Cabin WiFi is changing the centricity of in-flight entertainment from centralised servers to seatback systems to portable passenger tablets and smartphones. The Internet of Things uses the WiFi network to help cabin crew sell ancillary products and improve customer care.

Cabin wireless architecture as an infrastructure for multiple applications

The onboard WiFi network was once the preserve of passengers that wanted to connect their laptops or personal digital assistants (PDA) to the internet. Today, the cabin wireless network is used to support inflight entertainment (IFE) and different cabin devices that can perform myriad functions.

WiFi is a two-way portal that is commonly used to distribute electronic information via radio technology. Transmitted through a wireless access point (WAP) in the cabin, WiFi has an approximate range of 20 metres and is compatible with smartphones, laptops and tablets.

Anyone with a wireless network interface controller can attempt to access a WiFi network. As the technology is lot more accessible than a wired network, WiFi is more vulnerable to a cyber attack. WiFi-protected access (WPA) technology is used to protect the system from unwanted interference from intruders.

Pioneering the onboard wireless local area network (WLAN) was Connexion by Boeing (CBB). The legacy high-speed Internet service was launched in 2004, and gave passengers internet access through a wired Ethernet cable or by a wireless 802.11 connection.

Tariffs charged to access the service varied between airlines, but it was not uncommon for passengers to pay $9.95 for one hour of internet access; equivalent to $13.49 today. By using a Ku-band antenna, a CBB-equipped aircraft could have a maximum download speed of 20 Megabits per second (Mbps), and a maximum upload speed of 2 Mbps.

Poor passenger uptake rates led to CBB's discontinuation in 2006. Yet CBB's early demise was not due solely to high usage costs, or the quality of the network infrastructure. It must be remembered that passengers' mobile technology at the time was cumbersome, with little meaningful functionality.

CBB was ground-breaking in the way it signalled the arrival of the wireless cabin network. Yet the rapid development of affordable smartphones and tablets is of equal importance to the centricity of the IFE and today's passenger use of the aircraft's WLAN.

Smartphones & Tablets

In 2007 the first LG Prada and Apple mobile phones with large capacitive touchscreens were launched. This generation of smartphone manufacturers realigned their focus from a business to a consumer entertainment market and popularised the smartphone.

By 2010 smartphones had faster processors and longer battery life. The development of larger screens enabled smartphone users to easily consume a variety of multimedia content. Bluetooth and the 4G cellular network increased mobile connectivity options, while home and public WLAN hotspots made it easier for smartphone users to consume films, music and TV shows.

Apple introduced a new tablet computer - the iPad - in 2010. The iPad could seamlessly synchronise media content and data between a cloud-based network and a user's smartphone. Using the same software and operating system as a smartphone, the iPad had a larger screen and more memory, which enabled a large amount of media to be stored and recalled effortlessly, without the need for cellular or WiFi connection.

Technological advancements in personal electronic devices (PEDs) influenced the way airlines disseminated IFE. Instead of exclusively storing media on a headend server, airlines started to imitate the home network and facilitate a bring-your-own-device (BYOD) culture.

Headend-centric

Traditional embedded IFE systems use a single server that delivers content to individual seatback screens. These headend-centric systems rely on wires to distribute audio-video on-demand (AVOD) services and are prone to a single point of failure.

Later systems have improved reliability, and store content on the built-in memory of the seat display units (SDUs). Content for this seat-centric system is updated by the aircraft's server. Since the system is not reliant on a single server, faults are likely to be at an individual seat level instead of an aircraft level. Faulty SDUs can be successfully replaced in flight, causing minimal disruption to other passengers.

Introducing a WLAN to the aircraft allows passengers to stream cache content from the aircraft's server directly to their PEDs. Since BYOD systems are PED-centric, this eliminates the need for complex wiring and SDUs, thereby making them an economic alternative for aircraft without an embedded IFE system.

Service Platform

Service Platform by Axinom aims to reduce the complexities in the management, delivery and deployment of data, content and services on an aircraft.

Service Platform streamlines and simplifies the many systems that use an aircraft's WLAN by making them all work together seamlessly with standardised software architecture from the digital passenger, cabin and crew systems.

"With the Service Platform, we open avenues to create unique experiences that benefit the passenger, crew and service providers. All this is done through a single system that lowers the need for certifications," says Axinom chief executive of operation, Ralph Wagner.

The system allows integration of multiple products and services, such as IFEC, maps, the internet of things (IoT) and advertising engines. By using Service Platform, operators can safely manage and deploy data and services.

Using the aircraft's WLAN and real-time connectivity, operators can use Service Platform to create new revenue-generating business models, such as electronic shopping on board the aircraft.

"Operators have control over the service orchestration, deployment and resources," says Wagner. "They can request resources such as disk space or sensor controls, and the operator can decide how to allocate resources or remove the services as needed."

Service Platform uses Axinom's Inflight Services (IFS) component to provide an interface to ingest and manage different software and content packages. The system also has a provision to give third-party vendors access.

IFS can enable operators to build smart systems for gathering and reporting sensor-derived data, or acquiring passenger loyalty data from the booking systems.

Wireless Seatback

Axinom's Wireless Seatback uses the aircraft's wireless network for both passenger PEDs, and an embedded seat-centric seatback system. The system is designed around a single wireless infrastructure that simplifies the IFE software requirements by reducing the need for different formats and encoding.

Stefanie Schuster, chief commercial officer at Axinom, says that a key feature of the Wireless Seatback System is the 'WiFi-network infrastructure'. This is because WiFi simplifies the IFE system by eliminating the need for lots of unnecessary complicated wiring, thereby lowering the aircraft's overall weight and its maintenance costs.

"Traditional IFE screens are wired with cables, and these require a lot of maintenance. If one cable breaks it can be problematic and expensive to gain access and fix the fault," explains Schuster.

Wireless Seatback uses an Android tablet device that is paired to the aircraft's network and installed into the passenger seat. As the system is wireless, it is also possible to pair a passenger's PED to the seatback to give a dual screen experience.

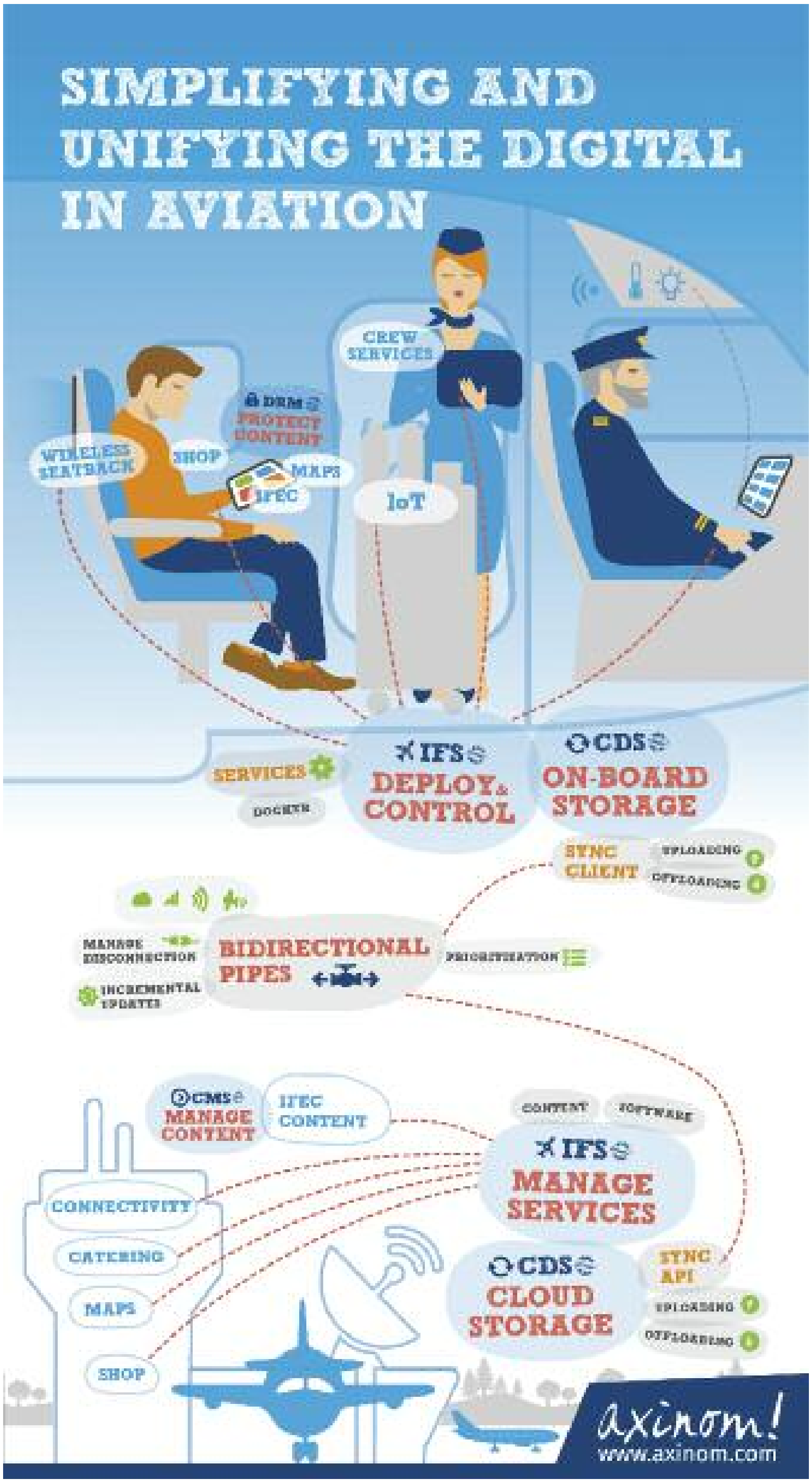
It is possible to synchronise the PED and the seatback tablet together and transfer content between them. Once paired to the seatback, the PED can be used as a remote control or to stream preloaded content to the larger seatback display.

"Pairing both seatback screen and a PED gives the passenger more choice in the way they consume their onboard content. This creates a very personalised viewing experience," says Schuster.

It is necessary to process the media content beforehand to allow common encryption and adaptive streaming. This ensures that the content is formatted to work on the Wireless Seatback system's tablets and a diverse mix of passenger PEDs. The process can also include multi audio and subtitles.

The Content Management System (CMS) enables airlines to create their media product library and make Content Sets (CS). Typically, CSs comprise movies, TV shows and music. "The CMS is where editors can see the properties of media and change the descriptions and pricing, and create bundled passenger offers," says Schuster. "The CMS can be also used for reporting analytics."

The Content Delivery System (CDS) allows data and media to be uploaded to the aircraft server via different connectivity pipelines, such as cellular



Seat-centric systems store media content in the seatback display unit's memory. Typically outages are at seat-level and do not affect the whole aircraft.

and satellite networks, or by WiFi connectivity, SSD and USB connections.

Schuster describes how the CDS can control which pipeline should be used to send data to the IFS server. "The IFS includes IFEC software components built into the in-flight server," says Schuster. "If incremental updates are needed, or if something is changed in the CMS, the CDS will send these changes to the IFS. The CDS is the 'postman' between the ground and the aircraft's IFS."

The CDS has a bi-directional functionality that enables uploading and offloading of content sets to and from the aircraft. Offloaded data can then be processed through the CMS for analysis. This will allow the airline to view passenger IFE preferences and revenue trends, such as eCommerce performance.

The IFS server administers adaptive streaming, advertising and PCI payments inclusive of Digital Rights Management (DRM), ensuring that all content licences are adhered to.

"If you want to stream content then you need the correct DRM to give you the necessary licences. This is important because it is Hollywood content that needs to be protected and encrypted," says Schuster.

The IFS can distribute containerised media content to the passenger-facing seatback IFE display. All connectivity between devices is done by the WiFi.

When the IFS is linked to the Connected Services module it will help personalise the passenger experience by accumulating data from the airline's booking system, and, with the assistance of leverage recommendation engines, will create a unique passenger IFE experience. Connected Services also manages monetisation and payment gateways, as well as reporting to business-to-business partners.

"Because of the AD Server, you can handle payments and entitlements, so this is really in the background," says Schuster. "The payments work in real time through connectivity where the system directly connects with a payment gateway."

If aircraft do not have external connectivity, passenger credit card data must be stored onboard the system, which has to be PCI-compliant. "This means there is a lot more complexity to the project," says Schuster. "Some elements may require development to become PCI-compliant."

Axinom builds in reliability by uploading the most popular content onto the memory of the seatback tablet. This hybrid approach means the system can always run independently from the aircraft server in the event of a connectivity issue.

"An aircraft full of passengers streaming movies at the same time will put a large load on the WiFi network. Pre-positioning parts of the content on to the android tablet makes the network much more stable," says Schuster. "You cannot store everything on tablets because they do not have the space."

By analysing data, it is possible to work out what is the most popular content and where best to store it.

Air Streamer

WiFi Technologies' Air Streamer concept uses a 50Tb server to create a localised content cloud that passengers can access by pairing their PEDs to its WiFi inbuilt WLAN.

Air Streamer was designed as a primary passenger PED-centric system, but WiFi Technologies is developing it to synchronise with an embedded SDU.

It is expected that WiFi Technologies' embedded seat-centric system will use a light seatback screen. It is estimated the touchscreen SDU will weigh about 400g. "The advanced materials we are using will make the installation process very easy, and will reduce the overall aircraft weight considerably," says Yves Hendrickx, chief executive officer, WiFi Technologies. "The SDU will need a power source and will be touch screen enabled."

Using a smart network system that monitors and manages the WLAN, Air Streamer can provide WiFi for up to 500 passengers through one access point. "We do not increase the power of the WiFi transmission," says Hendrickx. "We manage it better, so that Air Streamer can provide a very unified WiFi signal for the whole cabin from one access point."

Air Streamer is DRM-compliant and WiFi Technologies has arranged licensing rights with many TV companies, making it possible to upload a diverse selection of TV shows from around the world.

"Research shows that passengers are more likely to watch TV shows than movies. We can get the right approval from any TV network like the BBC, CNN and NBC to name a few," says Hendrickx. "If an aircraft is operating out of a specific location we can make arrangements with local TV stations."

Content can be updated while the aircraft is on the ground by the gate. This means passengers can access the latest magazines, newspapers and news broadcasts. The server's large capacity means it is possible to store about two months of viewing content.

"Air Streamer's content library is so vast that it will be able to provide a high level of personalisation, similar to the passenger's Netflix or Amazon Prime subscription they access at home," says Hendrickx.

The Internet of Things (IoT)

The IoT is a computing concept that describes the idea of everyday physical objects being connected to the internet. By connecting devices such as sensors or actuators, it is possible to use the IoT to monitor inanimate objects and to perform a physical movement or action.

ViatorAero by FliteTrak employs IoT technology in a variety of ways to improve passenger comfort throughout the cabin, and to advance cabin crew performance by helping them complete their everyday tasks.

Andrew Barnett, managing director FliteTrak, says: "ViatorAero systems and sensors are designed to work on their own, but they can also leverage off any existing WiFi infrastructure. The technology is driven by an IoT framework that we have adapted to fit within the cabin."

ViatorAero typically uses its own server that is dedicated IoT. "We prefer to use our own server because of the experiences we have in other markets, where the server is working autonomously, so there are no inter-operability issues," says Barnett.

It is possible to load the operating software onto the aircraft's existing server. Yet from a retrofit point of view, it makes more sense to install a new server and take advantage of the inherent reliability and seamless software integration.

Sensors connected to the cabin WiFi can be used to monitor a passenger's movement on the seat. By data-profiling a passenger's movement, their well-being can be directly and wirelessly reported to a cabin crew portal or tablet, so that flight attendants may easily identify if a passenger is unwell, agitated or fearful of flight.

Sensors that monitor passenger seat movement can also analyse wear and tear and predict seat maintenance. "By implementing IoT technology, it is possible to know when a seat part like an armrest is about to fail," says Barnett. "In addition, sensors can notify the operator that the seat foam has degraded to a level that will make it uncomfortable for the passenger."

Instead of waiting for the seat to fail, it is possible, using sensor-led data, to trigger a seating maintenance plan that fits into the aircraft's pre-scheduled maintenance cycle.

ViatorAero has a seatbelt sensor to allow the cabin crew to know when a seatbelt is open or closed. Without the need to use batteries, the seatbelt system uses the same technology that monitors the overhead storage lockers to denote if they are open or closed.

Using the technology for take-off, it is then possible for cabin crew to simply view a portal to know if all seatbelts are closed and the overhead bins are locked.

Another area where the same technology can make an impact is the aircraft's galley area. "The sensor does not care if it is monitoring a seat or galley area," says Burnett. "This is because the sensor only sees data, and by changing its parameters a sensor can send reports about many things."

A sensor can measure the temperature and monitor the usage of different galley appliances such as the coffee percolator. By monitoring usage patterns, it is possible to inform the airline when an appliance needs servicing or replacing.

Sensors added to a service trolley can adjust the trolley's operating temperature. This will ensure that food or drink will be ready to be consumed fresh, and at the right temperature.

IoT technology used in toilet sensors can sniff and detect anomalies in the air to notify the crew if a lavatory needs attention. Additionally, it is possible to monitor and manage water usage to ensure water is not overused, thereby resulting in an incapacitated toilet.

According to Barnett, passengers will not complain about the inconvenience caused by broken facilities, such as a lavatory, to the cabin crew. Typically, today's passengers post bad customer experience reviews on social media, often giving the operator a bad name.

"The challenge is to get airlines to

Sensors in the lavatory can smell the air. Notifications of any abnormalities can be sent to a cabin crew portal or smart watch.

recognise what is really meant by passenger experience and comfort," says Barnett. "If sensors are deployed in first or business class, then it is possible to tell when a passenger is asleep or awake. If a passenger is asleep, then the cabin crew need not bring them breakfast until they are awake."

For low-cost airlines the business case is about fast turn times and increasing ancillary revenue through onboard sales.

"Implementing the use of IoT to do checks and monitor passengers allows the cabin crew to be better focused on selling more services," says Barnett. "If the aircraft runs into turbulence, the cabin crew can be more effective by concentrating on the passengers that have not fastened their seatbelts."

According to Barnett, the whole public transport industry has become commoditised. Therefore, passengers are not recognised as individuals anymore, and are just a number in a section of the cabin. "You can use technology to bring some of that personalisation back into travel," he adds.

"The airline can combine interactive data with its loyalty programme. This means cabin crew will not only know if a passenger is asleep, but by profiling the passenger loyalty programme, they will know what sort of drink they would like when they wake up," says Barnett.

Mirroring ViatorAero's utilisation of IoT is Boeing's intelligent cabin assistant called Ellen. Named after commercial aviation's first female flight attendant Ellen Church, Boeing's system represents an extra crew member.

Actuated via voice-commands and the WLAN, Ellen is introducing aircraft type commonality to cabin crew so that they can easily switch between different types of aircraft. By saying "prepare the cabin for take-off," Ellen will lock all the overhead bins, correct the lighting and ensure all seats are in the upright position and window blinds are open.

Once the aircraft has transitioned to an altitude set by the airline, overhead lockers will unlock and passengers will be able to adjust seats and blinds. It is possible for seats to have heating and cooling pads that will adjust automatically to where in the world the aircraft is operating. Boeing's philosophy is that the cabin will be able to take care of itself.

Security

Deploying a high number of wireless IFE and IoT applications on the aircraft's WLAN increases the risk of a possible cyber-attack. This is because adding more devices to the WLAN increases the number of touchpoints, which are often used as gateways by computer hackers to unlawfully access a system.

Since today's cyber threats are evolving very rapidly and creatively, the question is how to find the right protection against these ever-changing threats. According to Markus Gilges of VT Miltope: "Traditional responses to cyber security events address 'known threats' via static and passive tools such as firewalls or authentications. As these methods are only useful against known attacks, the evolution of cyber threats requires a more proactive and dynamic approach."

Therefore, future cyber security solutions need to stay ahead and evolve faster than attackers to remain effective. In a move to future-proof cyber security, several national and international bodies are in the process of translating their recommendations into regulatory directives.

"The European Network and Information Systems (NIS) directive encourages European Union members to share cyber security information. This will help cyber security transition to a more proactive approach," says Gilges.

For airline operators this translates to continuous security monitoring, and anomaly detection for usage behaviour on the wireless network.

VT Miltope collaborates with software partners Galgus and RazorSecure to incorporate a diverse mix of technologies to optimise cyber-secured wireless cabin networks. According to Gilges there are two key elements that result in cyber security protection.

"To begin with, AI-driven machine learning of the RazorSecure solution monitors anomaly detection throughout the network," says Gilges. "Cleverly the system identifies the normal utilisation within a wireless network and is therefore able to recognise any abnormal behaviour."

Once abnormal behaviour has been identified, the system starts rectifying actions, triggered by the location, position and tracking feature within the Galgus CHT (Cognitive Hotspot Technology) solution.

In contrast to the old cyber security philosophy, the new approach allows for the system to become smarter with each iteration, thereby resulting in future-proof protection.

Conclusion

Wireless cabin networks are fast becoming a necessity within the aircraft cabin. As more domains and devices are feeding off the WLAN, its utilisation is growing exponentially. It is possible that the WLAN will become saturated due to high demand. This will result in sub-optimal performance of the network, and will subsequently lead to passenger dissatisfaction.

Yet it is possible to introduce individual networks to service different applications, such as IoT and IFE.