57th FITCE Congress, "Delivery and Consumption of Digital Media"

University of Salford, MediaCityUK, 6-7th September 2018

Formal Report written by Ed Smith, BT Research Fellow, on behalf of FITCE

The 57th FITCE Congress considered the delivery and consumption of digital media and was held in MediaCityUK, Salford, UK on 6th and 7th September 2018. There were 75 delegates, who enjoyed four technical sessions delivering 15 papers, 7 keynote speeches, an absorbing technical visit to dock 10's studios and an entertaining and thought provoking round table. The conference was staged as a joint venture between FITCE and the University of Salford. The conference was not all work and no play, with an interesting social and partner programme, which allowed plenty of scope for socialising and enjoying the local attractions.

The conference had been organised by Andy Valdar and Nigel Linge, who produced a strong programme, at an exciting venue, with a good selection of papers and keynote speakers. There has been strong support from FITCE, BT and the ITP, who have helped greatly with publicity and in providing and managing the booking system. The BT team, particularly Andy Sutton, Paul O'Brien, Kevin Blythe and Colin Phillips, have provided strong support. Strong support came from Mick Saunders of the ITP, Peter Leonhardt of BT and Ray Howarth of the University of Salford, who had a pivotal role in pulling together the companion programme. The role of sponsors is pivotal to all conferences such as this one and our thanks go to our financial sponsors, particularly Pennine.

The evening before the formal start of the programme, the University of Salford hosted a drinks reception, followed by a guided tour of their facilities and accompanying presentations, which were greatly appreciated by both delegates and companions.

All sessions were recorded and have been made available to watch online. An overview of the content of the technical sessions is given below.

Day One

Following an introduction by **Professor Nigel Linge**, the delegates of the congress were welcomed to University of Salford. by **Professor Helen Marshall**, the Vice Chancellor of the University of Salford. Helen, who has a background in corporate Law, noted the distinction between Salford and Manchester. Salford's growth goes back to the industrial revolution and the city has perpetually re-invented itself, this time as a producer of 21st Century deliverables, notably Industry 4.0. The University has strong links with industry and over the years, this has delivered a wide range of benefits. A hallmark of the University's identity is the number of students working closely with industry. Leading edge technology is vital and the university has just bought a driverless vehicle and is engaged in 5G mobile trials. The range of keynote speakers that this highly regarded conference has managed to attract reflects these links.

Professor Andy Valdar, the President of FITCE, formally welcomed delegates to the congress and thanked the University of Salford for both its hospitality and the effort it had put into the congress. In particular, he thanked Pennine for their sponsorship and others for their support. He emphasised the impact that video had had on the market place and spoke of the impact of user generated content and the need for the distribution channels to fit in with new technology.

Jamie Hindhaugh, the Chief Operating Officer of **BT Sport** spoke about the BT Sport studios facility and its construction. He reflected that BT Sport was now part of the establishment but the service was built and launched in 9 months. The industry standard build time for a studio is 5 years, but this was achieved in 18 weeks for BT Sport. One of the strengths of Sky was that it had retailed the products of others. BT had decided to retail their own product. It was important to identify what was needed to build credibility. It was important to drive the economics down and the quality up. The audience drove the strategy, which was to bring the audience to the heart of sport. Live sport is very different from other areas of video entertainment, where catch-up is prevalent.

IPTV channels have been around for a long time. Multiple channel facets have been delivered and the design of the BT Sport facility has the emphasis on adaptability and the capability of delivering faster. The organisation was able to deliver the first live 4K channel, which utilised a single workflow structure, the truck converts and produces HD and SD as wells 4K across 350 live events. The aim of the improved quality is to take the viewer nearer the action. Recent innovations include live 360-degree replays. They find that 19% of viewers watch events via the app and that the viewing experience is increased 60% by sound, which is improved by the use of Dolby ATMOS. For the champion's league final, which is a bigger event than the super bowl, Virtual Reality walk around was provided. The final was also televised using YouTube as a platform and this attracted 330,000 VR watchers, the VR is only provided for the highlights and only through a magic window. It is important to realise that sport is a social activity.

High Dynamic Range (HDR) was also used for the champion's league final, but HDR has not yet been completely rolled out. It is likely to be made available on mobile first, since HDR makes a much bigger difference on smaller screen sizes. The capability for personalisation is likely to come through mobile first. 5G will be an important technology and full remote production over 5G is likely to be possible from November. Jamie's prime conclusions were that content is king and his aim was to bring the audience to the centre of the action by creating a complete environment.

Ian Macrae, Director of Market Intelligence at **Ofcom**, spoke on "the changing picture: trends in how we access and watch TV and other video". The Market Intelligence Unit at Ofcom is responsible for building the evidence base that often is useful for its policy-making. The Media Nations Report and Communications Report are significant recent publications and are widely available on the web.

In the media industry, we have seen a decade of demand in streaming services, starting with the 2007 launch of iPlayer and Amazon Prime. Ian stressed the importance of mobile data and the importance of smart TVs connected directly to the Internet. Just over half of the population now have superfast broadband and there has been a continued growth in data consumption to 190 Gigabytes per month, an increase of 40% in 12 months. Of this around 1.9 GB of consumption is over the mobile channel. Online video is driving the growth and the average level of broadcast TV viewing is dropping (half an hour a day down on the level seen five years ago). The younger demographic now watches a third less television than it did 5 years ago, that is their viewing habits have changed. 16 to 34 year olds watch about an hour of YouTube per day.

Seventy-five percent of smartphone data traffic arrives via Wi-Fi, rather than originating from the mobile network. People tend to use their smartphone once every 12 minutes. There is however a

growing threat to broadcast revenues. Advertising revenues are currently holding up, but in 2017, there was a dip in this, however it is too early to say that this is a trend. The growth in Amazon Prime and Netflix may be hitting pay TV revenues and print and magazine advertising has been badly hit. Mobile is attracting the growth on mobile devices, which has seen a 25% increase in traffic, including video traffic, forming 9% of online advertising revenues. There is a movement towards media and collaborations. In mobile the number of voice call minutes is falling, with many customers moving towards messaging and voice apps. In mobile, there is increased focus on data revenues.

There are growing threats to the Public Services Broadcast system.

Andy Sutton described BT's 5G Network Architecture and its role in enabling the future delivery and consumption of digital media. This talk began with an overview of the standards, which Andy referenced against his recent paper in the ITP journal. Initially most applications are expected to use the 4G as the service evolves. He identified three major use cases eMBB (enhanced Mobile Broadband), MMM (Massive Machine to Machine) and URLLC (Ultra Reliable and Low Latency Communications). MMM is expected towards the end of 2019 and 4G LTE is expected to be a network slice. Lower latency services really need millimetre wavelengths, at frequencies higher than 3.5 GHz and a bandwidth of 10MHz. These services will be delivered over dense architectures and sensible average figures available rather than peak. The delay targets for low latency are between 4mS and 1 mS, with URLLC requiring one-way delays of 1mS or less over the radio interface. The minimum requirement for both eMBB and URLLC is a mobility interruption of 0mS. An on-net CDN capability is to be introduced.

Andy moved on to discuss a service based architecture used for virtualising platform functionality onto an X86 computer architecture. He examined in detail the low latency requirement:

- Virtual reality and augmented reality require 7-12mS
- Tactile Internet needs less than 10mS
- Voice to voice needs less than 10mS
- Manufacturing and robotic control needs 1 -10 mS.

The initial design targets for BT's network are:

	Access	Aggregation	Core
Number of nodes	1200	106	10
1 way transport latency	0.6mS	1.2mS	4.2mS
eMBB estimated 5G latency	9.2mS	10.4mS	16.4mS
URLLC estimated 5G latency	2.2mS	3.4mS	9.2mS

There is an aim to push functionality to the edge of the network.

Juan Riol Martin of Universidad Carlos III de Madrid considered "Towards 5G: Techno-economic analysis of suitable 5G use cases".

A key consideration is the balance between improved technical performance and deployment costs. The basic architecture is now established and the 1mS latency target will be specified in the

IMT 2020 rather than the IMT Advance standard. He identified the same three major use cases as Andy Sutton. The starting point for the evolution of new services is LTE and the network can evolve through a combination of 4G and 5G technologies. The transition should start in 2019 and at this stage; providers should address at least one 5G segment.

Key Performance Indicators (KPI) and progress needs to be defined in terms of the weight of each KPI related to improvement. It is less clear of what is going in with hybrids. 5G will heavily influenced by LTE enhancements.

5G = LTE Enhancement + New Radio and next generation network.

He considered three commonly used approaches to roll out, incorporating either hybrid or dual point topologies. The new roll out was expected to be almost exactly the same for the hybrid and dual point options. In general, all three approaches were good for eMBB, but requirements for Massive Internet of Things (MIOT – called MMM in the previous talk) and Massive Critical Systems (MCS – called URLCC in the previous session) conflict with each other. The former is less demanding of the network, whilst the latter is latency sensitive and has stringent failure requirements, being potentially used for autonomous vehicles. A third compromise approach is possible, but giving KPIs which whilst much better than worse case, fall significantly short of best case.

Hassan Hamdoun of BT described "Media Delivery in 5G ". His primary interest was in broadcast and multicast services. Most services are typically based on HTTP and use a simple interface. He described the various options for interfacing between the Content Service Provider to the Network Service Provider for the provision of multicast and broadcast services and the corresponding protocols. There are several levels of end users, assessed by concurrent devices and here unicast is less attractive for media distribution. For good multicast an edge ceiling is needed. For LTE eMBMS (Evolved Multimedia Broadcast Multicast Services) multicast is standard, but for 5G a broadcast and multicast service is required. The network needs a multiservice contact edge. The use of FLUTE, a multicast capable protocol for file delivery over unidirectional transport was described. At this stage, it is still unclear how to do multicasting in the core.

Berit Bettina Schubert of ATOS in Germany described "Pathways to digital transformation in the media industry". She looked at charging options in the star economy, as the audience becomes digital. The impact of customer centric strategies in disrupting traditional players was of prime interest. The key challenges are audience mastery, tests, monetisation and agility. Team collaboration is a key opportunity. Useful applications are team collaboration, digital media supply and broad network control system. The third is control to help engineers.

Laurence Murphy of Salford University gave a keynote speech looking at 8K and holography, their impact on communications and future media technology. This considered the evolution of broadcasting and the marriage between broadcast and communications technologies. Key areas of concern are compression, usable bandwidth, network structures and changing protocols. OTT and CDNs give the opportunity to leapfrog the traditional bottleneck of standards.

Communications networks offer the potential to expand and the opportunity for collaboration between broadcasting and communications. Communications engineers are leading the

revolution. We see a change in mind-set from the viewer. Linear technology is not the way forward. The next generation of codecs will be important, H.266 presents opportunities, but AV1 is a royalty free codec, which can manage all formats between SD and 8K. Netflix has invested heavily in AV1 research, but currently relies on H.265, which carries a royalty payment.

There are wavelet-based approaches, such as JPEG 2000, rather than block based compression. These need to be handled in a different way. The UK roll out of broadband allowed the rapid roll out of new formats. The model will work. Virtual and Augmented Reality have been through a quiet period, but can now build on areas where it can work, especially when used in sport based services, appealing to those looking for newer experiences. There are prototype displays capable of providing haptic functions.

8K will be rolled out in time for the Japanese Olympics, where 8K pictures will be sent to overseas broadcasters, who will have to convert them into other formats.

BT research fellow **Ed Smith** described QUIC's role as a transport mechanism for IP video. QUIC is a candidate technology, which is expected to influence the future of media distribution. The presentation considered how networks and payloads influence the viewing experience, what the key performance criteria and the strategies for managing them are and what QUIC is and why it is worthy of consideration. The presentation covered IP payloads, the role of encapsulation methods, IP transport techniques, what QUIC is and how it performs.

QUIC is a new IP based transport protocol, which absorbs the bulk of HTTP/2's functionality, the error and congestion recovery capabilities of TCP and session level encryption. QUIC interfaces to the traditional IP stack by using UDP as a system level transport protocol.

QUIC has a number of technical merits, but their benefit depends strongly on the network environment. The protocol is not yet finalised and their remains uncertainty over which congestion avoidance algorithm will be used. Its penetration is currently low and it is only implemented in Chrome and Opera browsers, which are 60% of the market. Google and Akamai are big players in the IP market and Google are making extensive use of the protocol. There is also talk of its use in the 3GPP 5G packet core. With this emphasis, it is likely to be a significant development.

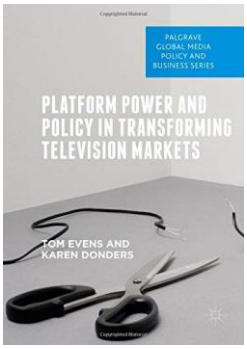
Tom Evens of Ghent University described "Platform Mania in Television Distribution". Tom suggested that platform "wannabees" were competing for leadership. The dominant business model in ICT/online is the insider charge. Network and over-the top (OTT) providers have entered the market and are exploiting network capacity. This allows them to leverage the strengths from one market to enter a new market. Whilst this is a global industry, US based firms have been predominant. There are four sources of structure: content, cable, customer and capital, which are interrelated. Content is a fifth factor, this can be seen as Murdoch with sports and Netflix with series.

Demand pricing is important. Facebook is in it for the revenue income. The control of infrastructure remains a bottleneck and the platforms are looking to pursue a paying relationship. They collect and analyse data using previous experience. Entry into new markets is important, as

is the use of bundling. Capital outperforms creativity and the deepest pockets will be the most resilient.

Critical control points are the tension in global and local markets. TV is not dead it is entering a new era of competition. TV revenues are under threat as their revenues are trickling away.

Tom's work also features in his recent book which was written with Karen Donders. It is titled, "Platform Power and Policy in Transforming Television Markets" and seeks to investigate 'platform power' in the multi-platform era and unravels the evolution of power structures in the TV industry as a result of platformisation.



Doug Williams of BT considered "Why the future of Media Distribution may be object based". The goal of this session was to explore the power of this new approach to media distribution using content genres as diverse as live theatre and sport. His view was that creative force led to creative opportunity. He looked at the traditional chain starting with objects such as video, audio and camera shots. These led to the assembly of a linear programme, which is broadcast, in its entirety, and played at the receiving device.

In this case, the image would be optimised for larger screen sizes. An object based approach sends components, with added metadata, to the receiving device, which could then reassemble the picture for the optimal format for that device. Hence, presentation will vary on a per device basis. This is a step towards personalisation. This will improve the viewer's ability to interact with the content.

This is built on the experience of users viewing across two screens and has been tested with users who generally liked the approach. Some features were less appreciated than others were.

Silvia Rossi of UCL talked about "Learning optimal streaming strategies for virtual reality applications". This was based on a discussion of adaptive streaming and obtaining a 360-degree view. The paper covered the main challenges, possible solutions and conclusions.

Virtual reality uses more information to compute the response to changes in head position. At the user end, viewpoint estimation is used and adapted curve screening is used. The problem is how to capture spherical geometry, identify which content to stream and content to send. Silvia used the analogy of flat plane projection of the globe to explain this.

Some new counter factors need to be considered and a new geometry is required, some kind of spherically weighted PSNR. The weight distribution would be allocated according to position. It is necessary to minimise the presentation of video and to find the trade-off between the number of representations to meet user's requirements. To improve the quality of experience, we need to minimise the number of freezing frames. The need to deliver 10% is exceeded. It is important to ensure that bandwidth is not wasted. Performance is dependent on the available bandwidth.

They use a tile-based system, encoded in independent blocks. This gives more flexibility; the rest can be downloaded at lower strategy. Navigation aware adaptive streaming is required, spherical user construction. The variation of quality depends on user position. The key VR question is how do you predict the user's position; analysing the user position to find consistency of behaviours. They used geodesic distance. This requires a several step following analysis leading to viewpoint prediction. They have defined a new algorithm to do this.

The first day concluded with a visit to **dock 10**, who are a studio facilities manager, programmes such as The Voice, Mastermind, Countdown and Match of the Day are produced here. This gave a comprehensive view of a multi-studio complex, showing the basic sets, set setups and the technology involved. There was ample opportunity to ask questions on both the technology and commercial sides.

Day Two

Ian Wagdin, the Senior Technology Transfer Manager with BBC R&D, considered "Developments in TV broadcasting". This focussed on the impact of future networks on media content creation and distribution.

This focussed on how 5G is likely to be used. Ian chairs the European Broadcasting Union group looking at film. He began by describing Peter Eckersley, the first BBC chief engineer, who was able to envisage future possibilities, but not necessarily the services that would deliver them. The BBC is involved in 5G trials in Bristol and 5G Rural trials in Orkney. The first IP is the best way for audiences to consume BBC content.

They need to deliver value for public money. Consumption on the move is becoming more common. They want to build their own 5G network. He raised the idea of object-based services, where the broadcaster does not perform rendering at the point of creation, but do rendering at the point of distribution.

He then moved onto consider production and why it matters. Object Stream Bonding, remote production, news contributing, ease of deployment, roaming and replacement of ISDN, which the BBC makes extensive use of, are important.

Artificial Intelligence is used in production and uses metadata exchange, camera control/robotics, low cost lines, squeezed spectrum, network management and popup radio. They are currently using 700 MHz spectrum for radio links for transport. The ideal transport technology should deliver low latency, which is relatively easy to achieve, and low packet loss, which can be more difficult. This is delivered over bonded 4G cells over 100 vehicles. Network management is aligned with business models.

They are doing a lot with IP in static structures; but there were issues on the road. Problems include security, contention, bandwidth, latency timing, synchronisation, network ownership, cost, coverage, use of backhaul, power and spectrum squeeze.

Fernando Garcia Calvo, the Director of at Huawei Video Business (Europe), spoke on new TV and video services. He considered that the mobile phone was the preferred device. The aggregator is no longer Sky or the network provider, it's the user. The revenues and share of independent TV are under pressure, as are those of pay TV players. This creates the option for the communications provider, to recapture the aggregator role, direct user capture and to exploit the mobile video space. There is a new shift coming in sports, which includes pre-competitors and allies. Mobile video can focus on monetising the video traffic and provides an opportunity for participating in the pay TV business. This is one of the drivers of telco revenue, as Streaming Video on demand is growing. Mobile video, PCs and tablets are poor entertainment devices compared to the large TVs, the mobile smartphone or smart TV. The dual device approach is now popular.

Deloitte's study of the mobile phone, show that news is often viewed using traditional channels, but the frequency of consumption over mobile devices is increased. The speed of acceleration is faster. The demographics are over-egged. Mobile is used at home or on the go. People are seeking entertainment. Mobile is changing the attention factor. These factors make it harder to define the proposition. It is necessary to think more widely. There have been many attempts to change this. There are variations in global usage; this is the same for American companies who are more successful than their European partners are.

Brahim Allan from BT Video Delivery Research looked at the subjective testing of High Dynamic Range. In general, contrast in film is managed through manipulating three exposures. HDR (high Dynamic Range) adds this level of contrast control to UHD (Ultra High Definition). HDR can eliminate the loss of detail in pictures, which comes when part of the picture is in shadow and the other is not.

They used both Perceptual Quantisers (PQ) and Hybrid Log Gamma (HLG), the BBC's preference, to produce the best Standard Dynamic Range (SDR) picture. BT experiments, using BT employees, started with a screening to 10 people using standard definition derived from PQ-HDR.

They have looked at the increase in resolution. Backward compatibility has not necessarily been good, with HDR linking bright areas with low contrast.

BT Hosted British Science Week, which is an event aimed at drawing school age students into scientific and engineering careers. A sample of 498 participants took part in the same subjective assessment of HDR, providing a useful contrast with the adults. The young students saw more benefit from HDR and found its backward compatibility was better. Students had high correlation with luminosity of picture. Young people appreciate brightness better.

BT research fellow **Ed Smith** presented work he has done with **Mauro Ugolini** of Roma Tre University, asking the question "What is the future for media in the Post Information Age? The important emerging technologies are and their impact on media evolution were considered paying particular attention to their impact on the value chain, forming a view of how these changes will shape the market. The nature of change and the concept of the Post Information Age that leads us to consider candidate technologies were considered, as were and how the developments will impact the value chain. The discussion progressed to consider how the changes can be modelled and their ultimate role in evolving the change of the market. Finally, they also considered the challenges and role for regulation.

They concluded that as in telecommunications, change and consolidation are evident. Competition tempered by collaboration is vital to success and modelling can help in understanding this complex market. They identified that regulation is important and is a cause for some concern. Finally they suggest that social media is the focus capability that ties together the user's experience of the other media segments and is the favoured approach for sharing experiences. It is where consumers exchange options about products and engage socially with the output of the other media channels. Examination of the long-term trends within the industry supports this view of a significant role for social media.

Peggy Valcke of KU Leuven looked at the proposition "Accountable, not liable: Is regulating video-sharing platforms under the new Audio-visual Media Service Directive (AVMSD) a slippery slope towards internet censorship? "Her treatment goes back to the Athens conference in 2006. The EU's AVMSD covered linear plus streaming delivery. The objective was to establish a single market within the member states. Video sharing platforms are used. This governed a big range of streaming services.

Short volume video, (like You Tube) is about 4% of the total physical video, but amongst the young demographic, this goes up to 20%. This gives rise to new stars like PewDiePie and extensive use of video channels by musicians. There are however controversial participants like ISIS, Suicide, Pro-Arian groups, who have bad intentions. MTV and Playboy have both been fined by Ofcom; the first for use of foul language and the second for displaying pornographic images. PewDiePie and YouTube were not sanctioned, when the former published content that was allegedly anti-Semitic.

The editorial content should be under the control of the service provider and has to be examined by an EU based regulator. YouTube claims that it has no editorial responsibility and tries to pass responsibility on to the artists, it is not TV like. Artists do not accept the responsibility. In the UK, Ofcom cover the role of streaming regulator. The French seem to be happier to impose control, warning against cooking videos for not adhering to the rules.

Information security services are governed as services, under the Electronic Services Directive, and therefore accommodate safe harbour rules. This covers a host acting as a conduit or cache and shields the hosting provider from liability for the third party content shared by their service. There is no general obligation to monitor and the regulator didn't want to stifle innovation. However, pressure for users, pressure from advertisers or pressure because of legal developments can be applied to these providers. Platforms are more liable to deal with case law, soft law and legislation. Soft law is recommended as opposed to obligation.

Video sharing platforms are a new category in legislation and provide programmes, user generated videos or both, and they do not have editorial responsibility but have platform control. They should have controls to protect minors and the general public from incitement to violence or persistent commercial communications.

What are the appropriate measures, if the accountable organisation is not liable for the content? Assessment of the stricter rules by auditors is still a concern. In practice, a website displaying paintings by Rubens from a Flemish museum had to be taken down, because assessment methods

could not distinguish art from eroticism. The role of the arbiter of speech is tricky, but vigilance is needed, this is a shared responsibility.

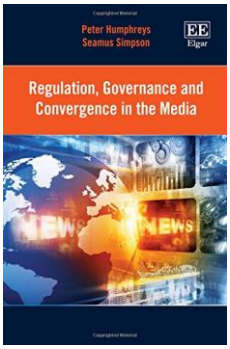
Seamus Simpson of the University of Salford spoke about public policy and media convergence paths and their limitations and prospects. Media policy and media convergence has a long history and is multifaceted. Their coming together in various ways is summarised in a definition by UK academic Des Friedman. Whilst we have seen a lot of focus on technology and markets there has been limited focus on the control of regulation. Therefore, communication configuration policy has led to the media growth path taken. Competition growth is important and has been successful, but is this sufficient? New Liberalism and Media Convergence can make a difference.

Fibre optic technologies have led to big changes and the Internet is very important. The boundaries are disappearing and Social Media has only a fleeting variance between social interactions heavily underpinned by commercial needs. He contests that a) this is inevitable and b) challenge that it automatically drives behaviour. Visualisation driven image achievement is thought by some to be one of the effects of Social Media. Convergence is a process not a dystopian analysis.

His book suggests that policy solutions need to have flexible approaches, in use of infrastructure, mobility and spectrum use, with the public good at the forefront. Reconsideration of wireless should input have a public service option.

Network neutrality needs to be reviewed, is it a myth or a new and enlightened opportunity? The idea as a positive force has to be challenged. It may be useful to rework ideas derived from broadcasting. Public service should not escape control as a counter balance to the public support for media impartiality. There should be a levy of charge on those with significant market power and dominance of advertising mechanisms. We need to create a new public service publisher, who can be leveraged through points to compatibility. Strong solutions are needed. This idea originates with Ofcom.

As mentioned above, Seamus has recently written a book with Peter Humphreys which is titled, “Regulation, Governance and Convergence in the Media” and covers a series of policy directions and innovations that should be developed to fulfil the promise of media convergence.



Andy Valdar of UCL looked at “Important Developments in Telecommunications Network Architecture”.

Developments in network architecture have yielded change within the marketplace and often determine the success of new technologies. He defines the four main architectural views as being commercial, techno-regulatory, functional or virtual, and physical.

He saw six major drivers: the shift in the location of the User Network Interface (UNI), multiservice platforms, layering, virtualisation, convergence and programmability. The UNI incurs 70% of the total capital cost of provision and is the card terminating the subscriber's line. Significant cost savings are realised when this moves from the provider's to the subscriber's equipment.

Multiservice platforms offer capacity savings, improved cost resilience to forecasting and improved time to market. There are possible problems with quality of service and it can be difficult to replicate features. It is a bit of a "Swiss Army Knife"; it does everything but is the optimum solution to nothing. Such platforms make the IP switching of voice cheaper and are only possible due to the shift in the UNI and the implementation of a multiservice platform.

Layering allows splitting of the application and service plane, the control plane, the transport plane and the user plane. Time critical traffic is handled in the data plane and non-time critical traffic is managed in the control plane. Virtualisation in the form of NFV is powerful and abstraction of this makes use of CHOTS. ETSI have delivered a reference architecture. Network slicing is a further development that allows network capacity to be allocated on a per customer (segment) basis. Convergence takes platforms towards common control, with fixed mobile convergence being a good example. Programmability allows the dynamic re-routing of traffic, an example of this is LTE, which will be a network slice on the 5G network controlled by the Network Slice function.

Doug Williams of BT asked the question "Does exploding data drive a demand for Gigabit connections?" The analysis started by asking how much is enough bandwidth? Modelling HTTP interactions shows that the size and complexity of web pages is growing with the average size expanding to 2 M bytes in 2017. 3M of bandwidth is good enough to support video on demand. There is a Moore's Law equivalent that suggests the efficiency improvement in compression is about 5% per annum. Broadly, the quality falls into three standards: acceptable, very good and premium. Head mounted displays need additional bandwidth. Netflix publish stream width for each ISP. Broadcast values are going down. Encoding adds delay to and VoD's requirements make the case that huge bandwidth creates delay. Backup for operating systems and applications will require at least 300M by 2030. Game downloads are very big.

Hence, in the future 1G may be better. Future demands are likely to be:

	2017	2030
Regular requirement - Low	3M	30M
High	30M	70M
Occasional requirement - Low	20M	60M
High	70M	0.5 to 1 G

It is assumed that games will be distributed and file sizes will grow.

Jon Hart from BT described 5G Network Slicing and Convergence: Key technologies in Next Generation Networks. There is a growing demand for video driving mobile broadband. Voice revenues are declining. Digital transformation continues and autonomous connected vehicles are

on the horizon. These factors offer significant challenges for operators and network slicing by traffic type becomes vital, use of a separate network slice for the emergency services network is an example of how this has been achieved. For example, a network can be segmented with slices for smartphones, emergency services and autonomous vehicles. Each slice would support its own service levels. A mobile device would need the capability to allow it to connect to several network slices. There is some work going on in the IETF to define the Slice Packet Network SPN. Virtualisation of the network would primarily be achieved through network slicing, supported by edge computing. Ultimately, the latter is likely to extend to all of the end points.

Orchestration as a network management concept is important. It is likely management will be executed hierarchically with one major orchestrator, directing the work of domain centric orchestrators. A key issue is that a single network slice may traverse the networks of several orchestrators. There is currently an EU collaboration known as "Slice-net".

Convergence is a broad topic and includes customer service and platforms. The main area for attention is currently fixed, mobile convergence. A consistent user experience is required and parental controls are needed, as is seamless mobility. A single 5G core is needed to manage fixed and mobile.

He picked three examples to look at, the first being convergence, where the residential gateway has connectivity to the Broadband and 5G RAN. In the multi-connected example, the mobile device is a convergence point. Multi-access is essentially a private network that needs to be connected to broadband and a separate femtocell. The handling of a bandwidth burst, fast provisioning and symmetric bandwidth provisioning are key requirements.

The EU is looking at collaborative 5G X-Cast project that defines a unified delivery architecture, which can dynamically exploit unicast, multicast and broadcast delivery modes as well as local caching. This project has a wide range of collaborators and aims to create a seamless user experience.

Jon's conclusions were that 5G services present a huge opportunity and that slicing is vital in exploiting this. 5G presents a possibility for industry to define a flexible and modular architecture and the current cost base of fixed and mobile networks, suggests that fixed leads to cheaper provisioning.

Panel Discussion

Nigel Linge then chaired a **round-table** discussion with Andrej Dulka (CEO Alcatel-Lucent, Poland), Laurence Murphy (University of Salford), Andy Sutton (BT) and consultant George Williamson. Nigel asked the panel where we would be in 5 years. George reflected on his experiences ranging from System-X development, advanced processing customer equipment, OSS development, his time as Open Reach Chief Engineer and finally as an independent consultant. In the next five years, he saw coverage and capacity as big areas to address. A priority is to close the digital divide and set the right level of expectation. He used the analogy of the garden shed to describe network development. You build a garden shed for a specific purpose, but soon you find it's full of "stuff"

that other people have put there and that you know nothing about. Andy Sutton reflected on his experiences as the architect of mobile networks for major providers. He has oversight of an open-ended RAN. He has worked in this area since the mid1980s. The 5G roll out is a very significant development and will start in urban centres. He sees there will be specialist developments to support the rural networks. The need to address more verticals and a wider geographic spread leads to the need for more spectrum. There will be an auction next year of 700 MHz spectrum and plans for 26 GHz spectrum. The outcome of these will impact cell layers and we are likely to have to go to very small cells and some more bespoke solutions. The ability to support VR will be advantageous. The cost could be significant and it is necessary to link budget with business models and the need to support new applications. One customer takes a petabyte. EMVS could address retail and a hybrid fixed and mobile network is a possibility.

Andrej traced his path from gaining his Ph.D. to the evolution of his career in Nokia, where his job title remained consistent, as his company's ownership changed at least four times. He noted that 5G is not about media, it is about the connectivity of things, which can start to communicate and make decisions. There is a revolution in spectrum tenders. He talked about A.I. in terms of the American legend of John Henry, who proved he could outperform a steam hammer, but ultimately killed himself in the process. He reflected that Gary Kasparov had not been defeated by a machine, but by the combined efforts of engineers. How do we deal with A.I., five years can almost be considered an era, but the biggest problem is in educating ourselves. We need to prepare our children to exploit, but not to compete with the new technology. The pattern is that success is not achieved through fighting progress and the problems are caused by people. Engineers can no solve the human being.

Laurence thought that the next five years would be ground breaking for broadcast and media distribution generally. What standards are we going to look at? Resolution is a tangible problem. Change but depth. To cope with the added 10-bit HDR information is a fundamental building block. Next generation codecs will be interpretive and need to be fleet of foot. We continually add complications including 12-bit premium. The commercial model will ask the question how much bandwidth is sufficient and the ADSL argument will apply.

George noted that fibre competition in local access networks would be an issue. Fibre to the premise presents a competitive dynamic. We have three businesses running at different speeds: utility, electronics and service. Andy is excited about the opportunities that 5G will generate. Massive MIMO and spectral efficiency will generate significant efficiency. More opportunities will be generated, such as the emergency services network. OTT go through to be through the mobile suppliers.

Concluding Remarks

Millie Banerjee, who had been chair and mentor for organising the Congress, gave some concluding insights and remarks. She identified that collaboration will drive the next five years. There is a role for aggregators and regulators: our role and contribution as individuals is to think about our own responses to the changes. We are in a privileged position and have an obligation.

Professor Andy Valdar, President of FITCE formal closed the 57th FITCE Congress, by thanking the University of Salford for their hospitality, Nigel Linge for his pivotal role in making the congress happen and Pennine for their sponsorship. He also thanked the contributors and delegates for making the congress a success. Finally, he looked forward to the next congress in Ghent, which will be held on 25th to 27th September 2019 and will address Smart Cities and ICT.

Summary

In summary, the major conclusions of the Congress were:

- There is a growing dependence on Media and networks, creating both opportunities and challenges for telecommunications companies.
- The increase in take-up of video streaming and improvements in picture quality will drive up the bandwidth requirements.
- Virtual Reality is an important technology, which will drive some media companies to seek low latency network performance, particularly for games.
- Age demographics will play an important part the mix of media that has to be delivered.
- Users will want to access multiple devices simultaneously, emphasising Social Media's role as a hub technology.
- Programming needs to be centred on enhancing the viewer's experience, potentially using a blend of formats and presentations. Viewing on the move will become increasingly important.
- All of these trends create opportunities for developing services based on 5G mobile; however, the economics of roll out and the development of a low latency capability need particular attention. 5G is likely to become a significant transmission medium for video.
- The migration from LTE to 5G will be driven by commercial requirements and will therefore take an evolutionary rather than revolutionary path; building out from the 4G infrastructure.
- Streaming services are taking away customers from traditional broadcast, satellite and cable channels, causing speculation about the life expectancy of broadcast based distribution. Public Service Provision remains a highly desirable facet of the industry, even though the prime mode of distribution may change.
- Whilst there is an increasing level of viewing using smartphone devices, the majority of this takes place over the Wi-Fi channel rather than over a mobile network.
- The media market is changing rapidly as new entrants make an appearance. Agility in addressing markets is a key factor behind success.
- New formats such as UHD and HDR will enhance the viewing experience.
- Artificial Intelligence is deployed in the media in a number of cases and will be an important technology.
- Regulation has struggled to keep up with changes in the market and whilst it has focussed on promoting competition, there are issues about the abuse of significant market power and the impartiality, accuracy and balanced nature of some of the material shown. Key concerns around ethical use are being addressed, but slowly.

- Advertisers exert considerable influence in the marketplace and have significantly exerted pressure on platforms to remove questionable content, especially where it reflects on their product.
- The term event driven takes on a new meaning when applied to the media, since progress can be driven by major events such as the Champion's League final and the Tokyo Olympics.
- The academic world can provide insights that inform the commercial viewpoint, providing both out-of-the-box thinking and in-depth analysis on an unbiased basis.

Companion Programme

The two-day companion programme proved to be highly enjoyable. This started with a day trip to Quarry Bank Mill, which is particularly relevant to the story of Manchester and its evolution. The location houses the mill itself, gardens, a house and workers village. The Friday Morning saw a visit to the Lowry, providing a guided tour of the L.S. Lowry paintings. It is particularly interesting to note that the building of the Lowry, demonstrated the feasibility and attractiveness of redeveloping the Salford Quays and ultimately development of Media City. The afternoon was spent on a hop-on-hop-off bus site seeing tour of Manchester providing companions with the opportunity to select which aspects of the cities rich facilities they wished to see.

Quarrybank Mill

Quarry Bank Mill

The Lowry was also the location for the Gala dinner, which offered an excellent opportunity to socialise with the other delegates and to enjoy excellent good food and wine.

The Gala Dinner in the Compass Room, at the Lowry

Our thoughts to the 2019 conference, which will be held in Ghent between the 25th and 27th of September 2019, which has the theme Smart cities and ICT. We hope that with the support of both the FITCE and ITP boards, we will be able to build on the successes of Salford and make this a very strong Congress.