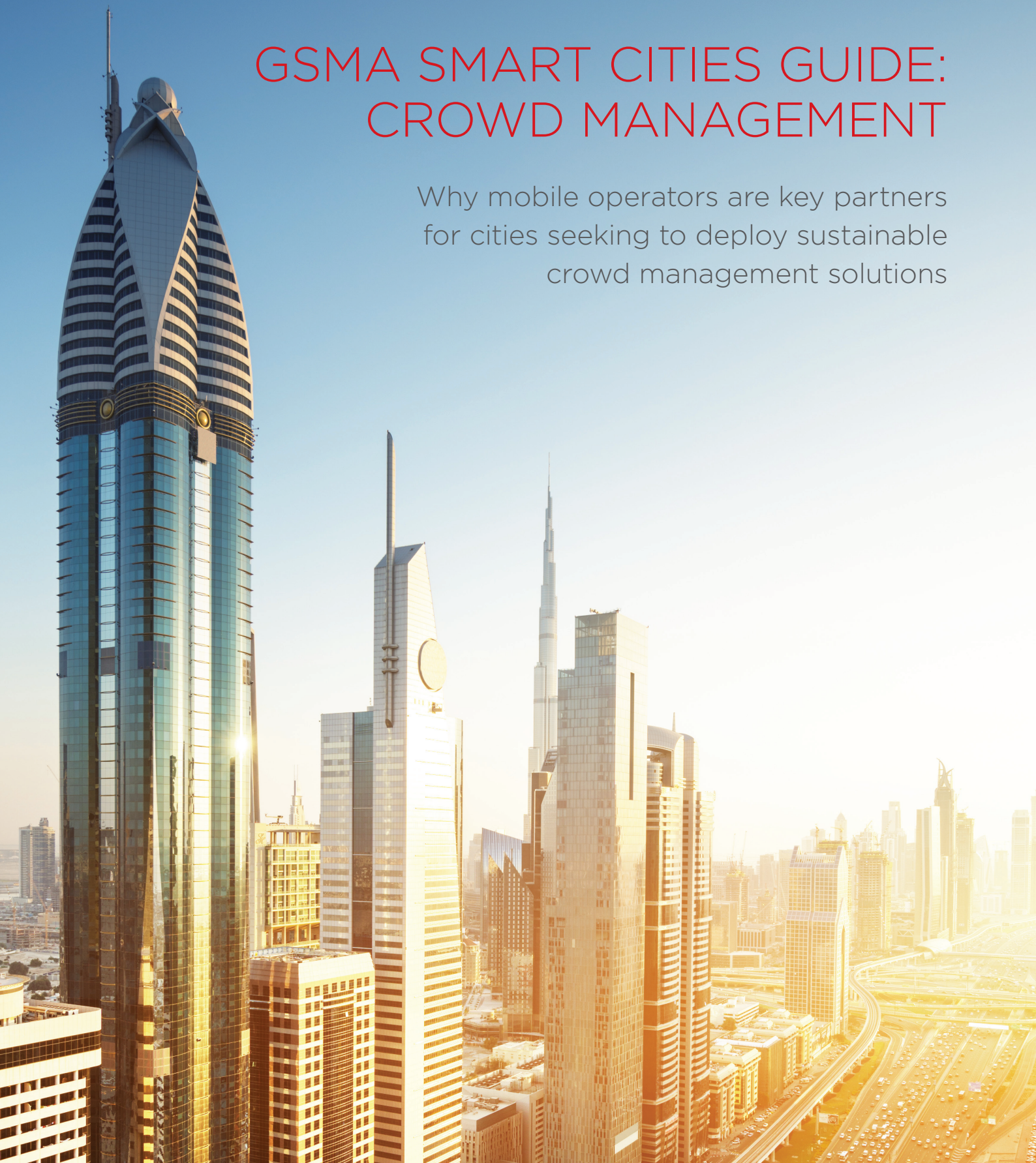
Connected Living

GSMA SMART CITIES GUIDE: CROWD MANAGEMENT

Why mobile operators are key partners for cities seeking to deploy sustainable crowd management solutions



INTRODUCTION

Crowd management is the ability to monitor and, where necessary, direct a group of people to ensure their safety. The same enabling technologies can also be used to help move people to their destination more efficiently and plan new services based on their behaviour. Crowd management isn't just restricted to people on foot. It can apply to people on public transport as well as people in cars. A full solution allows the city to see the movement of their citizens throughout the day, allowing better urban planning and resulting in improved satisfaction amongst city residents and visitors.

Crowd management technologies have moved on significantly over the past few years. Not so long ago, crowd management solutions relied on using video footage and facial recognition to count how many people were in certain areas. These expensive techniques have now largely been replaced by sensor technology.

Mobile operators are now particularly well placed to provide tools that can be used for crowd management. Tracking the location of mobile phones and analysing data collected by mobile-enabled Internet of Things (IoT) sensors provides an extremely accurate way to monitor and manage crowds of people across all sorts of gatherings – whether they be in city centres, or in remote rural locations.

USES FOR CROWD MANAGEMENT TECHNOLOGY

Crowd management solutions from mobile operators can be used for a wide variety of purposes. They can be used to monitor and analyse both crowds and transport – to identify how they move, how environments can be planned around them and the source of any issues or unusual behaviour. Mobile operators are well placed to offer these services using the information collected by their existing networks and by IoT sensors connected to mobile networks.

Operators can harness their existing coverage, their location-based services platforms and existing ways of collecting, storing and offering access to location data. By combining this network location data with their IoT management platforms, operators are able to offer a powerful and accurate crowd management service. Some of the different ways crowd management technologies can be applied are introduced below.

TRANSPORT

Improving transportation is a key use for crowd management technologies from mobile operators. Many transport hubs, such as airports and train stations, have issues with crowding. The capacity of transport infrastructure can also be optimised through crowd management techniques.

TRANSPORT CAPACITY OPTIMISATION

One of the most valuable applications of crowd management on public transport is capacity optimisation.

On metro networks, the train operator will already know where and when a passenger enters the network and then where they eventually exit the network. However, they generally have no idea how they travelled between those two points - which trains, lines and facilities they used. Crowd management technologies give the transport operator a very accurate view of how people move around the network, and they can tweak services appropriately to ensure smooth operation is maintained at all times. Once this information is available, guidance on the most efficient routes to take can be sent directly to people via apps on their smartphones, increasing passenger satisfaction.

Moreover, many cities' transport infrastructures are already operating at or near capacity at peak times and so it is important to ensure that capacity is utilised as efficiently as possible. IoT sensors, combined with crowd management tools from network operators, allow transport operators to see how many people are travelling not just on a train, but also in each carriage. IoT sensors can also be used to monitor how people are spread across platforms. The two data sets can then be tied together to allow the operator to encourage people to move along platforms to ensure that all carriages on trains are full. Simple tools like this can delay the need for costly spending on new infrastructure.

Crowd management solutions can help match transport to demand by optimising routes and capacity, and ensuring that maximum value is obtained from capital transport investments.

SINGAPORE CASE STUDY

With a long history of focusing on innovation, StarHub in Singapore is now working on new big data initiatives to support Singapore's Smart Nation ambitions. A key area of focus is mobility. Singapore is investing heavily in new public transport networks and wants to ensure that citizens travelling around Singapore are able to do so efficiently through new services, such as on-demand public transport and real-time journey planning.

StarHub has deployed a service called Grid 360 that allows the city to examine different data sets as new transport options come online and routing options become more complex. The data available includes aggregated and anonymous geo-location data to understand crowd densities, travel patterns and the group profile of the crowds travelling.

StarHub is offering these aggregated insights as an API service that both the government and public transport operators can use to understand how crowds move both through the transport network and the first mile and last mile – from their point of origin to eventual destination.

Grid 360 works by overlaying a grid of small hexagonal tiles over Singapore, allowing areas of interest to be highlighted. This grid is tied to a database of points of interest and transport networks.

The Grid 360 platform provides a function to overlay additional datasets for further analysis. For example, it could overlay locations where there are higher density of elderly travelling and check if there are sufficient facilities, such as lifts at overhead bridges or extended traffic light timings, for the elderly.

Through the combinations of different layers, the users could derive different insights into crowd movement through the city. For example, flow analysis of people from point to point allows the choice of transport mode to be analysed.

StarHub has also been working with public transport operator, SMRT, to analyse in depth all of the travel to and from areas of interest, such as the university campus. It explored how the flows of people can be improved to ensure people can efficiently get to and from the site, analysing the last mile of the journey in particular.

TRANSPORT HUBS

Crowd management issues at transport hubs are very similar to those found in other public buildings, except that the flow of people is dictated by transport departure times rather than other factors. Crowd management services can help an airport plan for when people are arriving at security queues and monitor the impact that wait time may have on passengers arriving at gates. Through intelligent placement of mobile-enabled IoT sensors, train stations can monitor how many people are queuing at ticket machines or waiting to get through barriers. At peak times of the year, such as Christmas or Chinese New Year, crowds can be corralled and managed in such a way as to optimise efficiency and prevent people descending en-masse onto already crowded platforms.

The same principle applies to bus networks, where mobile-enabled IoT sensors installed on individual bus stops allow the number of people waiting at each one to be counted. Bus services can then be re-routed, if needed, to ensure adequate capacity is available across the network.

TRAFFIC MANAGEMENT

Traffic Management Crowd management technologies can also be applied to traffic management. If you assume that people travelling at certain speeds and in certain groupings are travelling by car or bus, the information takes on a different dimension. In fact, the same data can be used for multiple services. There is no need need to track individual vehicles to understand traffic flow if that data is already available when analysed in an appropriate way.

The data can also be combined with other sources, such as the increasing volume of IoT connected cars on the road, or IoT sensors on the roadside. By tracking smartphones and vehicles together, an extremely comprehensive picture of people movement around a city can be established.

By applying appropriate analytics to the available data, mobile operators can provide city administrations with dashboards that highlight roads and incidents and understand how they are affecting traffic.

LOS ANGELES CASE STUDY

AT&T will improve your morning commute

Rush hour traffic in the USA is a real economic issue, resulting in lost hours and associated costs. In Los Angeles, congestion cost an estimated $160 billion in lost productivity. AT&T is helping develop smart cities to address this issue.

> *In Los Angeles, congestion cost an estimated $160 billion in lost productivity.*

AT&T Labs are specifically exploring how smart traffic design can help commuters spend less time on the road and more time doing the things they want. They have some of the world's top data science experts conducting research – in collaboration with University of California at Berkeley and the California Department of Transportation – that shows how aggregate and anonymous cellphone data can improve urban planning.

These efforts come at a particularly important time in California, where billions of dollars-worth of traffic sensors are reaching the end of their useful lives. The state needs a more innovative and more efficient way to monitor and estimate traffic.

Insight from aggregate and anonymous mobile phone data could be the answer. It could also save taxpayers' money and ease transportation woes, while at the same time ensuring consumer privacy. Through AT&T's research, they're exploring two ways to do this – the Connected Corridors Project and the SmartBay Project.

AT&T's Connected Corridors Project is being developed to understand how AT&T can use anonymous data to forecast traffic patterns in Los Angeles. The information could be used to create "play books" for traffic managers that chart traffic patterns and volume. If an accident occurs, managers can then adjust traffic lights in a way that eases traffic flow.

AT&T is getting similar insights with the SmartBay Project. The analysis can help plan for the best place to build ride share parking lots. It can also help predict local traffic during a temporary closing of the Oakland Bay Bridge. It can even help determine what happens to traffic when a new stadium is built in Santa Clara.

SPORTS AND ENTERTAINMENT

Sports and entertainment events are a key market for crowd management technologies. These events are planned in advance, attended by thousands of people, and crowd management issues arise regularly. The sector covers a broad range of events: music festivals; sports stadiums; cultural events; outdoor sporting events, such as marathons; museums; nightclubs; tourist attractions and so on. However, the technologies that can be used to provide crowd management services at these venues are broadly the same.

> *"Network data and IoT sensors to gauge crowd densities at different locations on site"*

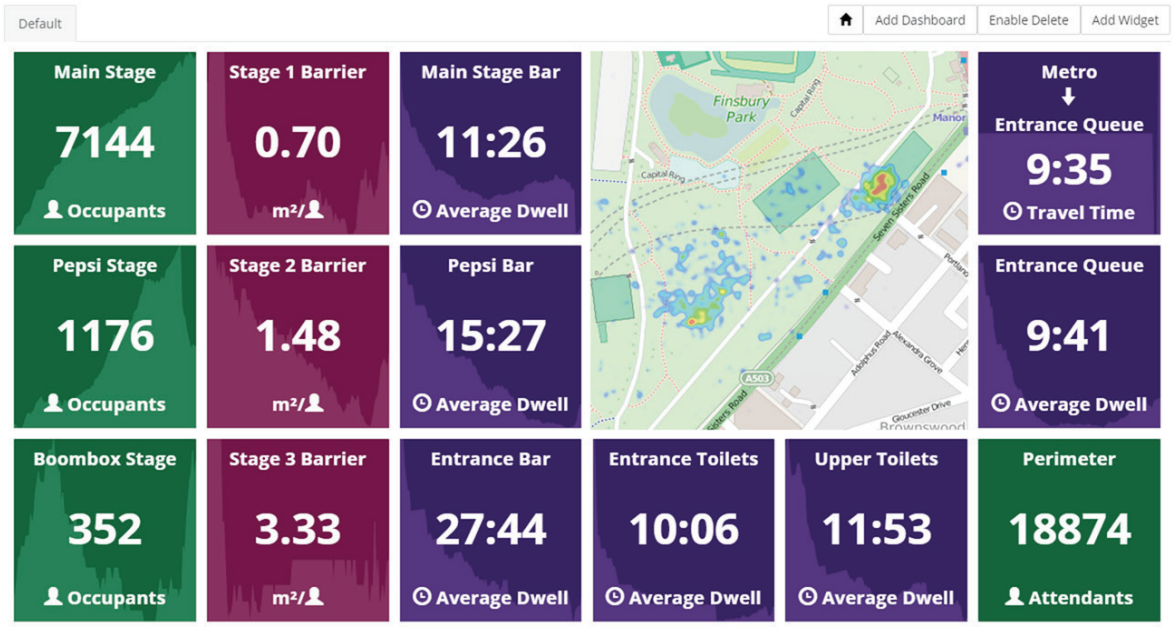
The managers of these types of events have similar concerns – how to safely manage the crowds of people attending, how to ensure that they arrive and depart by appropriate means, how to ensure customers have a satisfactory experience and return again, and how they can maximise the revenue opportunities from having a sizeable crowd in place. By utilising appropriate crowd management technologies, the event managers can put plans in place before an event to ensure the above criteria are met, and then effectively view and manage a crowd during an event to ensure its success.

A crowd management service for an event manager can provide them with a large amount of valuable information based on where people are located, how they are moving and how they are arriving at and dispersing from the site.

For example, a music festival organiser will be able to use a combination of crowd management technologies, including network data and IoT sensors to gauge crowd densities at different locations on site, how many people are visiting the concessions and food stands, how long the queue for the toilets is, how many people are approaching the site and by what means they are arriving, for example, by car public transport or on foot.

All of this data gives the event organiser real-time insight into the event so that they can maintain safety and ensure that people are moved around the site appropriately. This will enable them to plan the layout of their site to maximise the visits and revenue to concession and food booths, and then improve the festival goer's experience year-on-year.

Example of a dashboard for a music festival [1]



> *Mobile-enabled IoT sensors installed locally give a precise view and count of the entire crowd*

Likewise, sports stadium managers can use the same technologies to see how people flow through and around their venues, ensuring that enough staff are allocated to security gates and bars, and providing safety marshalling at appropriate times.

Ad-hoc events, such as local city celebrations involving large crowds, need a slightly different approach to that of some other events. If the city works with their local network operator, then crowd management services can be quickly switched on by the local operator for a specific period of time to cover a pre-set area at the city's request. Mobile-enabled IoT sensors installed locally give a precise view and count of the entire crowd, and a sample of each dataset can be taken to understand the movement of the whole crowd. By building a relationship with the network operator, the city can ensure that it has the flexibility to provide safe, well-managed events with only minimal notice.

[1] *Crowd Connected*

ANTWERP CASE STUDY

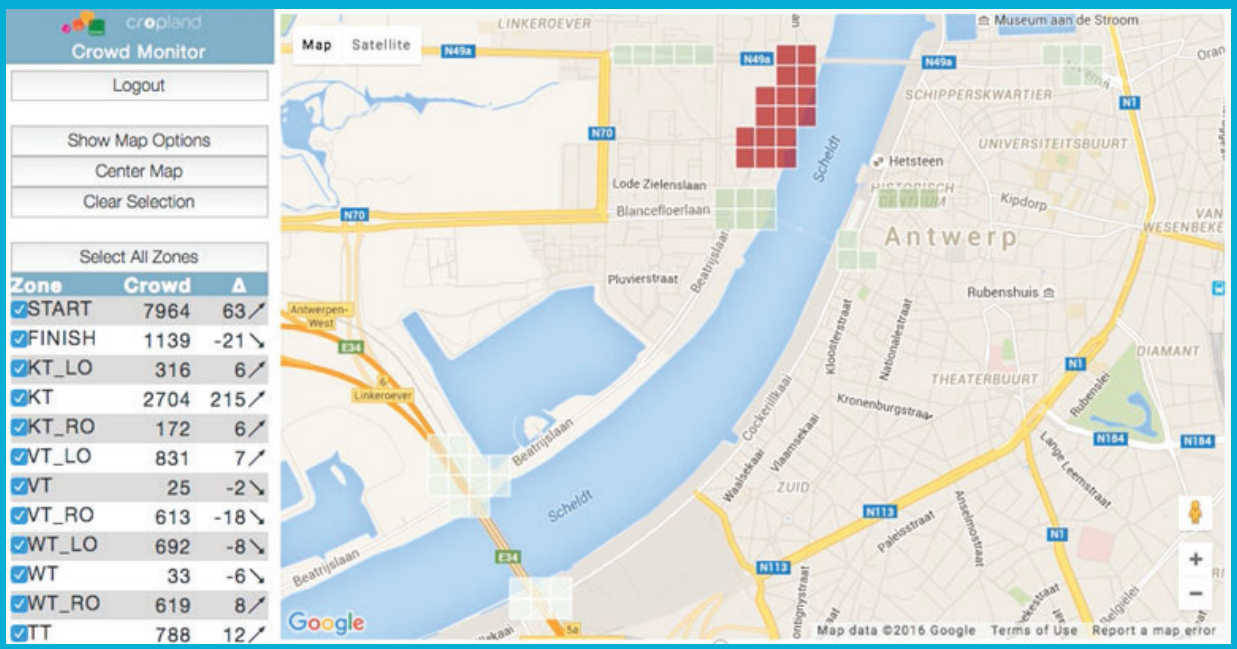
Orange Belgium has been collaborating with local service provider Cropland and the City of Antwerp to deploy a crowd management solution for local events, such as the hosting of the Tour de France and the Tall Ships Races event.

Orange Belgium is able to provide a real-time data stream of the location of all mobile phones connected to its network within a given area. This positioning data is derived from an analysis of the connection of phones to masts across 2G, 3G and 4G networks, as well as use of a timestamp to accurately position a device. Mobile phones in the area are all given a unique, anonymous ID.

This data is displayed via a crowd monitoring tool developed by Orange Belgium and Cropland for the City of Antwerp to use for security, mobility and city marketing purposes.

This dashboard shows the density of people within small squares across the given area, and allows the city to monitor the crowd in real-time. It can also be used to forecast the number of people that will be entering certain areas as people arrive at the event and move around the venue.

> *"Orange Belgium is able to provide a real-time data stream of the location of all mobile phones connected to its network within a given area"*



RETAIL

Crowd management tools can be applied in retail environments, where accurate positioning data is needed for both planning and effective merchandising. Retailers and managers of city retail zones can use this accurate data to improve both the visitor experience and increase the monetisation opportunities for the store and city. Supermarkets have long looked at people's shopping habits and used proprietary means to track customers around their stores, but retailers are now able to use mobile network-based solutions to understand crowds in city centres. These technologies show how people move around, not just within stores, but also between stores. Moreover, retail managers are able to see where their customers have come from.

Crowd management technologies, such as IoT sensors from mobile operators, enable retailers to understand how many customers are in their store and how they move around it. IoT sensors can yield new insights including understanding how many people walk past the store without visiting, and how different promotions persuade people to come into the store. If customers opt-in, they can also analyse when individual customers last visited. This information can be tied to sales data to understand if the retailer's products are competitively priced and displayed correctly. City centre and shopping mall managers can also use an analysis of network data to show people arriving and leaving, how long they stay and which zones they visit.

PILGRIMAGES

Religious pilgrimages tend to be the largest movements of people on earth. Thousands and thousands of people can descend on a single location, straining authorities and systems to the limit. Tragically, people have been fatally crushed due to the sheer numbers of people crowding together at past events. New crowd management technologies available through mobile networks offer a way of monitoring these mega-crowds, enabling contingency measures to be applied if needed.

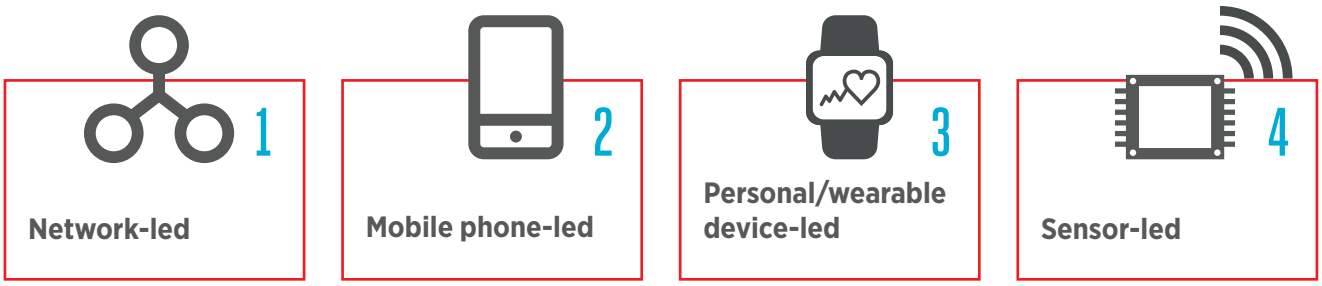
The same technologies and techniques as in other sectors can be used, but the scale is much larger, and the need to be able to communicate with, and guide pilgrims much more important. As such, a considerable amount of planning with the involvement of the relevant mobile operators is required in advance of an anticipated pilgrimage. The authority responsible for managing a pilgrimage will likely merge all available data from all of the local mobile operators to obtain a comprehensive view of activity.

As the dates for many pilgrimages are fixed, it is possible to monitor people arriving at holy sites from a long distance away. This means that the managers of the pilgrimage sites may be able to get a good view of the people arriving in the vicinity some days in advance of the actual event. They are able to prepare for the expected numbers and guide people to travel via certain routes and use certain entrances, ensuring crowd safety at all times from formation to dispersal at the end of the event. IoT sensors can play a critical role in maintaining safety. They can monitor people arriving at the site through specific gates, and can reliably inform the management team of accurate crowd densities in real-time. The more IoT sensors that are deployed, the more granular this data can become, allowing dynamic management of the crowd.

Before a pilgrimage begins, historic data can be reviewed and used to plan for new entrances and pathways or clearing certain areas of facilities to ensure crowds can be safely held there. As each event is different, the use of real-time data is also very important, as it allows monitoring and management of any issues happening on site in real-time. Predictive analytics can also have a role, as crowd volumes can be extrapolated into issues at points further down the line, so if a certain volume of pilgrims gather at one place, it is likely they will then move onto another. This can be predicted so that preventative measures can be taken well before an actual issue occurs.

HOW MOBILE OPERATORS SOURCE CROWD MANAGEMENT DATA

Crowd management solutions can be broadly split into four different categories:



Hybrid services that cross these categories are, of course, possible and can offer distinctive benefits, including the ability to obtain the most relevant data for specific scenarios and locations.

NETWORK-LED

Network-led crowd management techniques require no additional infrastructure or buy-in as they employ existing 2G, 3G and 4G mobile networks.

Mobile alliances such as the OMA (Open Mobile Alliance), have standardised several location services to support network-based crowd management. Therefore, all mobile network operators should be able to offer a location-enabled platform for location-based services. These platforms offer several extensions to standard mobile networks to allow for the accurate positioning of a mobile handset or other device directly connected to the network. This data is then made available through consistent APIs.

Mobile networks are able to instantly give the approximate position of a group of handsets through triangulation[2], and thus can be used by a service provider to quickly setup a crowd monitoring service. The network can be partitioned into very granular grids, and the number of people within each grid square counted. Movement of people from grid square to grid square enables a picture of crowd movement to be created.

Network data is a great asset to smart cities wanting to influence or understand crowd behaviour. As mobile networks do not rely on any third party services to provide location data, they are a good source of historical data of crowd movement. Historical data, which is stored by the network for a defined period of time, can be used by cities and their commercial partners to assist with urban and venue planning and to monitor crowd behaviour over time. Using this data to set a baseline for crowd

[2] A device's location can be determined by measuring the strength of the signal received by the three nearest base stations.

volumes at certain locations can help to detect unusual behaviour. For example, people ebb and flow through streets and metro stations in increased volume at certain times of day, known as rush hours. Changes in volume can be compared against the base volumes and, if necessary, alert area managers to possible issues. Likewise, if crowd volumes are reduced due to a road closure or another reason, the city can quickly understand how to route those people effectively without causing overcrowding on the diversion route. All of this data is available directly from local mobile operators.

Third parties can partner with multiple mobile operators to bring together multiple data-sets, so that a fully comprehensive view of all people in an area can be realised, as opposed to that portion of the population represented by only one operator. Gaps in data availability can be filled by either use of local IoT sensors or through predictive analysis.

As mobile operators have extensive coverage over urban and rural areas, no additional infrastructure is required to build a crowd management service for a high-level view over a large footprint. Mobile operators also store geo-location data for a considerable period of time, so that data can be used after an event to provide detailed analysis. Using mobile operator data for crowd management means that the service can be switched on for a specific area at very short notice. Mobile operators are also able to connect other assets in the city, so the location of vehicles and status of city infrastructure can be overlaid on top of crowd data.

MOBILE PHONE-LED

Accurate positioning data of certain sub-sets of people can be obtained by engaging people directly through their smartphones, using the handset as a positioning device. This can be useful for certain events or venues where a defined group of people (for example, ticket holders) have opted-in to provide very detailed data to the event organisers. The opt-in is typically via terms and conditions on an app download, or could be a condition of an e-ticket. The app then relays accurate positioning information taken from the device's GPS sensor or local beacons, via the app provider, to the event organiser.

Although only those people who have opted-in can be measured, very accurate data can be obtained. Moreover, direct communications can be used to encourage people to move around a venue by, for example, promoting other areas or special retail offers.

Large event and venue managers, such as a music festival or sports stadium, typically use this type of crowd management service. As well as tracking fans within the stadium's perimeter, a football club's app, for example, could enable tracking further afield, so that the stadium can tell when fans are arriving at the car park or by public transport, so that they can be efficiently managed through security and to their seats. If an individual hasn't installed the relevant app, their mobile operator could still track their device within the venue (defined by a set geofence) via network location data, for example. That would enable a very comprehensive picture of crowd movement and activities to be built in real-time. By combining two or more datasets, anomalies can be reduced, and insight on crowd behaviour can be more quickly established.

Mobile operators are able to advise and assist with the development needed to utilise the GPS functions on smartphones. GPS positioning is extremely accurate, widely available in smartphones and provides a precise location of the device. However, obtaining this data from smartphones is difficult unless there is a specific application installed to harvest the data. Even then, GPS only works in outdoor environments, and cannot provide positioning data for people indoors. As GPS data will typically only be available for a small proportion of the people in a crowd, mobile operators are best placed to combine this data source with others to provide a comprehensive view.

PERSONAL / WEARABLE DEVICES

Another method of crowd management is to employ bespoke wearable devices. The venue owner is able to track crowd behaviour and provide incentives for certain behaviours, such as discounts at venue shops and restaurants, by providing each visitor with a bespoke device.

A good example of this is Disney World, which offers its visitors a 'Magic Band' containing a transmitter, which allows the park to track the visitor, while enabling the visitor to pre-book certain attractions or get priority access to them. The band also acts as a ticket for entrance to the park.

These types of device can provide a very accurate service, tailored to precisely meet the needs of the venue or event. They can be linked to credit cards for payments and programmed to only give access to certain areas. But they are expensive to design, manufacture and supply to visitors. Companies, such as Sendrato and AGT International, supply wearable device solutions specifically for large crowd events, such as music festivals, where each visitor has a dedicated wristband that contains RFID technology. The wristband can then be tracked, used for access control and for remote payments in some scenarios. A mobile operator can enable these services by working with the solution provider to connect the relevant RFID readers positioned around a site to the IoT.

This ensures that complete coverage is available to the event organiser, allowing fast access to real-time information on site conditions. The operator can also use this network to broadcast instructions to the wristbands. For example, the LEDs embedded in the wristbands could be enabled at certain points of a show to enhance the visitor experience.

SENSOR-LED

Mobile-enabled IoT sensors, such as video cameras and Bluetooth beacons, are an important tool in crowd management, particularly in small, contained areas. By using these sensors, people can be counted and tracked without the need for larger data sets. The advantage of using mobile-enabled sensors is that they can be placed at the most appropriate point, for example, in a doorway, where it would be difficult to place sensors relying on fixed network connections. The use of mobile connectivity also allows a high density of sensors to be deployed, resulting in more accurate crowd behaviour data. Types of IoT sensor include Bluetooth beacons, cameras and general traffic counters.

Although they have a short range, Bluetooth beacons are a common way of tracking people for crowd management purposes, especially indoors. When they are linked to the mobile operator's platforms, they can be managed and accessed remotely. Mobile-enabled beacons can be placed anywhere there is mobile coverage, enabling the service provider to install enough beacons to cover the appropriate area. Note, beacons work by detecting devices within their range, providing an approximate location, rather than a precise location that may be required for refined crowd management purposes. When combined with a mobile operator's location data, beacons can provide a good way to get detailed information on crowd movement. Mobile operators can provide the central management portals and analytics necessary to aggregate and understand the data.

> *"Mobile operators can provide the central management portals and analytics necessary to aggregate and understand the data."*

Mobile-enabled IoT cameras can be used to understand the numbers of people and vehicles in an area, when connected to an appropriate analysis platform. If positioned correctly, IoT cameras can be an effective tool for counting people. By using mobile networks to connect the cameras, the most effective positioning can be achieved, both indoors and outdoors. However, cameras are only able to see people in their field of vision, and so may need to be combined with other IoT sensors and sources of data to build up a comprehensive picture of crowd movement.

Other mobile-enabled IoT sensors can be used to measure the size and movement of crowds. Connected counters are an effective, low cost way of measuring the size of a crowd by simply counting the number of people and vehicles passing a location. These sensors could take the form of simple cameras, infrared counters or sensors embedded in the pavement or road. They are suited to long-term deployments designed to build up a picture of people flows over time. The use of embedded SIM cards or LPWA networks makes it simple and cost-effective to connect these sensors to a mobile operator's management platform.

BARCELONA CASE STUDY

Mobile World Capital Barcelona, a public-private partnership, has been working with the city of Barcelona and local network operator Orange to monitor the number of visitors to the Sagrada Familia in Barcelona. This is one of the main tourist sites in Barcelona and is on the itinerary of most tourists visiting the city.

> *"a series of mobile-enabled sensors around the site to track the number of visitors in total and the direction from which they approach the site"*

Although many people visit the site, only a small proportion actually pay to enter the Sagrada Familia, with many more only visiting the piazza outside. The city of Barcelona wants to track more precisely the number of visitors to the immediate area, so that it can plan transport networks accordingly, and encourage more visitors to actually pay to enter the cathedral.

Mobile World Capital has worked with the city to set up a series of mobile-enabled sensors around the site to track the number of visitors in total and the direction from which they approach the site. By deploying IoT-enabled sensors, Mobile World Capital have been able to provide the city with detailed information on the number of visitors to the piazza throughout the day and their arrival route, enabling transport modes to be analysed and the city to set up ticket booths at appropriate locations to encourage the sale of additional tickets to visitors outside the Sagrada Familia.

This local information has been combined with data from mobile operator Orange in an IoT Big Data framework to understand how these visitors move around the city as a whole, where they stay and the sites that they visit. The City of Barcelona can use these insights to plan appropriate measures to accommodate and transport the visitors.

PUTTING A CROWD MANAGEMENT SERVICE INTO ACTION

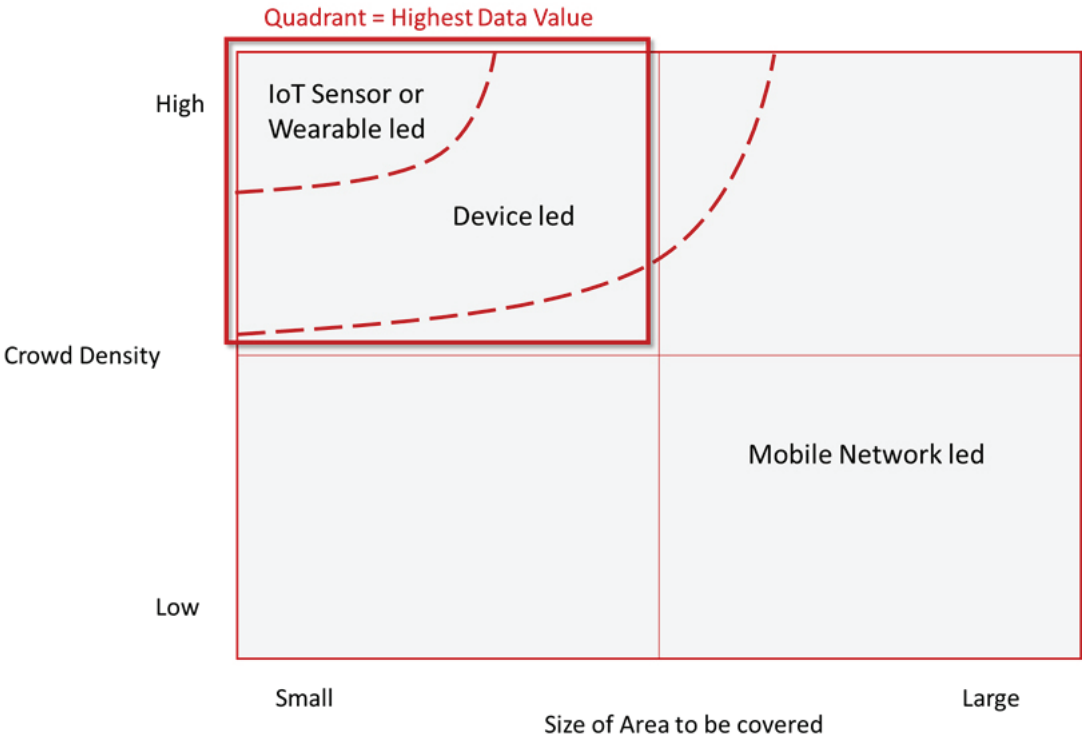
There are several criteria that a city or a location manager needs to understand before they are able to begin extracting value from a crowd management solution. A number of considerations come into making a decision as to which technology is going to be the best fit for a particular scenario.

These include:

- Expected crowd density
- Accuracy of location data needed
- Cost to obtain location data
- Location of area to be covered: urban/rural or indoors/outdoors
- Time to deploy

All of these factors will inform a decision as to which technology is most appropriate. In most cases, a crowd management solution will need to draw on a combination of network data and IoT sensor data, with some technologies offering a macro, wide area view of the city, and others offering a view of points of interest in finer detail. The more diversity in technologies that a city or venue is able to incorporate into their eventual deployment the more accurate a picture they will have.

The chart below indicates the most appropriate technologies for different use cases. Although these technologies are not restricted to this categorisation, it can become uneconomical to obtain the data if an inappropriate tool is used.



- IoT sensor-led – Using mobile-enabled IoT sensors, such as Bluetooth beacons or IP cameras, to monitor crowds.
- Wearables-led – Using wearable devices, such as RFID bracelets, to monitor a high-density crowd.
- Device-led – Enabling a mobile phone to provide its location through GPS
- Mobile network-led – Using mobile network data to plot the position and activity of a crowd

The chart indicates the appropriate technology mix for different crowd management scenarios. An urban planner looking to understand the movement of people at a road junction may find mobileconnected IoT sensors give the most accurate data, with mobile network data providing historic context, whereas a transport network covering a large area may find that mobile network data alone gives enough information to understand usage.

Cities and commercial venues should engage with mobile operators to understand these technologies in more detail. A crucial step in building out a crowd management service, whether it be for transport, safety or revenue opportunities, is to pilot a proof of concept that is limited in scope. This will allow the city or venue to understand the technology mix best suited to their requirements.

As every location is different, the data analytics requirements will be unique to each deployment. Again a city or venue should use a pilot to understand the types of data that need to be generated, and the analysis that needs to be conducted to ensure valuable insight is available after a larger scale deployment.

Cities and venues should ensure that they have appropriate governance over any pilot, ideally overseen by a Chief Information or Innovation Officer, and are aware of how the local data privacy laws determine what data can be collected, used and stored.

“Cities and commercial venues should engage with mobile operators to understand these technologies in more detail.”

MOBILE OPERATOR CAPABILITIES FOR CROWD MANAGEMENT

As explained in this paper, mobile operators and their partner ecosystems are a key resource for organisations and cities looking to deploy crowd management solutions. They have direct access to relevant data sources from their own networks, are able to combine multiple data sources into one set of analytics with their data management platforms, and are able to directly manage and scale IoT sensors around a location or a city that may be needed to augment the mobile operator's core capabilities. The diagram below shows the primary mobile operator and partner capabilities for crowd management.

- Personal mobile devices
- Sensor deployments

- Mobile network data
- Personal device data
- IoT sensor data
- Aggregation/anonymisation

- Real time analysis of current situation
- Analysis of historical trends
- Predictions for organisational and citizen planning

- Visualisation of crowds - real-time and historic

The sections below outline a few of the ways in which crowd management service users can obtain value from mobile network operators.

DATA SOURCES

Mobile network operators offer the best source of geo-location data for crowd management. This data is collected, anonymised and stored, and can be used for a wide variety of crowd management scenarios.

Other mobile-enabled IoT technologies can be used for locating devices and thus crowds, and they can be useful in indoor environments or where mobile network data is not available. Mobile operators can advise on which IoT technology and sensors would be the best fit for specific uses.

USE OF HISTORIC AND REAL-TIME DATA

Some applications of crowd management techniques may only require the use of historic or realtime data, whilst others may benefit from a combination of both. Mobile operators are best placed to provide historic location data. The data they are able to provide is detailed, accurate and typically stored for several months, so that data for a long time period can be overlaid on the relevant platform to gain a good understanding of crowd behaviour.

Mobile operator data is also good for understanding trends and establishing a baseline against which to monitor for anomalies and issues. Mobile operator data can highlight changes through the seasons to ensure that a baseline accurately reflects real life crowds.

Real-time data can come from a number of different mobile operator-led sources, and can highlight immediate issues, such a transport delay. It can also be used at both planned and unplanned events where crowd behaviour needs to be monitored and controlled more dynamically.

A combination of both historic and real-time mobile operator data provides a fully-enabled crowd management solution that lets cities and venue managers understand any issues that may occur, prepare for upcoming events, such as sports matches, and see how new transport and city enhancements affect the behaviour of crowds.

DATA ANALYSIS

Crucial to ensuring the successful deployment of a crowd management service, whether for a small area or city-wide, is the ability to turn raw data into valuable insight. Mobile operators work with leading data analytics providers to integrate analytical logic into their management platforms. This means that operators are able to build portals and reports that highlight both normal and unusual behaviour for use by the city or organisation requiring a crowd management service.

Using the correct tools, a user can zoom into crowds, highlight areas of concern and build reports for city managers to show the popularity of services, as well as highlight issues and opportunities for improvements.

PREDICTIVE ANALYSIS

Mobile operators can use machine learning to predict crowd movements. Machine learning tools take historic data from the operator's network, integrate data from other sources, such as weather reports, and apply logic to it.

The mobile operator can then provide analytical reports that show how different environmental stimuli affect crowd behaviour. For example, a train travelling into a city sees passengers embark and disembark at different stations. When it is raining, less people may disembark at certain stations, creating congestion and issues further up the line. Using the operator's machine learning tools, predictive analysis can be undertaken, allowing issues to be highlighted before they actually happen.

DATA PRIVACY

Mobile operators have a track record of providing secure products and services to their customers. As crowd management is enabled by the tracking of people and their connected devices, privacy concerns can arise. Mobile operators have very clear policies on how they collect and use data from people to enable these services and ensure that trust is retained.

Mobile operator policies cover the collection and use of identifiable data, storage of this data and access to this data, among other privacy issues. Operators are aware that even data that is not personally-identifiable needs to be treated with care, as any breach of data or trust could seriously damage an organisation's reputation. The GSMA has published both IoT Security Guidelines and Mobile Privacy Guidelines, which can be applied to crowd management implementations.

The guidelines can be found at:
http://www.gsma.com/connectedliving/future-iot-networks/iot-security-guidelines/ and
http://www.gsma.com/publicpolicy/mobile-and-privacy/mobile-privacy-principles.

CONCLUSION

New crowd management solutions for cities and large venues will improve the stakeholder experience and create efficiencies through better planning, both in the short term and longer term, by building a better understanding of how people move around a location.

Today, cities and location managers should be evaluating how crowd management services can be effective in their local environment, and which issues it could help to solve. By piloting the service with a mobile operator, cities and location managers can work out the optimum mix of big data and IoT sensors necessary to provide adequate coverage of various points around a city or venue. The technology will highlight immediate opportunities for improvements in safety, and allow stakeholders to make substantial improvements to how events, transport networks and venues are managed in the future.

About GSMA Smart Cities

Cities are getting smarter every day, using information and communications technologies to enrich and enhance city life. The growth of the Internet of Things will have a fundamental impact on the development of smart cities, helping to drive efficiencies and delivering rich new services. However, without effective strategies in place, cities will be unable to capitalise on these benefits. As part of the GSMA Connected Living programme, the Smart Cities project is working with mobile operators and cities to create real, long term benefits for businesses and citizens through IoT technologies.

To find out more visit: **www.gsma.com/smartcities**
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