

Impact case study (REF3)

Institution: Kingston University		
Unit of Assessment: 11 – Computer Science and Informatics		
Title of case study: Using ubiquitous networks to produce novel communication capabilities and to improve quality of life		
Period when the underpinning research was undertaken: 2012 – 2017		
Details of staff conducting the underpinning research from the submitting unit:		
Names:	Roles:	Periods employed by submitting HEI:
Christos Politis	Professor of Wireless Communications, Director of Digital Information Research Centre	Sept 2007 – present
Vasilis Argyriou	Professor of Machine Learning	Sept 2009 – present
Maria Martini	Professor, Leader of the Wireless Multimedia and Networking Research Group	Aug 2007 – present
Period when the claimed impact occurred: Aug 2013 – 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Research by Kingston University (KU) into methods for building ubiquitous Mobile Ad-Hoc Networks (MANETs), quality of service in streaming, and machine learning have led to:

- the development of the Vocality RoIP—an advanced radio gateway, to support disaster relief efforts and emergency responders across the globe
- the founding of Ubitech Ltd., a network and software solutions SME
- the improvement of motor skills for over 1,000 children with cerebral palsy in 6 countries including Ireland, Spain, Ukraine, and Malaysia through a hospital gaming application
- contributions to new technological standards and EU 5G policy

2. Underpinning research

Mobile ad-hoc networks (MANETs) can provide a technical platform for efficient information sharing in emergencies, and other scenarios. This is because MANETs do not need pre-planned infrastructure, can form dynamically as required, and have the capacity to be secure. They are reliable for communication and data-sharing during disasters.

The underpinning research was undertaken by members of the Wireless Multimedia and Networking (WMN) Research Group, part of the Digital Information Research Centre (DIRC). WMN focuses on both fundamental and applied research of novel communication networks, with efficient delivery and high-quality streaming.

Research on the use of MANETs by Politis has addressed the challenges of finding general solutions for secure multimedia communication and of providing day-to-day communication for emergency teams. Politis has investigated using Distributed Hash Tables to enable utilisation of a distributed name resolution/data service, which is required owing to MANETs decentralised and self-organising nature. This enables innovative ubiquitous services by virtually organising a peer-to-peer overlay without the knowledge of the underlying network. Further investigations used MANETs for emergency communications, securing the routing protocol by asymmetric cryptography and designing device-to-device based communication for vehicular users, using the LTE band and a novel cognitive radio-based resource allocation scheme [R1, R2]. This research has been developed and applied through various FP7 projects such as PEACE project

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(2008 – 2011, IP-Based Emergency Applications and Services for Next Generation Networks), RESCUE (2013 – 2016, Links-on-the-fly Technology for Robust, Efficient, and Smart Communication in Unpredictable Environments), and SALUS (2013 – 2016, Security and Interoperability in Next Generation PPDR Communication Infrastructures), as well as an EPSRC project (EP/P028764/1) and currently through a Knowledge Transfer Partnership. The research established the use of MANETS for securely, silently, and seamlessly using underlying networks.

Addressing the quality of service and experience (QoE) and adding medical applications, research by Martini ensured stringent requirements in terms of network performance and capacity demands were met. Martini's research established that medical quality video streaming could be reliably compressed using high efficiency video coding HEVC, which facilitated almost lossless compression even with low available bandwidth [R3]. Based on properties of the human eye, they also proposed an edge-based reduced reference quality metric [R4] whose results correlate well with both subjective observations and commonly used full-reference metrics. This algorithm maintains fidelity, complexity, and low overheads, outperforming state-of-the-art metrics. Following research on the modalities to measure QoE in networks, they suggested their usage to adapt the transmission in wireless networks [R5]. They found this strategy delivered both delay-sensitive and delay-tolerant best effort traffic. Applied in projects such as Qualinet (COST, 2010 – 2014), OPTIMIX (FP7, 2008 – 2011, innovative solutions enabling enhanced video streaming for point to multi-point in an IP based wireless heterogeneous system), and QoE-NET (Horizon2020, 2015 – 2018, innovative QoE maNagement in Emerging mulTimedia services), this research demonstrates how multimedia QoE can be achieved across networks through innovative solutions.

Whilst this research has immediate application to communication products, one application of WMN's research has been the use of these high-quality, ubiquitous networks for educational games with medical applications. Research by Argyriou has investigated utilisation of Virtual Reality to act as an immersive technology, which, when combined with novel variations of medical tests, can evaluate and diagnose conditions like dementia [R6]. Additionally, he has led the development of a personalised communication environment that adapts to a user's personal profile based on neural networks and reinforcement learning methods [R7]. In the original study, the simulated agents adjusted their behaviour based on their individual goals and surroundings; this laid the groundwork for facilitating dynamic adaptation to patients' individual profiles in medical applications.

3. References to the research

R1 – D. G.C., A. Ladas, Y. A. Sambo, H. Pervaiz, **C. Politis** and M. A. Imran, "An Overview of Post-Disaster Emergency Communication Systems in the Future Networks," in *IEEE Wireless Communications*, vol. 26, no. 6, pp. 132-139, December 2019, DOI: [10.1109/MWC.2019.1800467](https://doi.org/10.1109/MWC.2019.1800467)

R2 – Mumtaz, S., Saidul, K., Ashraf, I., Monteiro, V., Rodriguez, J. and **Politis, C.** (2015) Cognitive vehicular communication for 5G. *IEEE Communications Magazine*, 53(7), pp. 109 – 117. ISSN (print) 0163 – 6804 DOI: [10.1109/MCOM.2015.7158273](https://doi.org/10.1109/MCOM.2015.7158273) REF2ID: [11-48-1376](#)

R3 – Razaak, M., **Martini, M.G.** and Savino, K. (2014) A study on quality assessment for medical ultrasound video compressed via HEVC. *IEEE Journal of Biomedical and Health Informatics*, 18(5), pp. 1552 – 1559. ISSN (print) 2168 – 2194 DOI: [10.1109/JBHI.2014.2326891](https://doi.org/10.1109/JBHI.2014.2326891) REF2ID: [11-40-1372](#)

- The main reference in the Qualinet* Working Group on medical imaging

R4 – **Martini, M.G.**, Hewage, C. and Villarini, B. (2012) Image quality assessment based on edge preservation. *Signal Processing: Image Communication*, 27(8), pp. 875 – 882. ISSN (print) 0923 – 5965 DOI: [10.1016/j.image.2012.01.012](https://doi.org/10.1016/j.image.2012.01.012)

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R5 – Khan, N. and **Martini, M.G.** (2016) QoE-driven multi-user scheduling and rate adaptation with reduced cross-layer signaling for scalable video streaming over LTE wireless systems. EURASIP Journal on Wireless Communications and Networking, Article 93
DOI: [10.1186/S13638-016-0584-6](https://doi.org/10.1186/S13638-016-0584-6)

R6 – Fernandez, J. M. and **Argyriou, V.** (2017) Cognitive evaluation for the diagnosis of Alzheimer's disease based on Turing Test and Virtual Environments. Physiology & Behavior, 173, pp. 42 – 51. ISSN (print) 0031 – 9384 DOI: [10.1016/j.physbeh.2017.01.034](https://doi.org/10.1016/j.physbeh.2017.01.034)
REF2ID: [11-03-1337](https://doi.org/11-03-1337)

R7 – Jablonski, K., **Argyriou, V.** and Greenhill, D. (2014) Crowd simulation for dynamic environments based on information spreading and agents' personal interests. Transportation Research Procedia, 2, pp. 412 – 417. DOI: [10.1016/j.trpro.2014.09.046](https://doi.org/10.1016/j.trpro.2014.09.046)

* *QUALINET (European Network on Quality of Experience in Multimedia Systems and Services), coordinates European Quality of Experience (QoE) research, with membership across the globe. It aims at extending the notion of network-centric Quality of Service in multimedia systems, by relying on the concept of QoE, (<http://www.qualinet.eu>).*

Key Grants

A Knowledge Transfer Partnership between Kingston University and Cubic Defence UK Limited: KTP010071, funded by Innovate UK, awarded to Professors Brujic-Okretic, Martini and Politis; GBP133,866.00 between June 2015 and September 2018

A Horizon 2020 project coordinated by Rovira i Virgili University, Spain: GAmeficiation for a BEtter Life (GABLE), ID 732363, ran from November 2016 to October 2019 and had an overall budget of €1,320,650. Kingston University participated through Ubitech Limited, an SME founded by Politis Ubitech received €187,468.75 as participants.

4. Details of the impact

Kingston University's research has led to beneficial impacts on two businesses and their clients, on the quality of life of children with cerebral palsy, and on technological standards and policies.

Vocality RoIP: Development of an Advanced Radio Gateway

In 2016, Vocality International Ltd., now Cubic Mission Solutions, started a KTP with Kingston University to expand their portfolio of secure critical communication solutions. Vocality wanted to profit from Politis' research on secure, ubiquitous device-to-device communication using MANETs and Martini's research on maintaining QoE. This would secure solutions that allowed new and legacy devices to communicate and enhance quality monitoring and optimal data bearer selection.

After acquisition by Cubic Corporation, the KTP's focus shifted specifically to its new Vocality RoIP advanced radio gateway, for which the development was underpinned by the following achievements of the KTP **[S1]**:

- the addition of a dynamic routing solution that enabled the RoIP to offer the same capabilities as legacy devices
- the monitoring and evaluation of the signal quality of the wireless bearer
- the enhancement of the automated multi-bearer switching logic as a key technology to ensure reliable communications for new and future devices in competitive markets

The Vocality RoIP was launched in March 2017, an advanced radio gateway supporting wireless communication using the dynamic routing solution and automated multi-bearer switching feature started and developed in the KTP and based on Kingston research **[R1]**. These features equip the device to allow multiple handsets to be connected locally in an existing SIP network, and provides answers to common challenges such as beyond line-of-sight communication and cross-banding interoperability. The product's data sheet **[S3]** promotes the multi-bearer as a front-page software option. As highlighted in an April 2017 white paper 'Seamless secure communications for vehicles and mobile teams' **[S2]**, Cubic also saw the potential for both MANETs and multi-bearers in future products, with applications for law enforcement, military,

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and other first responders to danger or relief zones. Vocality RoIP has been sold across the world, from Italy to Canada, with a new expansion module launched in February 2019. The product has been used by:

- Overwatch Aero LLC, to aid airborne communication and tactical support to emergency responders
- The organisation Help.NGO's Disaster Response Team, to allow immediate team coordination between different sites in the Bahamas, following Hurricane Dorian which left more than 70,000 people homeless in the country,
- Hospitals, to create a single, unified solution across various radio system manufacturers during the coronavirus crisis.

Foundation and Growth of Ubitech Ltd

Ubitech Ltd., an innovative SME engaging in R&D in the field of wireless communications and machine learning, was founded in 2011 by Politis and his PhD student, Dr Ramrekha. It employs 7 people including 2 full-time employees, and has also fed back into teaching and career development, having welcomed 7 KU students as interns and currently funding a PhD. Turnover has grown by 140% (from GDP29,212, to GDP68,811) in 3 years, with a profit of GDP16,915 in 2018 – 2019.

Ubitech developed the UBINET platform, supported by a GDP130k grant by TSB and a €4.4M FP7 project (RESCUE, 2013 – 2016). The platform offers a ubiquitous network of smart devices through which users can communicate with each other without the requirement of a network provider or an access point. One platform app is UbiMessenger, which enables peer-to-peer local communication within Wi-Fi range, with over 10000 downloads from Google Play [S4]. Ubitech has been involved in other EU projects, including GAME-ABLING, 2012 – 2014 (€1.5 million), and GABLE, 2016 – 2019 (€1.3 million).

Improving the Motor Skills of Children with Cerebral Palsy

Cerebral Palsy (CP) affects 17 million people worldwide, causing difficulties with body movement and balance. The EU-funded projects GAME-AMBLING and GABLE enhanced the living conditions of 5 – 18-year-olds with CP through gamification. An online platform for accessible games that improves skills and coordination (using the Nintendo balance board) was designed.

UbiTech developed the backbone of the system's communication environment whilst Argyriou's machine learning allowed dynamic adaptation to the players' individual profiles, providing a high degree of personalisation. A paediatrician at the International Clinic of Rehabilitation in Ukraine commented how Ubitech '*made our work easier*' through '*visualisation of the analytics*' and '*interaction tools for end users*' [S5]. The Managing Director of Ubitech, reflected "*Several KU researchers [brought] their expertise and skills to the project*" and noted, "*not only his reputation but, specifically 'Christos' [Politis] expertise and experience contributed to the success of the GABLE project*" by enabling the development of "*the web platform and client application where the GABLE games reside*" [S6]. He went on to reveal that Ubitech are "*in discussion with a number of medical institutions, including a large London specialist school, to roll out the platform*" [S6].

A pilot study in 2017 showed that after two-week training in the experimental group TCMS [Trunk Control Measurement Scale], scores increased by 4.5 points (SD = 3.5, p<0.05) and DBT [Dynamic Balance Test] results increased by 0.88 points (IQR = 1.03, p<0.05). In the control group, changes were not significant.

From 2018, over 1000 children with CP took part in a fortnight of daily rehabilitation gaming sessions. All the therapists said that there were improvements in balance functions, that the games helped achieve therapeutic goals, with comments such as "*movements became more precise and smooth*" and that "*most of the children enjoyed the games much more than typical physical therapy.*" [S7] Parents and patients both describe how the platform "*improves coordination of movement*" and how the games "*entertain and relax*" the children. Afterwards, each child was offered home access to continue benefitting from their therapeutic effects in home settings. All responding parents said their children would continue playing the games, one saying "*training combining with games is the best way of rehabilitation*" [S7].

The platform has been used in 9 institutions treating children with CP in 6 countries: four clinic

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and rehabilitation centres in Ukraine, two in Spain, St. Gabriel's School & Centre (Ireland), the University of Malaya (Malaysia), and Kathmandu University (Nepal) [S8]. At the moment field trials are underway in the UK in 1 [clinic](#) and 2 specialist schools ([The Pace Centre](#) and [The Orchard Hill Academy](#)). The GABLE Games have been awarded for social impact by the Social Council of the Universitat Rovira i Virgili, and the study's results disseminated at a health-sector round table in the New York, and meetings of both the 29th and 30th European Academy of Childhood Disability in Amsterdam and Tbilisi, respectively, featuring a wide range of clinicians, therapists, and social workers.

Technological Impact

As part of Politis' research on MANETs, he developed the Chameleon (CML) protocol that is currently being considered (draft stage) as a new standard by the Internet Engineering Task Force (IETF) [S9]. Moreover, 5GIA [S10], his contributions to the white paper for the EU, has informed the EU's 5G policy work.

5. Sources to corroborate the impact

S1 – Kingston University - Vocality Limited KTP report

S2 – White Paper: 'Seamless secure communications for vehicles and mobile teams'

S3 – Vocality RoIP Data Sheet

S4 – [Ubi-Messenger](#)

S5 – Testimonial from a paediatrician at the International Clinic of Rehabilitation

S6 – Testimonial from the Ubitech Managing Director

S7 – GABLE Report: [D5.3](#)

S8 – [Ubi-Balance](#)

S9 – [ChaMeLeon](#) (M-CML): A multipath hybrid routing protocol for MANETs, IETF meeting 103rd, Bangkok, Thailand, 3 – 9 November 2018

S10 – '5G empowering vertical industries' Paper