# Indoor solutions

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                    Confidential

# Densification required to bring needed capacity
## Dense urban, indoors and strategic locations



Growing subscriber performance expectations
Worsening indoor coverage (environmental regulations)
Capacity requirements not fulfilled by macro upgrades

Densification for both indoor & outdoor
on-going now, scaling up towards and with 5G

| | Traffic volume density | 1 Gbps/km2 | 4 Gbps/km2 | 10 Gbps/km2 | 40 Gbps/km2 |
|---|---|---|---|---|---|
| New York (1 sq.km) | Dense Urban steps | 2014 Traditional Networks | 2017 HetNet | 2020 Dense HetNet | 2025 Very-Dense HetNet |
| | Outdoor ISD (m) | 240 | 139 | 128 | 82 |
| | Outdoor Site/km2 | 20 macro | 20 macro + 40 SC | 20 macro + 50 SC | 20 macro + 150 SC |
| | Number of buildings with indoor deployment /km2 | 0 | 1% buildings (20x LTE SC) | 4% buildings (100x LTE + LWA/LAA SC) | 17% buildings (500x LTE + LWA/LAA SC) |

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# Indoor challenges
## Restricting wide scale deployments

| | | |
|---|---|---|
| **Typically, indoor is 2nd phase of a new country wide network deployment** | **70-80% of data traffic is indoor <u>but</u> many buildings** | **Building environmental regulation impacting coverage** |

| Outdoor-in cases | Indoor UL Throughput |
|---|---|
| 2 layer glass | 8.4 Mbps |
| 2 LG + HEEW | 4.1 Mbps |
| 3 LG + HEEW | 0.4 Mbps |

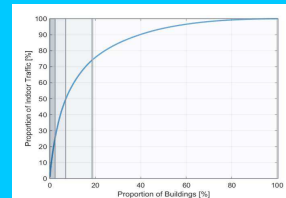| | | |
|---|---|---|
| **Varying requirements**<br><br>- Very different environments (home to large airports)<br>- Individual approval/building<br>- Building owners often requires neutral host solution | **DAS - Traditional indoor solution less than ideal**<br><br>Cumbersome, slow and costly… but great for neutral host | **Enterprises: Wi-Fi is king of Wireless LAN**<br><br>Lower enterprise 'pull' except from some specific industries |

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# Indoor ~~challenges~~ opportunities & benefits

Helping support the case for wide scale deployments

| | | |
|---|---|---|
| **Indoor deployments release outdoor capacity & make Macro more efficient** | **70-80% of data traffic is indoor…**<br><br>Urban: 70% of demand in 20% of buildings | **Scope to Add values (MEC) & IoT opportunity** |
| **Femtocells**<br>Perfect fit solution for small indoor<br><br>**New large indoor solutions**<br>Easier to deploy, agile, lower TCO | **Public indoor - highly strategic + opportunity**<br><br>- Massive data needs<br>- No "free" & automated Wi-Fi<br>- ARPU oppo (Airports, Stations, Touristic hotspots) | **Indoor will be key for 5G (higher frequencies)** |

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# DAS vs Small Cells – Stadium example

Beyond neutral host benefit, DAS are cumbersome, costly and inflexible

## DAS system
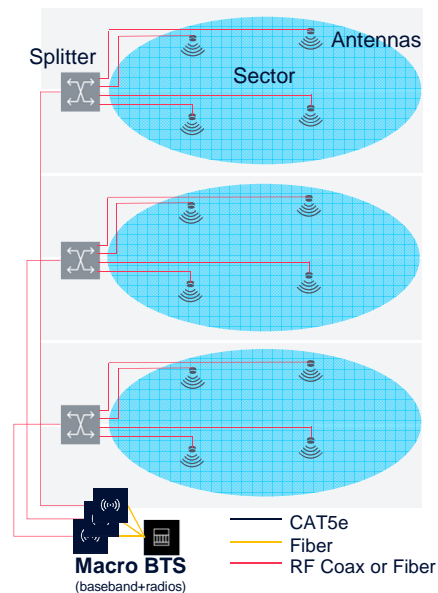
### Cabling



### Housing / cooling



+ 60 ton AC

### Equipment



Kilometres of "plumbing", tons of metal, millions of $ CAPEX, massive heat & OPEX…
…yet very little capacity & when you want to densify / add new RAT, you often have to start again
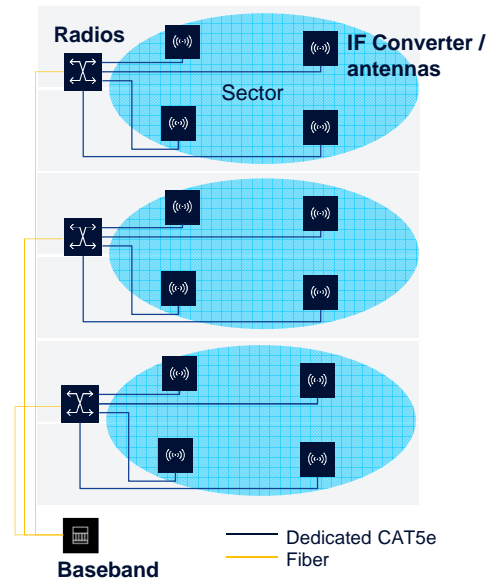
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# Indoor deployment approaches (excl. Femtocells)

Many solution types exist for the larger indoor spaces
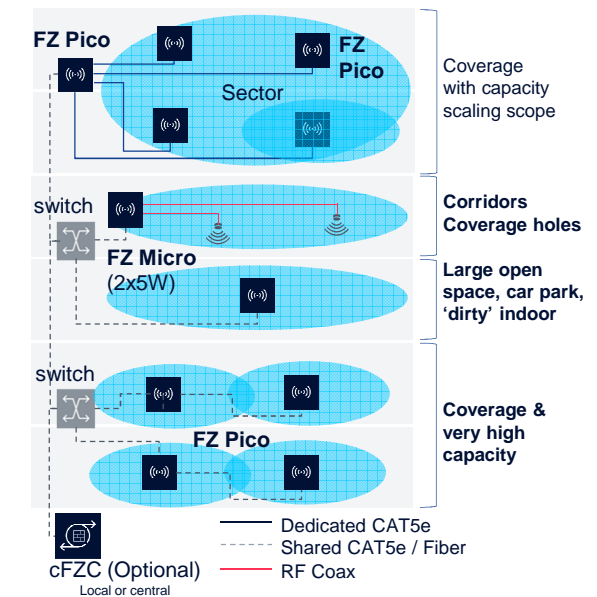


**Distributed Antenna Systems**
- Legacy solution
- Coverage focused
- Costly, Inflexible and slow to deploy
+ Neutral host (tech and MNO)

**Hybrid DAS**
- Architecture enhancement to DAS
+ Fiber/dedicated Ethernet cheaper to deploy
+ More flexibility/higher perf (dist MIMO)
- RAN sharing (not neutral host)

**Flexi Zone** (Macro Parity SC)
- Leverage Small Cell concept fully
+ Huge capacity, lowest cost & ease of install
+ Flexible deployment & cFZC allows scaling
- RAN sharing (not neutral host)

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# Toronto condo – Indoor solutions comparison

## 2x Multi-dwelling 60 floors residential buildings

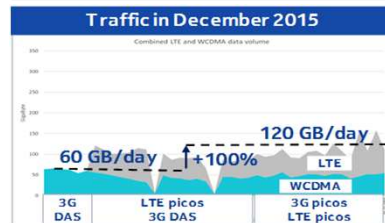| | Active DAS Solution | Hybrid DAS | Flexi Zone Indoor Pico (Integrated antenna) |
|---|---|---|---|
| # of eNB/NB/SC | 8 | | 910 |
| # of Antennas | 650 | | Integrated |
| LTE RSRP ≥ -90dBm | | | |
| HSPA RSCP ≥ -70dBm | | | |
| # RAT Sectors/ floor | 1 sector per 12 floors | | 5 sectors per 1 floor |
| **Total Capacity (Mbps)** | 338 | | 17,724 |
| **Worst case loaded subscriber perf. (Mbps)** | 0.13 | | 6.81 (+ Wi-Fi) |
| **CAPEX (normalized)** | 26 | Dedicated fiber/Ethernet to each floor RRH & dedicated Ethernet cable to each Antenna point | 22 (incl. Wi-Fi) |
| **IMPEX (normalized)** | 58 | | 25 |
| **TCO (normalized)** | **84** | 10-15% lower than DAS | **47** |

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# Use cases example

## Indoor Small Cells significantly improve services metro

### Chili, Costanera center - Largest shopping mall in LATAM



| Avg perf / sub | DL avg datarate | UL avg datarate |
|---|---|---|
| Legacy DAS | 730kbps | 430kbps |
| 3G Picos | 5.1 Mbps | 1.3 Mbps |
| 4G Picos | **46 Mbps** | 30 Mbps |

| FZ LTE Pico KPI | Xmas 2015 | Xmas 2016 |
|---|---|---|
| LTE Data Performance | 99,86 | 99,89 |
| Cell Avail. Excl. Blocked by User (%) | 100,00 | 100,00 |
| RRC Connection Setup Success Ratio (%) | 99,98 | 99,96 |
| RRC Success Ratio (%) | 99,76 | 99,78 |
| E RAB Setup Success Ratio (%) | 99,96 | 99,97 |
| E-RAB Normal Release Ratio User Perspective (%) | 99,71 | 99,76 |
| Total HO Success Ratio, X2 inter eNB (%) | 99,59 | 99,75 |

**Traffic in December 2015**
Combined LTE and WCDMA data volume
60 GB/day ↑+100% 120 GB/day
LTE
WCDMA
3G DAS | LTE picos 3G DAS | 3G picos LTE picos

**Traffic one year later (December 2016)**
Combined LTE and WCDMA data volume
180 GB/day ↑ 250 GB/day
LTE
WCDMA
3G picos LTE picos
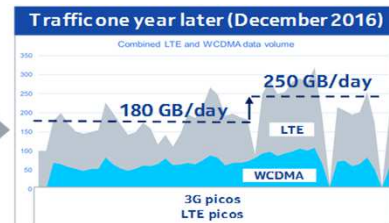
### China, Beijing Airport, Terminal 3 => Terminal 2
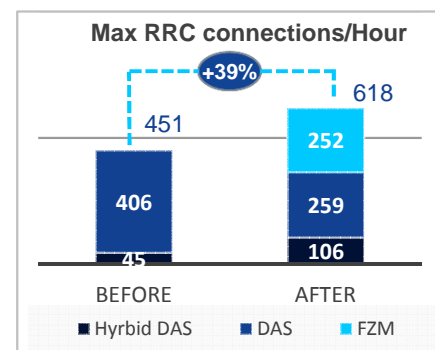


**Problem**
- Unable to capture all traffic despite multi-carrier DAS + Hybrid DAS
- Coverage (high ceiling areas) and capacity issue (everywhere)

**Objective**
- Test impact of small cell additions in most busy areas

**Benefits**
- Captured untapped demand lead to massive ARPU increase

**Avg Data Volume/Hour(MB)**
+61%
6.03GB → 9.65GB
BEFORE: 791 / 5237
AFTER: 1316 / 3950 / 4384
■ Hybrid DAS  ■ DAS  ■ FZM

**Max RRC connections/Hour**
+39%
451 → 618
BEFORE: 45 / 406
AFTER: 106 / 259 / 252
■ Hyrbid DAS  ■ DAS  ■ FZM

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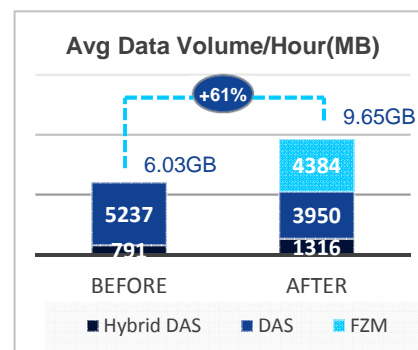
# LTE in unlicensed spectrum - MulteFire
## Kick starting indoor SC neutral host deployments & private LTE

### Unlicensed & shared licensed LTE technologies

**CBRS (US only)**
Innovative shared spectrum model opens up the "rarely used" 3.5 GHz spectrum to Communication Service Providers CSP and New commercial users.

**MulteFire (Global)**
LTE operating in unlicensed bands (e.g. Wi-Fi 5.x GHz) enables Private LTE networks operation in license free global spectrum

### Unlicensed LTE neutral host bring best of DAS in small cells

1 small cell system

Serving all CSP subs & private LTE users & guests

Anybody (CSP, CSO, ISP, Enterprise, Building owner) can deploy LTE small cells & lease services to others

- CSP get best of SC & DAS
  + ARPU by leasing out services to others
  + leverage other deployment to lower CAPEX yet cover more buildings

- New business models & private LTE will drive faster indoor deployments in more locations

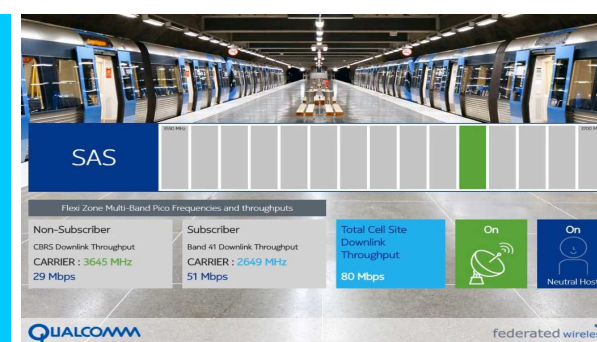### MulteFire & CBRS brings LTE benefits to unlicensed bands

|  | Wi-Fi | CBRS/MulteFire |
|---|---|---|
| Coverage | 1X | 2X+ |
| Multi-user capacity | 1X | 2X |
| Mobility/HO to 3GPP | Limited | Yes |
| Service reliability | + | +++ |

### Demonstration with NAM CSP

**Flexi Zone CBRS variants**

**Pure neutral host SC:**
2x CA CBRS bands

**CSP own freq band + neutral host SC:**
1x LTE + 1x CBRS



SAS

Flexi Zone Multi-Band Pico Frequencies and throughputs

Non-Subscriber
CBRS Downlink Throughput
CARRIER : 3645 MHz
29 Mbps

Subscriber
Band 41 Downlink Throughput
CARRIER : 2649 MHz
51 Mbps

Total Cell Site Downlink Throughput
80 Mbps

On

On
Neutral Host

QUALCOMM

federated wireless

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# Multi-access Edge Computing & Edge cloud applications
Bringing value beyond small cell coverage and capacity

## ETSI Mobile Edge Computing

Edge processing application platform:
- Low latency local processing (IoT)
- Contextually & geographically relevant applications
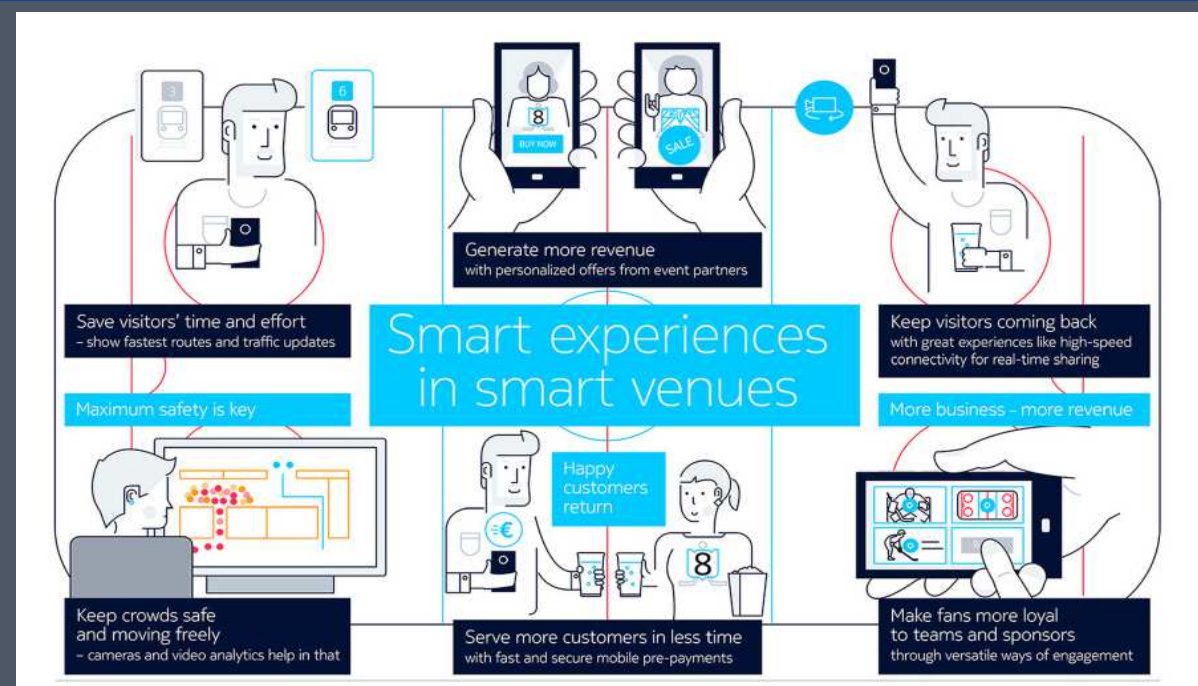- Maximum privacy with local break-out

## AppFactory

App store for access networks
- Ecosystem of app developers
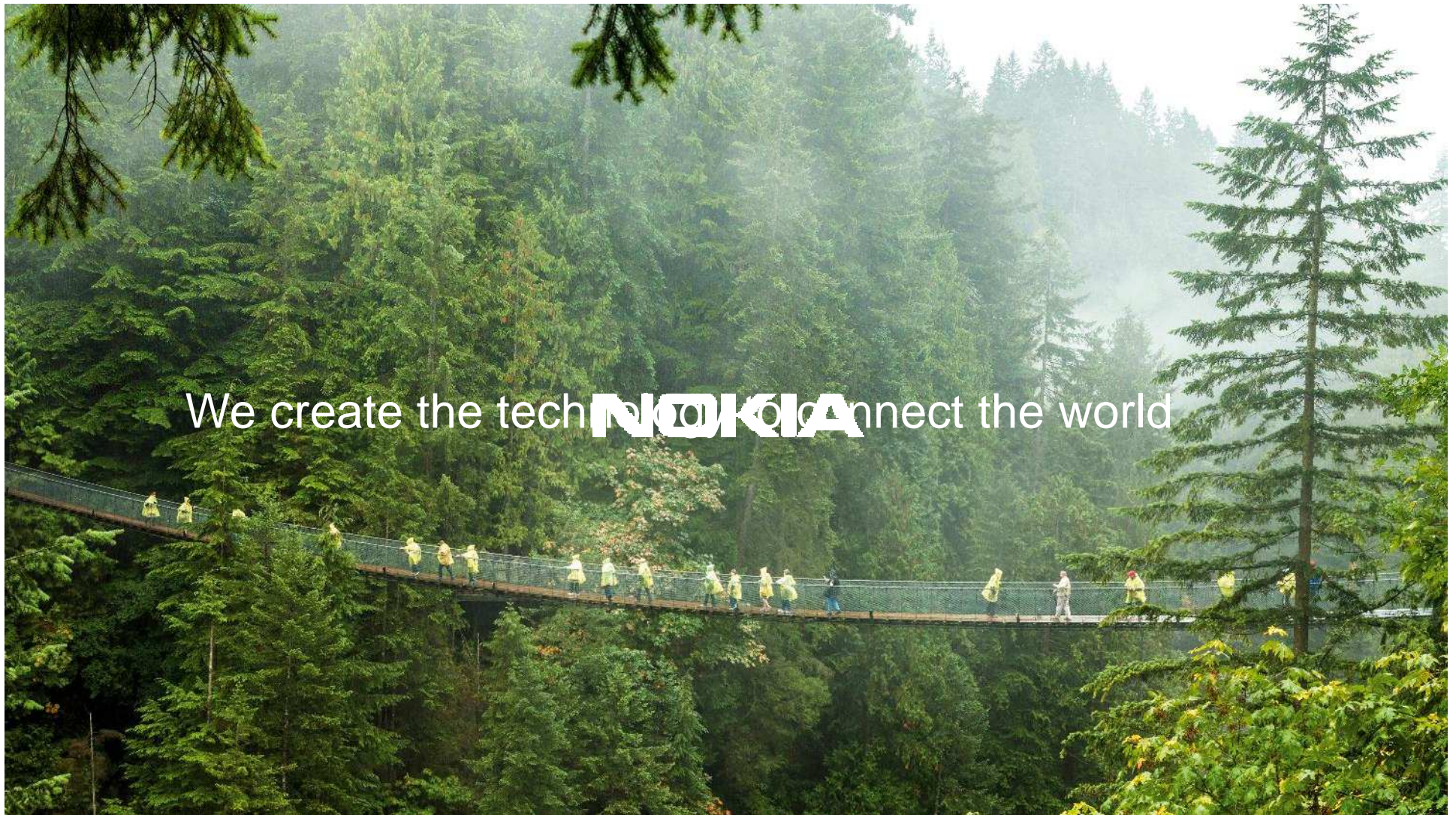- Strict app certification program

## Applications                    e.g. Smart Venues Private LTE & Wi-Fi



Generate more revenue
with personalized offers from event partners

Save visitors' time and effort
– show fastest routes and traffic updates

Keep visitors coming back
with great experiences like high-speed connectivity for real-time sharing

Smart experiences in smart venues

Maximum safety is key

More business – more revenue

Happy customers return

Keep crowds safe and moving freely
– cameras and video analytics help in that

Serve more customers in less time
with fast and secure mobile pre-payments

Make fans more loyal to teams and sponsors
through versatile ways of engagement

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