Indoor solutions – Technology options

The challenge of finding the right indoor solution in response to rapidly increasing data traffic

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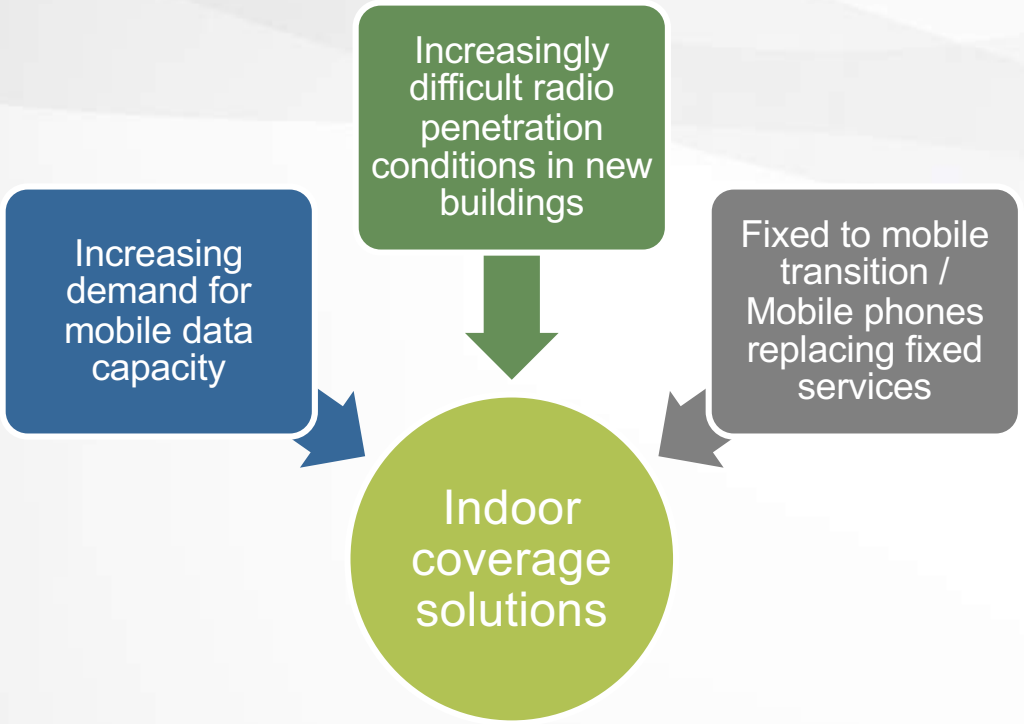
The key driving forces for indoor solutions

The need for improved indoor coverage is mainly driven by increased demand for mobile data capacity in combination with the general shift from use of fixed to mobile phones for basic voice services in increasingly difficult indoor radio coverage environments.

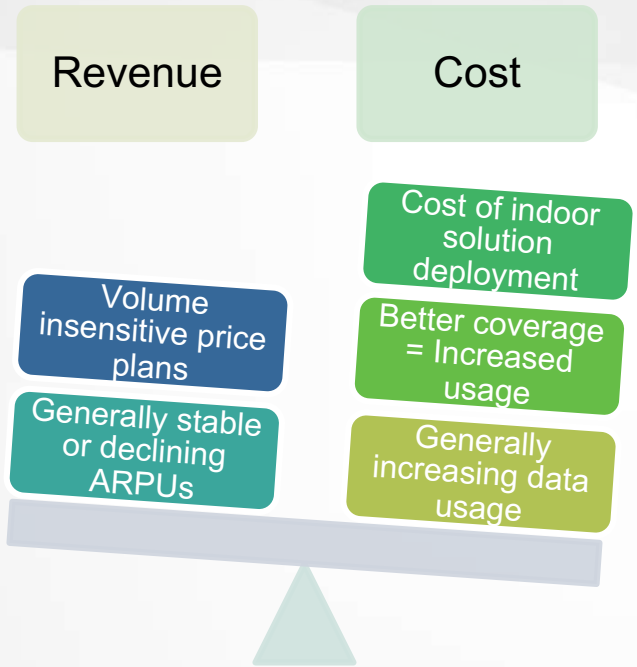


- Indoor network is the solution to meet demand for increased mobile data capacity
  - Indoor networks including compact remote active multi-band radio units may reduce the cost per bit of capacity delivered
  - A large proportion of mobile data demand will occur in various indoor locations (some studies indicate >70%)
- Indoor networks are needed for improved coverage when mobile phones increasingly replaces fixed phones
- Finally, poor radio penetration conditions in new energy efficient building structures add to the other issues

The operator's business case

Indoor coverage increasingly becomes a necessity because of generally difficult radio penetration conditions in new buildings, increasing data traffic, and use of higher frequency spectrum for more capacity,

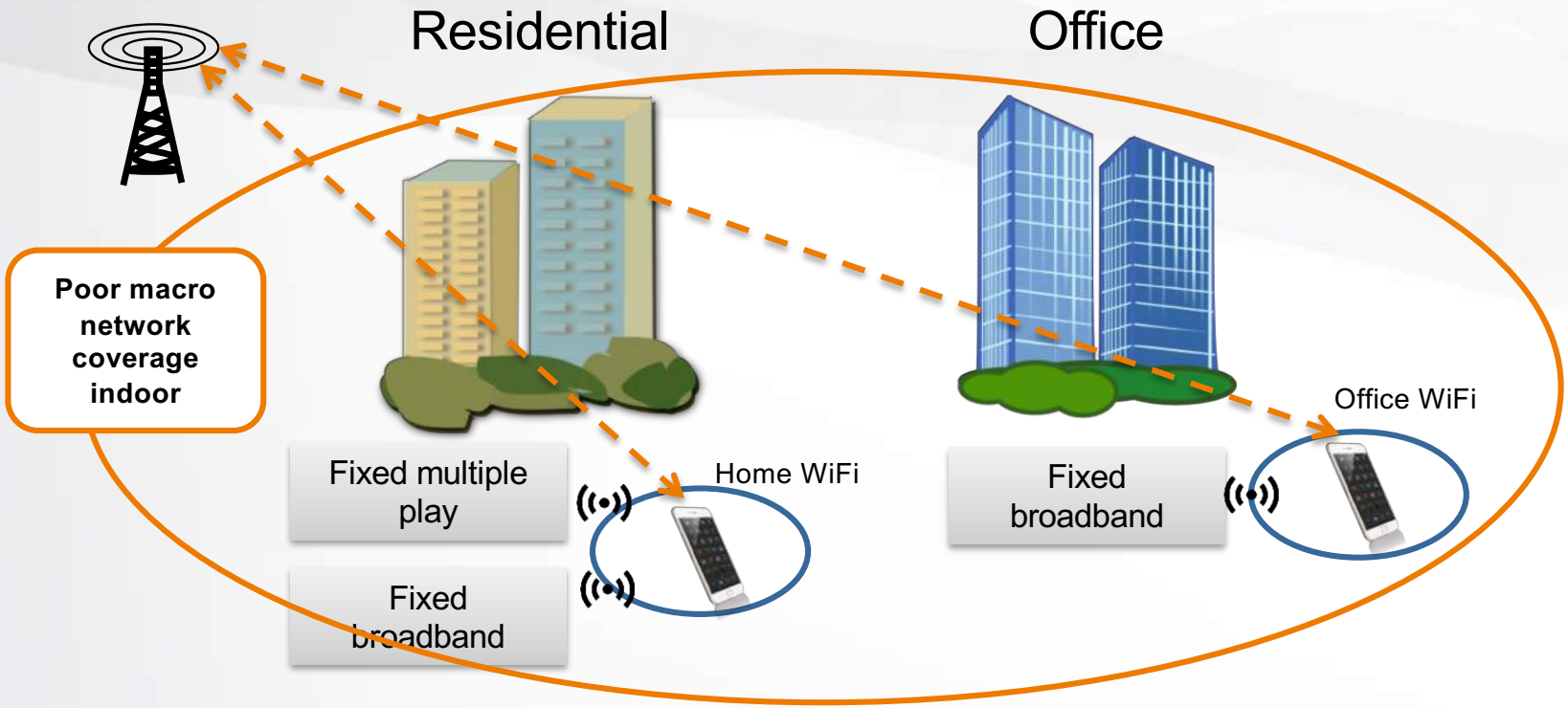
The indoor business case dilemma



- Operators need to provide indoor coverage in order to meet crucial customer demands
  - Difficult radio penetration conditions in new buildings
  - Increased dependency on mobile phones
  - Increased data traffic and use of smaller cells and higher frequency spectrum for more capacity
- Indoor coverage is mainly a cost issue, because:
  - Improved indoor coverage will result in more usage
  - Volume insensitive charges often means limited or no extra revenue from more usage
  - Mobile data usage is increasing faster than revenues

Home and office environments

Home and office environments are mostly well served by various fixed line services (fixed multiple play, fixed broadband), which in combination with home/office WiFi solutions meet most data communications requirements. The problem therefore, is often just voice coverage.



- Indoor coverage is often mainly a voice problem
- Problems can be addressed by targeting a specific group:
  - Residents in a particular building
  - Employees / office workers in a specific company and location

Commercial site environments

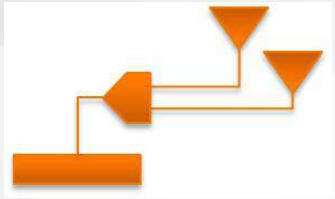
Commercial sites require indoor solutions for all types of services and subscribers. The main target is visiting ("passing by") users requiring ubiquitous mobile coverage (data and voice). WiFi services need to supports seamless (SIM based) connectivity.

- Improved indoor coverage needed for voice and data
- Solution need to target all kinds of users
  - Employees and visitors
  - All types of subscribers (of national and foreign operators)
  - All types of terminals
- High demands for mobile data in areas with high density of nomadic users (cafés, hotels, airports etc.)
- WiFi services increasingly need support seamless (SIM based) connectivity

Indoor coverage – the technology alternatives

Economic and technical feasibility of various indoor coverage technologies are changing as result of developments in technology, user behaviour (traffic patterns changing from voice to high speed data), spectrum availability and deployment scenarios.

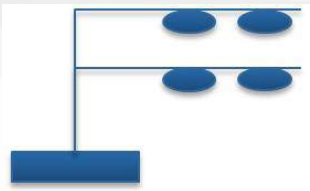
DAS



Pro's:
- Multiple operator sharing
- Outsourcing to e.g. building owner
- Improved capacity with next generation active DAS

Con's:
- Lower broadband performance & expensive capacity expansion with passive DAS

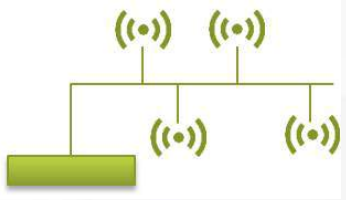
Small cells



Pro's:
- High capacity
- Versatile solutions, flexible and easy to expand

Con's:
- More complicated sharing options (shared RAN, roaming, etc.)
- Less cost efficient with low traffic intensity

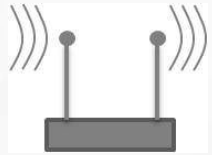
WiFi



Pro's:
- Low cost, use of existing infrastructure
- Access to additional (unlicensed) spectrum
- Voice over WiFi from any WiFi network

Con's:
- Requires latest generation of terminals
- Interference issues

Repeaters



Pro's:
- Low cost installations

Con's:
- Regulatory constraints
- Possible disturbances in mobile network
  - in particular in high density environments
- Various other technical issues

Active versus passive DAS

Active DAS resolves capacity limitations of passive DAS, thereby reducing the expansion costs for DAS.

Passive DAS

- Has antennas driven centrally by base stations through a network of coaxial cables connected by splitters
- Has too high noise levels for high data traffic throughput
- Allows mobile operators to share installation and operating costs

Active DAS

- Has remote DAS repeaters each driving a small number of antennas, providing low-noise amplification
- Has fiber-optic cables connect to the head-end units which interface to the base stations.
- Is similar to remote radio heads connected to a base station, but DAS repeaters can be connected to multiple base stations for several different operators, reducing the amount of equipment which needs to be installed in the coverage area.
- Allows mobile operators to share installation and operating costs.

Development of active DAS technology

Next generation active digital DAS technology resolves the limitations of analogue DAS technology.

First generation active analogue DAS

- Suffers from limited RF bandwidth which can be carried over a single fiber link
- Active analogue DAS performance interdependent between the connected operators
- Extensive tuning even required by minor modifications in the DAS
- Provides no generic separation of bands, technology and operators

Next generation active digital DAS

- Using digital transport over the fiber-optic cables
  - Digital fiber-optic modules providing abundant link capacity
  - Digital signals over fiber suffer no degradation from noise or linearity
  - Digital signal processing in the signal path allows for the signals to be filtered into separate data streams which can be routed to where needed
- Including compact high power multi-band remote radio units
  - Consuming much less power than current solutions and eliminating cooling fans
  - Reducing required footprint
- Including digital routers increasing system routing flexibility
- Smart auto-configuration features making installation and commissioning easier
- Providing generic separation of bands, technology and operators

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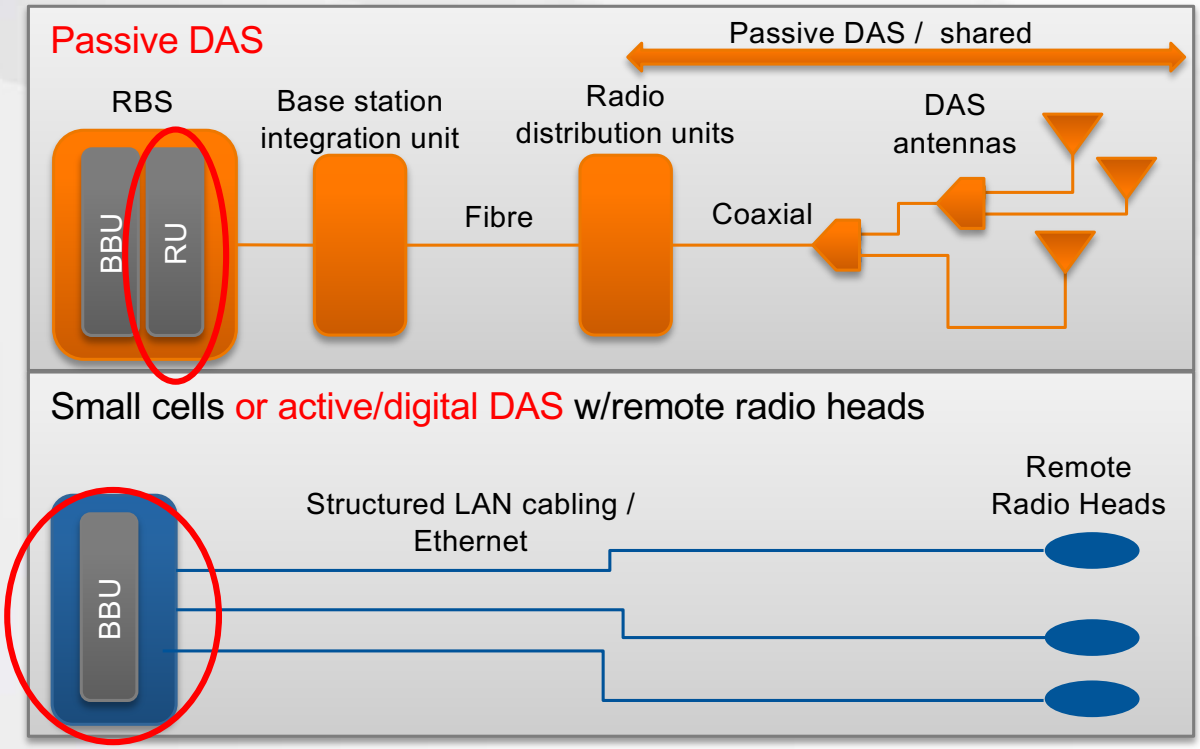
Analysing small cells vs. passive/active DAS

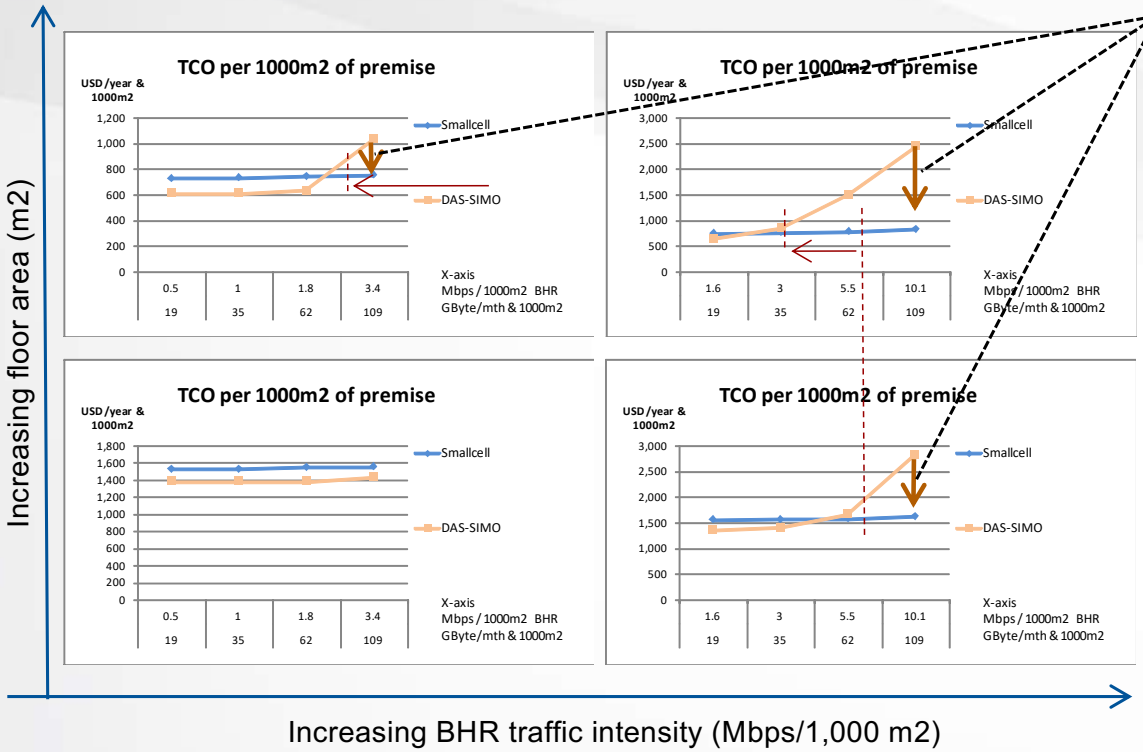
DAS has advantages over small cells with regard to sharing options, but latest small cell technologies with remote radio heads appear in many cases to have advantages over DAS with regard to flexibility and ability to absorb substantial traffic increase.



- Various factors may limit capacity of passive DAS, require additional sectors and antennas, and thereby drive costs:
  - Increasing number of bands in multi-operator shared passive DAS solutions will limit throughput capacity
  - Spectral efficiency and traffic capacity dropping with multi-operator shared passive DAS
- Small cell and active digital DAS solutions with remote radio heads, will typically:
  - Provide higher spectral efficiency with MIMO
  - Have no feeder losses, reduce number of sectors
- However, various factors, in particular traffic density over the area in question, will impact choice of preferred solution
- Scenarios for typical premises as Hotels, Shopping malls and Airports illustrate these aspects on the next following slides

Analysis: cost drivers for small cells vs. passive DAS (1)

As traffic intensity increases above the DAS capacity limit requiring additional antenna configurations, costs will increase rapidly compared to small cells. The example cases below compare small cells with multi-operator DAS solutions.



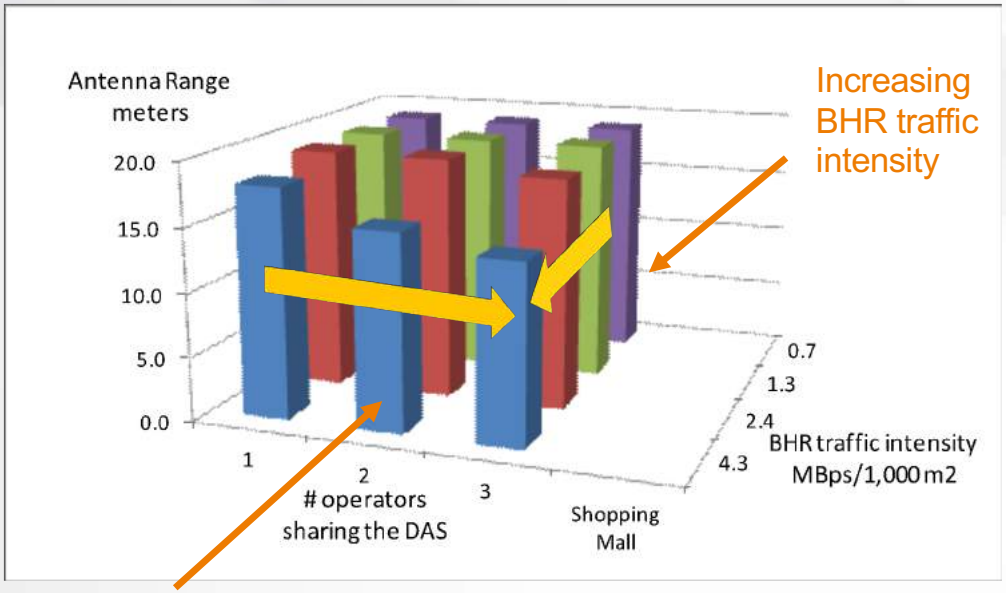
Active vs. passive DAS

- When passive DAS configurations reach their capacity limit: Additional antennas and more expensive feeder cabling will be required, driving up the cost compared to the small cell solution
- Increasing floor area will also drive up the costs of passive DAS: Shifting the break point between DAS and small cell (i.e. increasing cost of DAS will start at lower traffic per user)

Note for those charts:
- Small cell solution is MIMO
- Passive DAS solution is SIMO

Analysis: cost drivers for small cells vs. passive DAS (2)

Multi-operator passive DAS configuration in combination with high traffic intensity require reduced antenna range, resulting in increasing costs due to increased number of antennas, more feeder cable, etc.



A. *Multi-operator passive DAS configurations* with multiple bands:
   - *Require more combiner steps* that will increase attenuation of the uplink signal.
   - Generate *downlink signal intermodulation interference* distorting the uplink signal.

   Reducing the uplink path loss by shorter antenna range, i.e. *more antennas per site* will be required to *compensate for increased attenuation/distortion of the uplink signal.*

B. *A growing downlink traffic intensity* will gradually increase the need for a stronger uplink signal:
   - These negative *effects are insignificant at low traffic intensity*

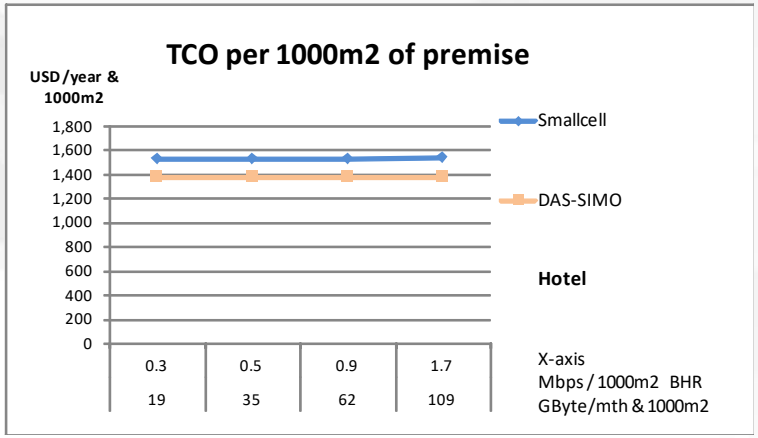
   With increasing traffic intensity, a need to *compensate with lower uplink path loss* by shorter antenna range, i.e. *more antennas per site* will be required.

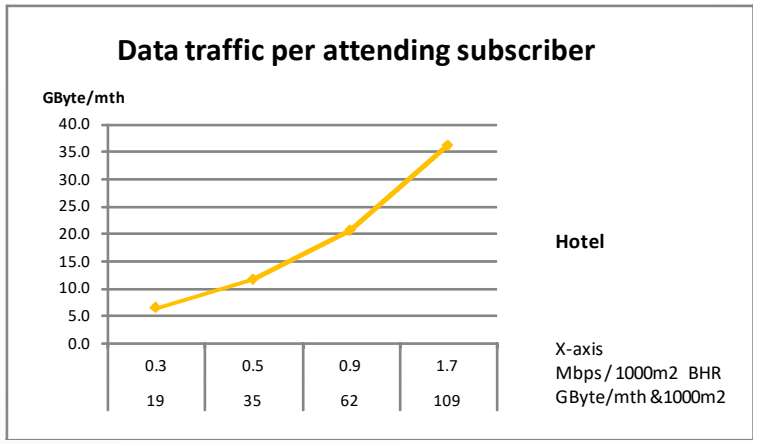
Case: Small cells / DAS – Hotel

Minor difference between the two alternatives because of low traffic density.

- Comparing Total cost of ownership (TCO)

- Passive DAS:
  - Low population & traffic density allows strong traffic increase per user without exceeding the capacity limits of DAS
- Small cells & Active digital DAS
  - Provide additional traffic capacity which remains unused in this case due to the lower traffic density assumptions





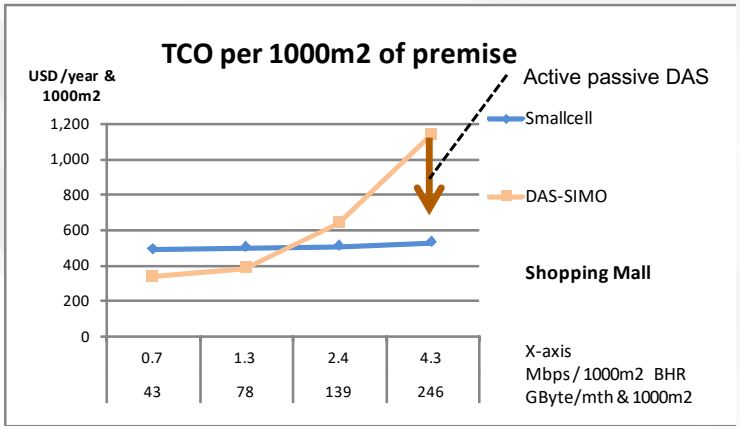
- Premise area 22,000 m2
- Floor levels 25
- Employees 75 ; Guest nights/months 9,500
- Open 30.4 days/months ; 24 hours/day
- Average population attending 180
- Peak population 550
- Operator ‘s own penetration 36% for both single operator small cell and multi-operator DAS cases

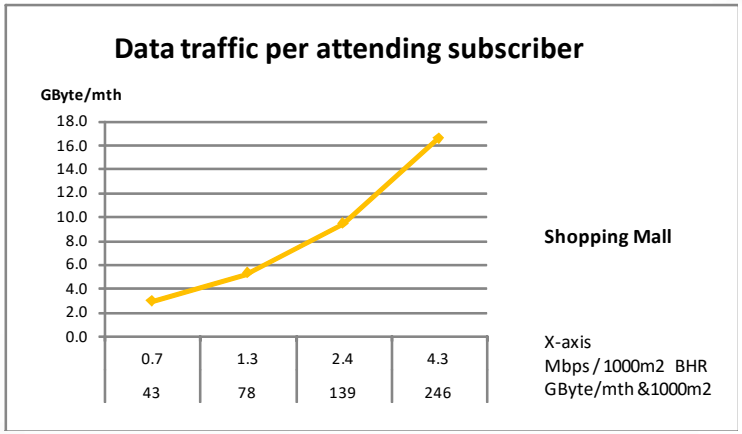
Case: Small cells / DAS – Shopping Mall

Lower DAS cost for low traffic, but rapidly increasing costs with DAS as traffic increases.

- Comparing Total cost of ownership (TCO)

- Passive DAS
  - Lower cost with DAS before exceeding DAS capacity limit
  - However, intermodulation interference in multi-operator DAS requires additional sectors to compensate for capacity loss as traffic per user increases
  - May also experience uplink signal losses in filter combiners
- Small cells & Active digital DAS
  - Provide higher spectral efficiency with MIMO
  - No feeder losses & less sectors
  - Independent selection of UMTS/LTE sectors





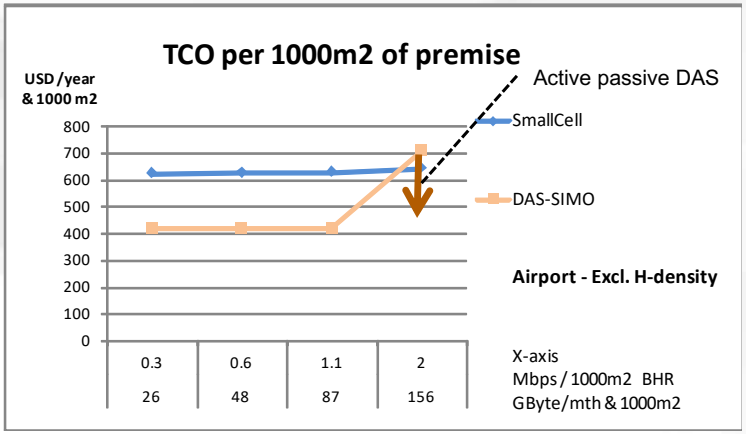
- Premise area 50,000 m2
- Floor levels 9
- Employees 1,000 , Visitors/mth 550,000
- Open 30.4 days/mth ; 12 hrs/day
- Average population attending 2,000
- Peak population 4,000
- Operator ‘s own penetration 36% for both single operator small cell and multi-operator DAS cases

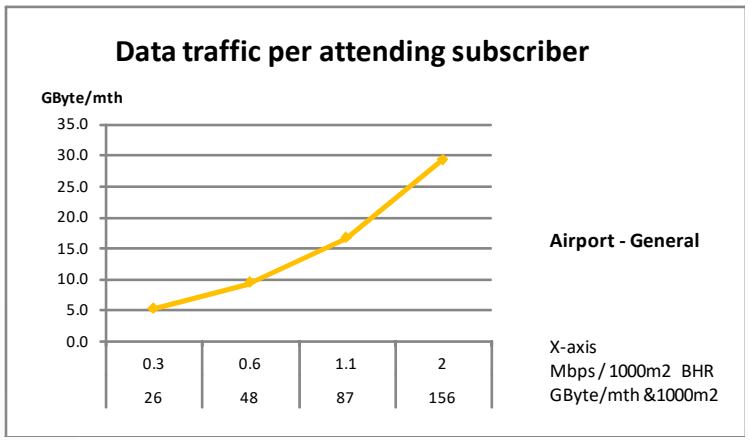
Case: Small cells / DAS – Airport (A) Average except high traffic areas (*)

Other airport areas, arriving areas etc. Low traffic intensity makes DAS the best option.

- Comparing Total cost of ownership (TCO)

- Passive DAS
  - Low population & traffic density allows strong traffic increase per user without exceeding the capacity limits of DAS
- Small cells & Active digital DAS
  - Provide additional traffic capacity which remains unused in this case due to the lower traffic density assumptions





- Premise area 130,000 m2
- Floor levels 1
- Employees 800 ; Visitors/mth 2,100,000
- Open 30.4 days/mth ; 24 hrs/day
- Average population attending 1,700
- Peak population 4,400
- Operator ‘s own penetration 36% for both single operator small cell and multi-operator DAS cases

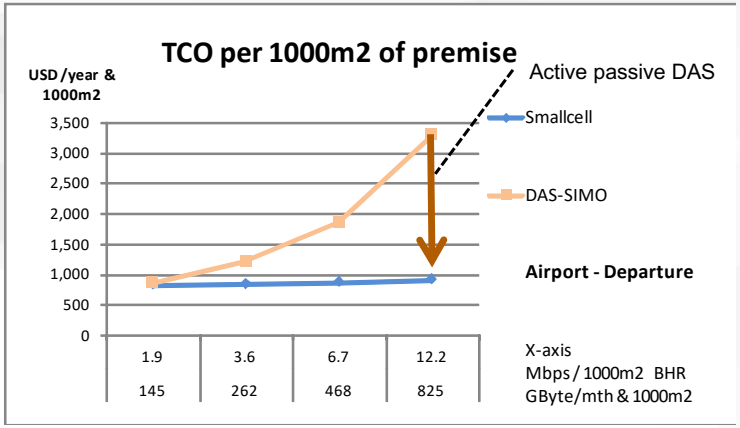
(*) Average all areas except high traffic zones.

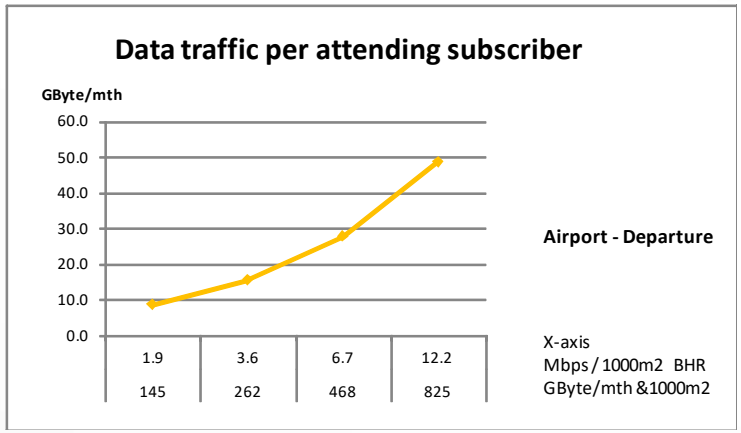
Case: Small cells / DAS – Airport (B) High traffic areas (*)

Airport departure/waiting areas. High traffic intensity makes small cells the best option.

- Comparing Total cost of ownership (TCO)

- Passive DAS
  - DAS & small cell cost similar for the lowest traffic assumptions,
  - However, intermodulation interference in multi-operator DAS require added sectors to compensate for capacity loss as traffic per user increases
  - May experience uplink signal losses in filter combiners
- Small cells & Active Digital DAS
  - Provide higher spectral efficiency with MIMO
  - No feeder losses & less sectors
  - Independent selection of UMTS/LTE sectors





- Premise area 20,000 m2
- Floor levels 1
- Employees 125 ; Visitors/mth 640,000
- Open 30.4 days/mth ; 24 hrs/day
- Average population attending 920
- Peak population 2,700
- Operator ‘s own penetration 36% for both single operator small cell and multi-operator DAS cases

(*) For example departure waiting areas.

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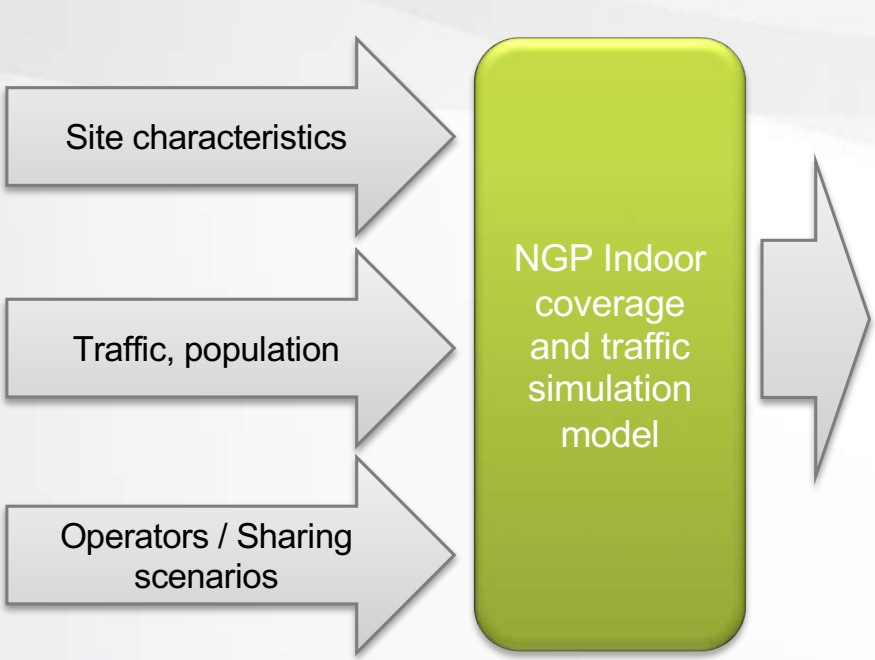
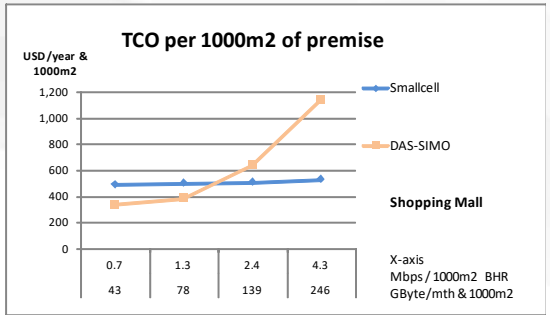
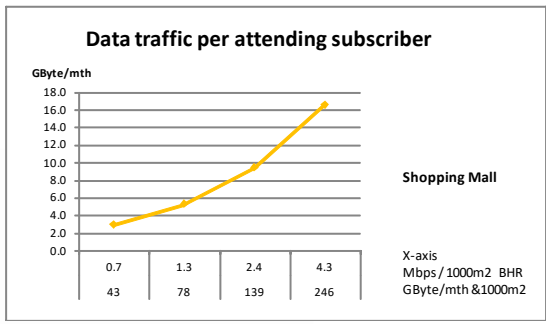
Established analysis model

NGP has developed for analysis of indoor deployment costs based on site characteristics, traffic scenarios and network sharing configurations between mobile operators.



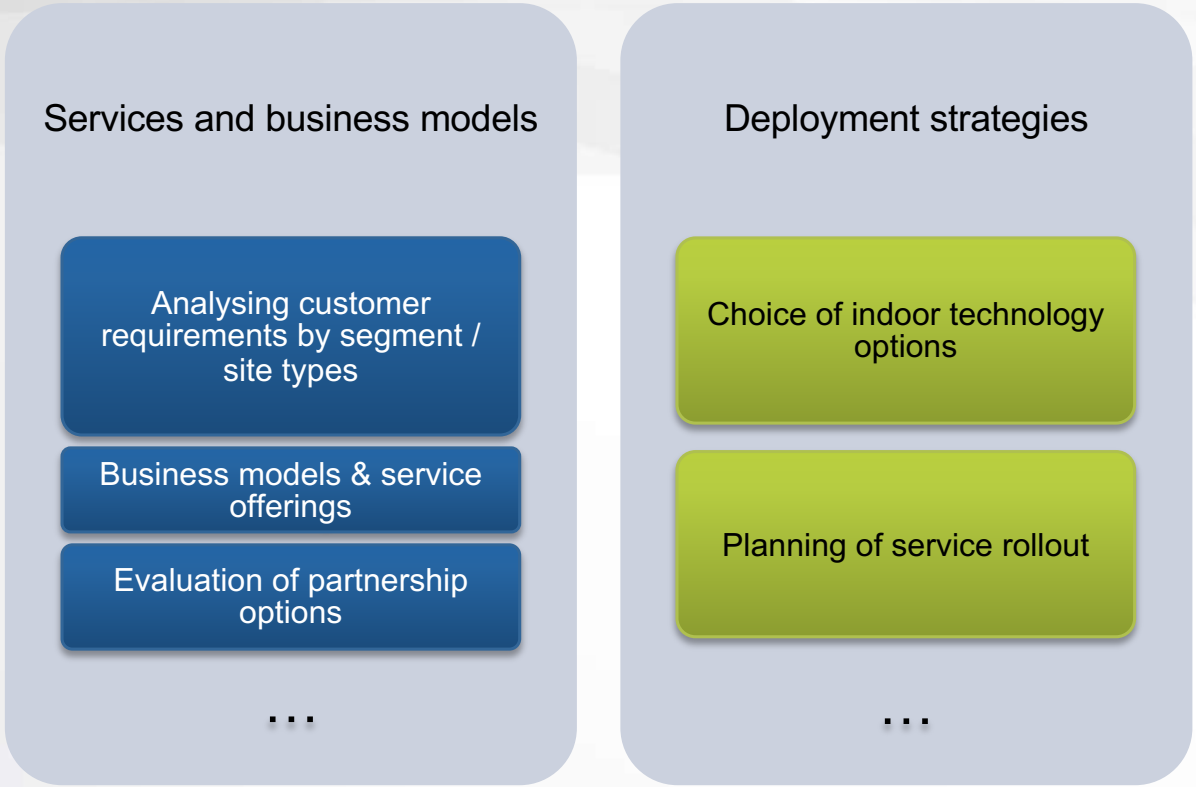




- The model can be used to analyse deployment cost (TCO, 'Total Cost of Ownership')) for various technology options for different site types
- The model has been developed particularly to analyse the effects of rapidly increasing data volumes

Some service offerings

Netcom Global Partners can provide a wide range of services related to the processes of planning, implementation and deployment of indoor solutions. Some examples …



- Feasibility studies addressing issues such as customer requirements, business models, partnerships, etc. which need to be addressed at early stage
- Deployment strategy considering
  - Total cost of ownership of various technologies (small cells, DAS) in perspective changing requirements, data focused usage, etc.
  - Use of other networks (e.g. WiFi networks) for new services such as VoWiFi, etc.

Services and business models

We can assist with Feasibility studies on various strategic issues which need to be addressed at an early stage in the planning process. For example:

Analysing customer requirements by segment / site types

- Customer requirements by site types:
  - Homes
  - Offices
  - Public places (hotels, shopping malls, railway stations, airports, etc.)
- Multi-operator indoor requirements vs. exclusive enterprise deals
- Service requirements, specific coverage issues:
  - Voice coverage
  - Data capacity
  - Requirements of “resident users” (e.g. office workers) versus nomadic/”passing by” users

Business models & service offerings

- Analysis of potential business models & application areas for use cases
- Partnership options:
  - Operators
  - Specialised indoor service providers
  - Landlords, etc.

Deployment strategy analysis

Based on our established simulation model, we can assist with analysis of various site requirements, resulting in specific deployment strategies for different site types based on site and traffic characteristics.

Choice of indoor technology options

- Total cost of ownership (TCO) analysis for various technology and implementation options, for example:
  - Evaluation of technology options (DAS, small cells…)
  - Site types (Office, shopping malls, hotels, airports, etc.)
  - Population characteristics, traffic intensity
- Cost analysis for alternative, service specific solutions (Voice over WiFi etc.)
  - Technical market conditions (e.g. state of WiFi networks in VoWiFi target segments)
  - Terminal requirements, availability, etc.

Planning of service rollout

- Planning deployment scenarios:
  - Site categories
  - Service requirements and traffic characteristics for different site types
  - Capacity issues
  - Tuning of technology parameters
  - Tuning of key cost items
  - Tuning of traffic data and projections
- The analysis form the basis for deployment plans optimised for various site categories
- Service monitoring / customer support

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Indoor solutions – Some of our work in the area

NGP has done considerable work recently related to indoor coverage solutions, including business models, partnership strategies, technical solutions, business case analyses, as well as on new tools for planning and monitoring of indoor solutions.

- Analysis of business drivers and customer requirements:
  - General coverage problems in new energy efficient buildings
  - How to meet growing demand for high capacity data
  - Problems with indoor voice coverage as mobile phones increasing replaces fixed phones
- Solutions for various site scenarios, typically with very different requirements, technically and commercially:
  - Residential (multi-apartment block)
  - Business/ Office costumers of various size and categories
  - Commercial hot spots (e.g. hotels, shopping malls, railway stations, airports, etc.)
- Partnership options:
  - For example building owners and independent specialist providers of indoor coverage ‘as a service’
- Business models and product concepts:
  - Models for cooperation with various partners
  - Service bundling (e.g. indoor coverage as part of multiple play services)
- Evaluation of various indoor technology options based on site characteristics and traffic patterns:
  - Small cells, active / passive DAS, etc.
  - Creation of TCO (‘total cost of ownership’) models for various technical solutions simulating TCO for different traffic assumptions and operator sharing arrangements
- Use of technical/commercial visualisation tools for:
  - Indoor services market and sales planning
  - Monitoring of service quality on various types of indoor/WiFi sites

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Our company

NGP is a global consultancy providing telecommunications sector clients expert advice and support on strategy, technology, operational and other issues, enabling clients to profitably compete and grow their businesses.

- The collective telecom expertise of our team of advisors, all specialists in their field, sets us apart as consulting partner to progressive telecom companies worldwide
- Our teams are engaged in projects worldwide, mostly in Scandinavia, Europe, Asia, Africa and Latin America.
- The global reach of our partnership creates the foundation for an international perspective and cross-cultural understanding of market and organisational issues
- As a strongly focused consultancy, with an in-depth understanding of our niche market, Netcom Global Partners is a responsive and flexible partner for the most demanding clients

Service overview

Based on our extensive experience in design, deployment and operation of telecommunications services, we help clients converting business ideas and technologies into successful products and services.

Market and business planning

- Providing effective market strategies and business plans

Network sharing, interconnection and regulatory related issues

- Providing expert advisory services in connection with network sharing opportunities, licence award processes, spectrum auctions, interconnection and access, and other regulatory issues.

Network planning, design and deployment

- Supporting procurement and deployment of networks, systems and infrastructure
- Network planning and design, review/audit and optimisation

Service development & product management

- Managing development and launch of innovative and profitable services

Organisation and operations

- Assisting telecommunications operators in improving operational performance and efficiency

Our expertise and capabilities

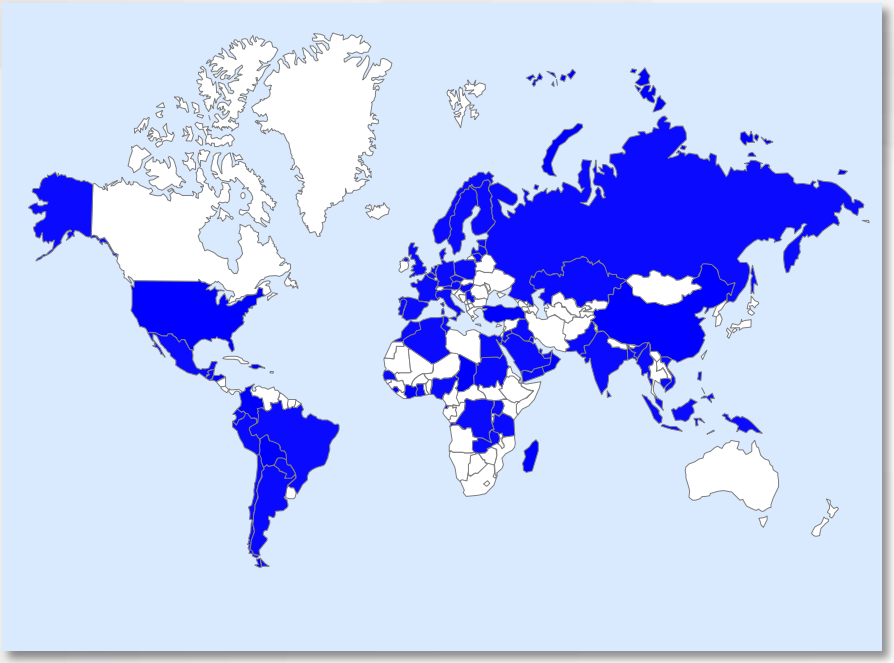
We provide advisory and management expertise in planning, design, deployment and operation of telecom networks and services.

Some project examples:

- Operational reviews and audits
- Market opportunity evaluations
- Network planning and design
- Managed Services feasibility reviews
- Indoor coverage solutions
- Network consolidation strategy definition
- Market entry consultancy services for mobile operators and service providers
- License acquisition support / spectrum valuation
- Interconnection, access and wholesale agreements
- Roaming and clearing audits - commercial and technical
- Regulatory, standardisation issues, network numbering
- Number portability implementations (mobile/fixed)
- Fibre rollout, fibre unbundling and fibre sharing and access
- M2M/IoT technologies, solutions and concepts
- Operational KPI benchmarking Service feasibility studies
- Customer Experience management
- Project portfolio and governance strategy
- Project Management Office (PMO) implementation
- Management of service launch and transition projects. Some recent examples: VoLTE, MVNO
- Network procurement RAN, Core
- Project management of mobile and fixed broadband network roll-out
- IMS Migration projects
- Power solutions, “Green Connectivity”
- Commercial and technical due diligence
- Tower, Network and Infrastructure Sharing agreements and implementation

Our global experience

Our partners, coming from leading telecom operators, vendors and consultancies, bring experience from work with clients in a wide range of countries and regions with different market and regulatory conditions.



Some clients our partners have worked for:

- Amara Communications
- Axiata
- Bell Canada
- Batelco
- CellularOne
- Canadian Imperial Bank of Commerce
- Digicel
- Du
- Emtel
- Ericsson
- FarEasTone
- Hi3G / 3
- 3GIS
- ICE / Net1
- Intelig, Brazil
- Meteor
- Mobifone
- Mobtel
- Nokia Networks
- Orange / Getesa
- Orange / Jordan
- Orange /Switzerland
- Umniah / Jordan
- Orascom Telecom (now Global Telecom Holding / Vimpelcom)
- Ooredoo Group
- OnePhone
- Sabafon
- SmarTone
- Smart Philippines
- Sumitomo Group
- Swedish Post and Telecom Authority
- TAL
- TDC
- Telefonica
- Tele2
- Telenor
- TeliaSonera
- Telkomsel
- Teracom
- T-Mobile / Germany
- T-Mobile /Poland
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- TIM Brazil
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