment in indoor solutions and also being well supported by the macro network.

A key metric for measuring user experience is time-to-content. In a separate Ericsson Smartphone Lab study, results indicated a strong relationship between available downlink throughput and time-to-content.[3] With a time-to-content scale we can derive the throughput that would be required to meet a certain target. This scale grades sites as:

- excellent (<1.5 s)
- good (1.5–2.5 s)
- fair (2.5–4.0 s)
- poor (>4.0 s)

Throughput results are graded as:

- excellent (>20 Mbps)
- good (10–20 Mbps)
- fair (5–10 Mbps)
- poor (<5 Mbps)

When we overlay this onto cell-edge performance across the key venues, shown in Figure 33, we can see that excellent performance is only realized in a small portion of office and stadium deployments, with airports being the worst performing venue type by far.

These high levels of utilization and relatively poor cell-edge performance for time-to-content highlight the need to improve indoor network performance. In a venue with 5G indoor small cells deployed there was double the throughput on average and three times better throughput at the cell edge. Adding 5G mid-band TDD provides a significant improvement in user performance.

Figure 32: Percentage of venues with high radio-resource utilization (above 50 percent)

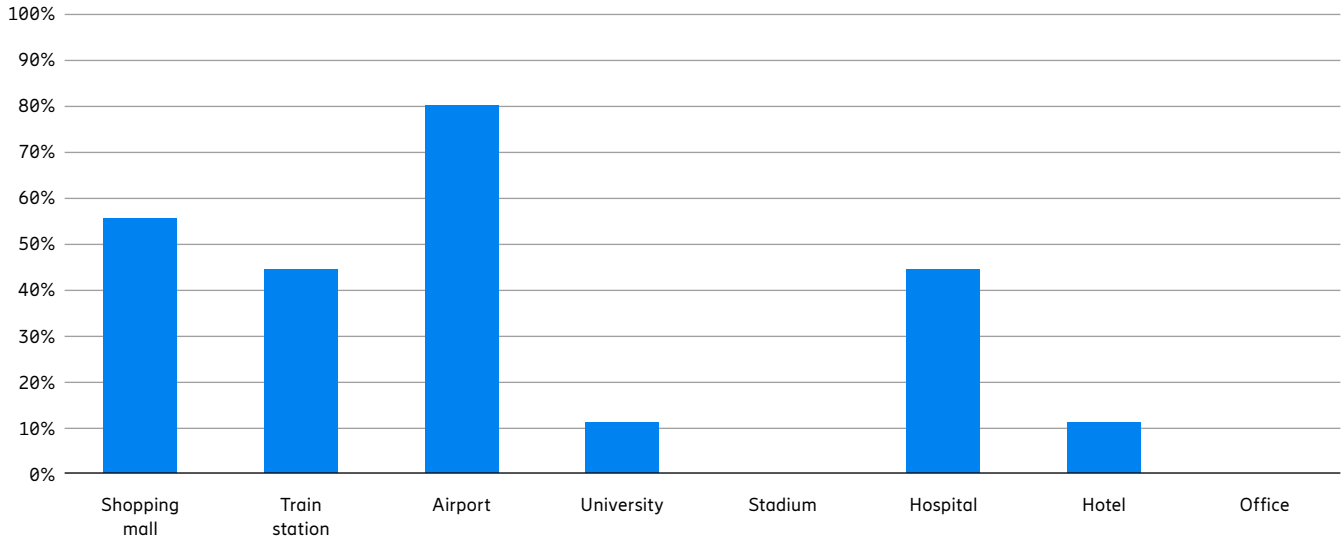
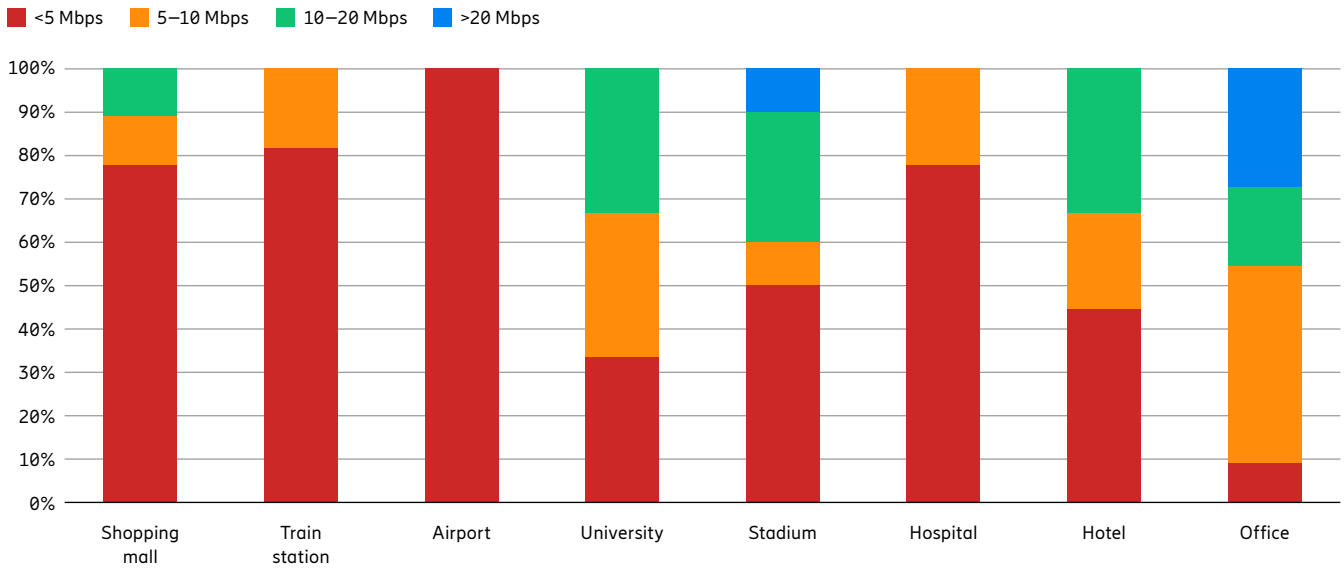


Figure 33: Percentage of different categories of 4G downlink cell-edge throughput



[3] Ericsson Mobility Report, "Time-to-content: benchmarking network performance" (November 2021).

Indoor deployments dominated by 4G DAS in the US

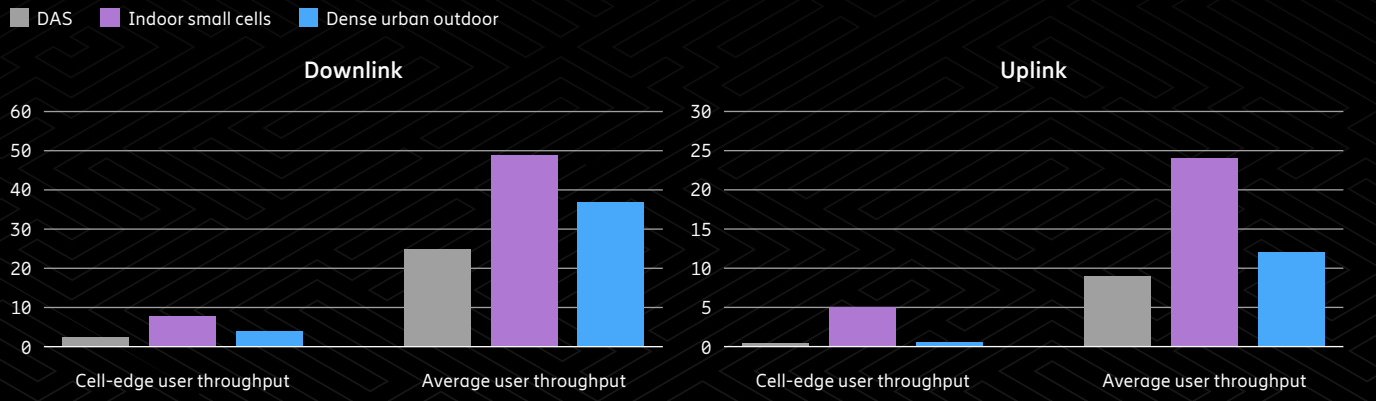
To better understand current indoor network characteristics and the performance of different solutions, a range of deployments from the US across typical indoor sectors has been analyzed. Today, the vast majority of these indoor deployments are still based on 4G solutions, with indoor DAS being the most common, making up over 70 percent. A typical indoor sector is deployed with 20–40 MHz mid-band FDD which is quite limited compared to typical macro 5G mid-band TDD bandwidths.

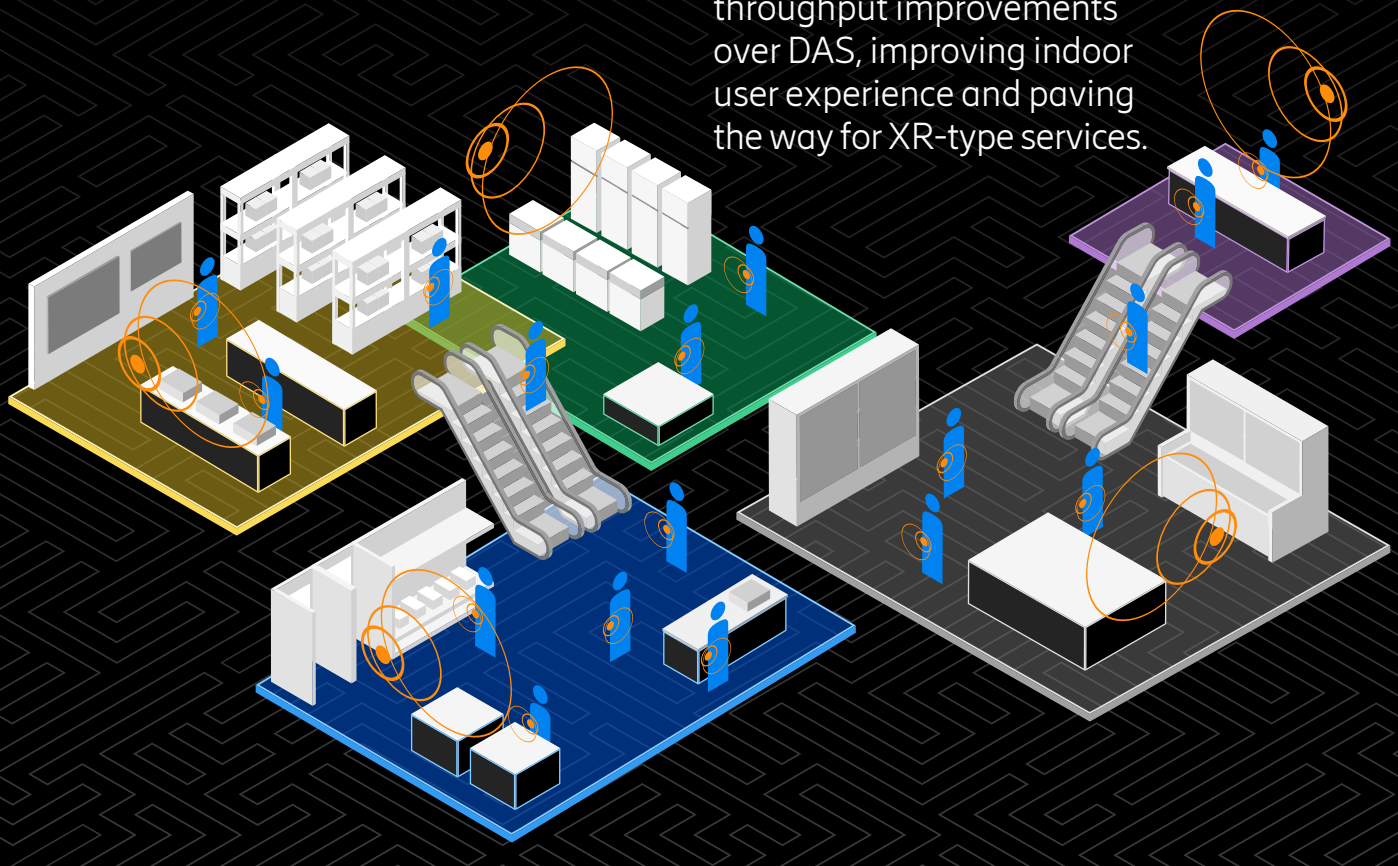
When analyzing the busy hour user experience, Figure 34 shows that an indoor DAS solution falls short compared to outdoor macro deployments for serving these venues, even though DAS has antennas deployed much closer to the users. In comparison, indoor small cells provide a superior user experience in both uplink and downlink, including at the cell edge, which will drive the required improvement in time-to-content. This significant advantage indoor small cells have in the uplink is important for growing uplink traffic, especially in key venues such as airports and stadiums, and will be critical in paving the way for new services like XR.

The time is now to enhance the indoor experience

Upgrading the indoor experience is required today to drive customer satisfaction. The examples discussed here show that user experience is key to driving customer loyalty, and given the time spent indoors, it offers service providers an opportunity to deliver on, or even to exceed, consumer expectations with enhanced experiences. There is a clear need for investment in key locations, especially airports which have some of the worst performance data, alongside being a key location driving churn. 5G mid-band TDD and indoor small cells are the optimal solutions for significantly improving network performance for downlink time-to-content, and even more so for uplink, which will be key to paving the way for new immersive XR services.

Figure 34: 4G user experience shown as downlink and uplink throughput (Mbps per second)





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