# iCIRRUS

**intelligent Converged network consolidating Radio and optical access aRound USer equipment**

**DELIVERABLE: D6.4**

**Final Dissemination, Communication, Standardisation and Exploitation: Plan and Report of Activities**

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<td>Coordinator:</td>
<td>Nathan Gomes, University of Kent, Canterbury, UK</td>
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<tr>
<td>Authors / contributors (contributing partners)</td>
<td>PTL, UniKent, WT, ORANGE, IDCC, HHI, UESSEX, ADVA, TS, VIAVI, IAF</td>
</tr>
<tr>
<td>Internal reviewers</td>
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Document history

Version 0.1: 26/10/2017 Table of contents
Version 0.2: 1/11/2017 Inclusion of Dissemination activities
Version 0.3: 1/12/2017 Inclusion of Standardisation activities
Version 0.4: 15/12/2017 Inclusion of Communication activities
Version 0.5: 30/12/2017 Inclusion of Exploitation Plans
Version 0.6: 15/01/2017 Updates on Exploitation Plans
Version 0.7: 30/01/2017 Abstract, Introduction and Conclusions
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Abstract

This is the final deliverable on Dissemination, Communication, Standardisation and Exploitation activities of the iCIRRUS project with a focus on the achievements of Year 3 (1/1/2017-31/12/2017) but also containing a short summary of the overall outcomes of the project.

The first section lists the various dissemination outcomes of Year 3 summarising also the outcomes since the beginning of the project. The next section describes the standardisation activities and new updates that occurred in Year 3 contributing to the associated standardisation bodies.

The deliverable then lists the exploitation plans of each partner, where for the industrial partners the lean business canvas was used as a guide, in order to achieve a common derivation methodology for all partners.

The final part of the deliverable provides a detailed description of the communication activities undertaken in Year 3 of the project with some illustrative examples of specific events.
## Index of terms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3GPP</td>
<td>3rd Generation Partnership Project</td>
</tr>
<tr>
<td>5G</td>
<td>5th Generation</td>
</tr>
<tr>
<td>C2C</td>
<td>Clone to Clone</td>
</tr>
<tr>
<td>CHARISMA</td>
<td>Converged Heterogeneous Advanced 5G Cloud-RAN Architecture for Intelligent and Secure Media Access</td>
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<tr>
<td>D2D</td>
<td>Device to Device</td>
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<tr>
<td>DMP</td>
<td>Data Management Plan</td>
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<td>EC</td>
<td>European Commission</td>
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<tr>
<td>ECOC</td>
<td>European Conference on Optical Communication</td>
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<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EUCNC</td>
<td>European Conference on Networks and Communications</td>
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<tr>
<td>ICTON</td>
<td>International Conference on Transparent Optical Networks</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>IET</td>
<td>Institution of Engineering and Technology</td>
</tr>
<tr>
<td>MWC</td>
<td>Mobile World Congress</td>
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<tr>
<td>OFC</td>
<td>Optical Fiber Communication</td>
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<tr>
<td>NFOEC</td>
<td>National Fiber Optic Engineers Conference</td>
</tr>
<tr>
<td>OSA</td>
<td>Optical Society</td>
</tr>
<tr>
<td>PIMRC</td>
<td>Personal, Indoor and Mobile Radio Communications</td>
</tr>
<tr>
<td>PPP</td>
<td>Public Private Partnership</td>
</tr>
<tr>
<td>VTC</td>
<td>Vehicular Technology Conference</td>
</tr>
<tr>
<td>WWRF</td>
<td>Wireless World Research Forum</td>
</tr>
</tbody>
</table>
Contents

Document history _________________________________________________________________ 2
Abstract ________________________________________________________________ 3
Index of terms _____________________________________________________________ 4
1. Introduction _________________________________________________________________ 7
2. Dissemination Activities ______________________________________________________ 8
   2.1. Journal and Magazine Publications __________________________________________ 8
   2.2. Conference Publications __________________________________________________ 9
   2.3. Book Chapters _________________________________________________________ 11
   2.4. Invited Presentations ___________________________________________________ 11
   2.5. Activities and plans for liaisons with other projects __________________________ 12
   2.6. Public iCIRRUS Deliverables ______________________________________________ 13
3. Communication Activities ______________________________________________________ 14
   3.1. iCIRRUS website updates ________________________________________________ 14
   3.2. Brochure Update _______________________________________________________ 14
   3.3. iCIRRUS Social Network Page Updates ______________________________________ 15
   3.4. Individual Consortium Partner Pages Updates ________________________________ 15
   3.5. Events attended _______________________________________________________ 16
   3.6. Events planned ________________________________________________________ 18
   3.7 Other Publicity and Visibility ______________________________________________ 18
4. Standardisation Activities ______________________________________________________ 20
   Key standardisation activities in Year 3 __________________________________________ 20
5. Exploitation Planning _________________________________________________________ 23
   5.1. Industrial Exploitation _____________________________________________________ 23
       5.1.1. Wellness Telecom Exploitation Plan ______________________________________ 23
       5.1.2. ADVA Optical Networking SE (ADVA) _____________________________________ 27
       5.1.3. Orange S.A. (Orange) _________________________________________________ 28
       5.1.4. Telekom Slovenije, d.d. (TS) ____________________________________________ 28
       5.1.5. PrimeTel PLC (PTL) ___________________________________________________ 29
       5.1.6. Viavi Solutions (VIAVI) _________________________________________________ 30
       5.1.7. IAF GmbH Future Radio Technology (IAF) _________________________________ 35
       5.1.8. InterDigital Europe LTD (IDCC) _________________________________________ 38
   5.2. Academic Exploitation ____________________________________________________ 39

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
5.2.1. University of Kent (UniKent) ................................................................. 39
5.2.2. Fraunhofer Heinrich-Hertz- Institute (HHI) ............................................ 40
5.2.3. University of Essex (UEssex) ................................................................. 41
6. Conclusion ........................................................................................................ 43
List of Figures ....................................................................................................... 44
List of Tables ........................................................................................................ 44
Appendix I ............................................................................................................ 45
Appendix II .......................................................................................................... 47
1. Introduction

D6.4 provides a summary report on the dissemination, standardisation, exploitation, communication tasks and activities and outcomes achieved in Year 3 of the iCIRRUS project (1/1/2017-31/12/2017).

Associated outcomes of Year 1 and Year 2 have already been summarised and can be found in D6.2 [D6.2] and D6.3 [D6.3] respectively. This deliverable reports on the outcomes of Year 3. It is broken down into 4 main sections one for each task starting with dissemination.

In the dissemination section, this deliverable summarises all dissemination outcomes that took place in Year 3 with a list of all international conferences attended, scientific journals and magazine articles published, book chapters, invited talks, and publications at relevant workshops and special sessions. It also includes a short summary of all project dissemination outcomes to get an idea on the total number of publications of the project, the overall visibility and contribution to the research community.

The second section describes the updated exploitation plans of each consortium partner. In the case of the industrial partners, the lean business canvas was recommended as a guide, in order to arrive at a coherent template that could be more understandable, including by the rest of the consortium. The lean business canvas provided by the common exploitation booster was utilised for this purpose.

The third section of the deliverable gives a short summary of the different updates and contributions that took place at the standardisation bodies from iCIRRUS participants in Year 3. Besides contributions to the various bodies, this engagement ensured the alignment of the project with standardisation activities as well.

In the fourth section, the deliverable describes the various communication activities which further supported the visibility of the project in the community and reaching a wider audience. This included, but was not limited to, the use of project brochures, project website news, updates on company sites, existing projects’ social network pages and industrial workshops.

The final section provides the conclusions of this work together with a brief consideration on future plans.
2. Dissemination Activities

In the following subsections, the dissemination activities of Year 3 are described. These include any research outcomes undertaken in the form of Journal Publications, Conference Publications, Invited Presentations, and books.

Table 1 summarizes the dissemination activities of iCirrus since the beginning of the project.

<table>
<thead>
<tr>
<th>Publications</th>
<th>2015</th>
<th>2016</th>
<th>2017+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal &amp; Magazines Publications</td>
<td>1</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Conference Publications</td>
<td>0</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Invited Presentations</td>
<td>0</td>
<td>17</td>
<td>10(^1)</td>
</tr>
<tr>
<td>Book Chapters</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Notice that in Year 3 more emphasis was given in producing high quality journals as the project was at a more mature stage and subsequently had obtained more representative and complete set of results.

2.1. Journal and Magazine Publications

The number of iCIRRUS journal publications increased dramatically during the final year of the project. The total number of papers published in journals is 13, with 10 of these published during the final 12 months. It has to be noted that all journals are top tier journals (or magazines) with a high impact factor including two papers at IEEE Journal on Selected Areas in Communications, two papers at IEEE/OSA Journal of Lightwave Technology, two at IEEE Wireless Communications Magazine, two at IEEE/OSA Journal of Optical Communications and Networking and one in IEEE Transactions on Wireless Communications. Below is a complete list of the journal and publications accepted in Year 3:


\(^1\) 3 more Invited Presentations to be presented in 2018
2.2. Conference Publications

iCIRRUS partners published more than 20 conference papers during year 2 and a similar number in year 3. During year 3, iCIRRUS was present at the most significant optical communications conferences (OFC 2017 and ECOC 2017) and the most significant communications/wireless communications conferences (ICC 2017 and Globecom 2017). Two posters (C15 and C18) can be found in Appendix 1: C15 was presented by iCIRRUS at the ECOC 2017, and C18 at the International Symposium on Wireless Communication Systems (ISWCS 2017) in Bologna, Italy. iCIRRUS was also present at EuCNC with contributions to a joint workshop together with H2020 5G-Crosshaul and H2020 5G-Xhaul project, a booth dedicated to iCIRRUS and poster presentations (see more in Section 2.5 and Section 3). Below is a list of all conference papers published and presented in Year 3:


C20. G.S. Birring, P. Assimakopoulos, N.J. Gomes, An Ethernet-Based Fronthaul Implementation with MACPHY Split LTE Processing, Globecom, Singapore, 4-8 December 2017, doi: 10.1109/GLOCOM.2017.8254712


2.3. Book Chapters

One book chapter was also accepted for publication as part of the book “5G System Design: Architectural and Functional Considerations and Long Term Research” (ISBN: 978-1-119-42512-0) edited by Patrick Marsch, Ömer Bulakci, Olav Queseth, Mauro Boldi and expected to be published in April 2018:


2.4. Invited Presentations

Besides the aforementioned conference publications, a number of invited presentations also took place in year 3 and these are listed here:


P5. V Jungnickel, Considerations for mm-wave fronthaul/backhaul, in EuCNC Workshop 9, Millimetre-wave technology for 5G access, fronthaul and backhaul, Oulu, Finland, 12 June 2017.


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2.5. Activities and plans for liaisons with other projects

iCIRRUS was active in 2017 establishing liaisons with a number of other EU projects including H2020 5G-Crosshaul and H2020 5G-XHaul. In fact, a number of the aforementioned invited presentations in Section 2.4 took place at the joint workshops together with H2020 5G-Xhaul and H2020 5G-Crosshaul projects at the EUCNC 2017 conference. In Section 3, some snapshots from the co-organised workshops between the three projects are shown.

Figure 3 shows the combination of an Ethernet-based convergence layer for fixed and mobile services with an agile WDM access layer. ADVA Optical Networking demonstrated the successful pairing of key technologies from the iCIRRUS and 5G-Xhaul projects at the BT innovation week in June 2017.

A similar set-up is planned to be demonstrated at the ADVA booth at Mobile World Congress 2018.

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2.6. Public iCIRRUS Deliverables

The vast majority of iCIRRUS deliverables were designated for public dissemination and can be accessed via the website’s ‘Media Centre’ page. The following deliverables were submitted during 2017:

D2.3 - iCIRRUS Techno-Economic Analysis and Business Case

D3.3 – SLA and SON Concept for iCIRRUS

D3.4 – Updated Low-Cost Energy Efficient Fronthaul Architecture

D4.2 - Joint Resource Management and Cooperative Allocation

D5.1 – Methods, Materials and Platforms for Testing of High Bandwidth Mobile Wireless Solutions

D5.2 – Tools, Scenarios and Results Analysis Methods for Validation Test

D5.3 – Validation Test Setup and Execution Report

D6.3 – 2nd Year Dissemination, Communication, Standardisation and Exploitation: Plan and Report of Activities
3. Communication Activities

This section highlights the different communication activities that took place in Year 3 of iCIRRUS. The consortium continued to provide regular updates through the project website, brochure, project social pages, individual company pages, and through various events.

3.1. iCIRRUS website updates

The iCIRRUS website is available at [www.icirrus-5gnet.eu](http://www.icirrus-5gnet.eu) and has been live since the beginning of the project. The ‘Activities’ and ‘Media Centre’ pages are updated regularly. The former to reflect meetings, workshops and conferences that iCIRRUS members have taken part in and the latter listing publications, deliverables and open data when they are published.

![Figure 2 iCirrus Website ongoing updates](image)

3.2. Brochure Update

The iCIRRUS brochure was updated in Year 3 especially to support the visibility of the project at the EUCNC 2017 event, where it was distributed to a large number of participants. Whilst still providing a
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Similarly, other consortium partners have promoted the iCIRRUS outcomes of 2017 on their Company Websites and Social Pages (see example in Figure 4).

3.5. **Events attended**

iCIRRUS was represented at a number of events during 2017. The list includes:

- Session during a national infoday event in Madrid in January 2017
- Open EUREKA Innovation week in Barcelona, 15-19 May 2017
- Net Futures 2017 in Brussels in June 2017
- Nordic Edge Expo with Microsoft Azure in Norway in September 2017 (Figure 5)
- Smart City Expo World Congress in Barcelona in November 2017

![Nordic Edge Expo y Microsoft Azure](image_url)
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The iCIRRUS project was also represented at the 2017 edition of ECOC, Europe’s largest conference on optical communications, being held from 17-21st September in Gothenburg, Sweden. Nathan Gomes (University of Kent) presented a poster entitled ‘Effects of contention and delay in a stitched Ethernet evolved fronthaul for future cloud-RAN applications’. The Special ECOC Symposium in Copenhagen, Denmark on EU-overseas research strategy (14-15 September 2017) was a separate event but linked to the main conference and Howard Thomas from Viavi Solutions, gave a talk on ‘The iCIRRUS project: Ethernet in the evolved fronthaul’.

3.6. Events planned

At Mobile World Congress 2018, which takes place in Barcelona from Feb 26th to March 1st, participants will be able to inform themselves first-hand about the iCIRRUS project and its results. Placed at the heart of ADVA Optical Networking’s booth, touch screens provide a direct entry point to watch the iCIRRUS video, visit the website or download publications (Figure 8). Converged Ethernet technology as promoted by the iCIRRUS project can also be seen live in action in a combined front- and backhaul demo. More information on the event will be shared at the final project review meeting.

3.7 Other Publicity and Visibility

An article was published in Lightwave-online: ADVA Optical Networking tests time sensitive Ethernet for 5G fronthaul with TransPacket IP cores [Online]. Available:

Telekom Slovenije produced a video for the iCIRRUS project, summarizing the concepts and key achievements (at a high level for public consumption). The video incorporates real-life footage of iCIRRUS researchers at work on the integrated showcase demonstration with illustrative imagery and footage to aid public understanding. It can be viewed on YouTube:
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4. Standardisation Activities

Several partners of the iCIRRUS consortium continued to be heavily engaged in associated standardisation forums and represented the consortium in these. One of the main aims during participation was the attempt to support suggestions proposed in the standards with ideas that were backed up with validated outcomes and results of the iCIRRUS project.

Key standardisation activities in Year 3

Described below are the main activities that took place in Year 3 activities in the various standardisation bodies:

Standardisation FSAN/ITU-T SG15Q2

G.Sup.5GP: architecture & functional splits have now been comprehensively covered in an ITU-T SG15 Q2 supplement document based on the lead of ZTE and Huawei. The title of this document is “5G Wireless Fronthaul Requirements in a PON Context”. This supplement enumerated the various requirements arising from 5G wireless systems, concentrating on the fronthaul portion of the network, and considers how they compare with current and future optical access transport systems. Practical passive optical network solutions to serve the 5G fronthaul application were hypothesized. The last discussions concern:

- Collection of necessary line rates and delay allowance has been made across standards bodies, but there is little faith that they can be compared because of mismatching definitions and service dependent
- E2E or User experience values are available including from ITU-R
- A possible joint meeting with Q.11/Q.13 might consolidate gathered material on 5G
- Target for consent for G.Sup5GP and the Cooperative DBA is set to October 2018’s SG15 plenary

A 5G survey questionnaire has been launched by AT&T for all FSAN operators

3GPP

In 3GPP, IDCC provided novel contributions on the mmW-based uplink and downlink beam management procedures aiming high-throughput eMBB communications. Additional contribution on link recovery for improved error performance is also submitted to 3GPP.

R1-1714143 On efficient UL beam management
R1-1714170 Common and Beam Specific Power Control Parameters
R1-1718482 Remaining issues on beam management
R1-1718483 Remaining issues on beam failure recovery

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IEEE1904.3 (RoE) / IEEE1914 (NGFI)

IEEE P1914.1 is the standard for (next-generation) packet-based fronthaul transport networks. It describes use cases, scenarios, architecture, and network and node requirements. It defines different transport service classes and maps them to the front-haul interfaces between the radio and distributed unit (NGFI-I) as well as between the distributed unit and the central unit (NGFI-II). The last technical inputs were received in 2017 and the standard is expected to be completed by end of 2018.

IEEE P1914.3 (ex1904.3) is the standard for Radio Over Ethernet (RoE) encapsulations and mappings. It includes three operational modes: A (protocol) structure-agnostic mapping, a (CPRI) structure-aware mapping, and native RoE encapsulations and mapping for transport of IQ in time and frequency domain. P1914.3 is an advanced state, its approval is expected 2018.

iCIRRUS was represented in a number of work group face-to-face meetings with active and productive participation. During this past year, the work carried out within iCIRRUS concerning Ethernet fronthaul delay modeling and time-sensitive networking was presented to participants of the WG as an input to the first draft of the IEEE 1914.1 standard.

IEEE 802.1

IEEE P802.1CM has progressed to Sponsor Ballot stage in IEEE 802.1, and is expected to be completed during 2018. The purpose of this project is to enable the transport of time-sensitive fronthaul streams in Ethernet bridged networks. The standard will define profiles that select features, options, configurations, defaults, protocols and procedures of bridges, stations and LANs that are necessary to build networks that are capable of transporting fronthaul streams, which are time sensitive. Class 1 requirements refer to legacy CPRI streams. In 2017, the draft standard has been extended to include requirements for eCPRI transport as Class 2. 802.1CM profiles IEEE 802.1Q and its amendments, specifying two fronthaul profiles: Profile A is based on bridging with strict priority queuing. Profile B adds frame preemption.

ITU-T Q13 (Synchronisation and Timing)

ITU-T Q13 focuses on network synchronization and time distribution performance. Network synchronization performance specifications are essential for successful operation of digital transmission networks including the support of, for example, mobile networks. Network timing performance standards are necessary to define the feasibility and most effective means of implementing a time reference distribution service. This includes the distribution of both precision time and frequency. Current work items include:
- Time transport for the Partial timing support
- Enhanced SyncE and new time sync architectures
- Sync OAM and Management

The most relevant recommendations the group is working on are:
- ITU-T G.8262 Timing characteristics of a synchronous Ethernet equipment slave clock.
- ITU-T G.8262.1 Timing characteristics of an enhanced synchronous Ethernet equipment slave clock (EEC). (draft recommendation)
- ITU-T G.8264 Distribution of timing information through packet networks.
- ITU-T G.8272.1 Timing characteristics of enhanced primary reference time clocks.
- ITU-T G.8273.2 Timing characteristics of telecom boundary clocks and telecom time slave clocks.
- ITU-T G.8273.3 Timing characteristics of telecom transparent clocks.
- ITU-T G.8275.1 Precision time protocol telecom profile for phase/time synchronization with full timing.

The following documents have been prepared in 2017 and are expected to be consented in 2018: G.8264 Amd1, G.8266 Amd1, G.8271 Amd2, G.8271.1 Amd1, G.8271.2 Amd1, Revision of G.8273, G.8275.1 Amd2, and G.8275.2 Amd2.

**IEEE 1588**

The v2.1 revision of the IEEE 1588 standard (currently in advanced working group ballot stage) will add various features to the IEEE1588v2 protocol, which devices or more importantly profiles for specific applications (e.g. telecom) can incorporate. Enhancements include performance monitoring, ultra-high accuracy metrics, security and redundancy options. The next version may pass working group ballot. Sponsor ballot could then finalize this year, offering the opportunity for an approved standard by end of 2018 or early 2019.

**IETF 100**


IDCC contributed also, on the investigation of SDN based and URL-based transport of service function chain operations in the edge network. See [https://tools.ietf.org/html/draft-khalili-optimized-service-function-chaining-00](https://tools.ietf.org/html/draft-khalili-optimized-service-function-chaining-00) for the associated IETF draft.

**ESTI ZSM**

5. Exploitation Planning

This section describes the exploitation plans by all consortium partners. It is split into industrial and academic exploitation subsections for clarity.

5.1. Industrial Exploitation

For the industrial exploitation plans the lean business canvas was utilized as recommended by the common exploitation booster. An example of the Template used is shown in Figure 8.

![Lean Business Canvas](image)

This allows all consortium companies to derive their business exploitation plan with a common methodology making it also easier for other departments (e.g. business department) and/or investors to realise.

5.1.1. Wellness Telecom Exploitation Plan

Wellness Telecom (WT) is an innovative small ICT company, specialized in new technologies that offers solutions to its customers throughout the entire life cycle, from design to maintenance and support. Customers often rely on Wellness Telecom services to manage their security requirements.

WT has a complete catalogue of services and solutions, adapted to companies and organizations’ needs in order to improve their efficiency and competitiveness such as communications consultancy, unified communications or cloud computing services.

WT mainly targets two business sectors related to the iCIRRUS topics as described below:

**Network and IT Systems**

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
• WT offers an expert comprehensive consultancy service on telecommunications and IT Systems.
• WT provides tangible solutions on deployment and maintenance of infrastructures, no matter the size.
• WT assists companies to offer the best service, to improve their productivity and to save costs.

Cloud Computing

• WT created the first cloud in the South of Spain
• Companies can contract IT resources Systems can be deployed rapidly, both infrastructure and software solutions

Wellness Telecom could envision cloud services business cases based on the reuse of the clone as a cloud infrastructure (developed in iCIRRUS project - backhaul).

Mobile Cloud Market

Cloud computing offers myriad benefits to customers: scalable storage, flexibility according to current needs, transparent updates and maintenance, ubiquity and close collaboration of distributed teams, etc. Although cloud computing can offer benefits to any person in his daily life, businesses from multinationals to SME (Small and medium-sized enterprises) are evolving and improving together with this technology: we could say that cloud computing is to the 21st century what electricity was to the 20th, as it’s revolutionizing the way we do business. Furthermore, cloud computing is a rapidly growing business: IDC predicts that the public cloud market will grow from around $48 billion today to $130 billion by 2018.

In particular, Mobile Cloud market includes a combination of cloud computing, mobile computing and wireless technologies and networks to enhance the computational power. The beneficiaries of the technology mainly are the mobile/smartphone users, network operators and cloud service providers, since the smartphone, tablet and cloud computing technologies are converging into the new mobile cloud market. It is estimated a growth of this market from US$ 9.46 billion in 2014 to US$ 38.48 billion in 2020.

WT approach exploits this next statement as market driver: apart from functional improvements, smartphone users can also benefit from the power available in clouds, ranging from enhancements of compute power and battery life through computation and communication offloading to the improvement of data services. In the framework of iCIRRUS, WT is implementing a mobile cloud clone as an IaaS, with the following purposes:

• Increase UE’s battery life, optimizing power consumption.
• Augment processing capacity of the UE, thanks to the offloading of heavy tasks to its cloud clone.
• Optimize UE’s memory usage, as multimedia content can be stored in the mobile clone. This way, content can be shared with other device or clone directly from the cloud.
• Reduce server overload, by means of cooperative caching.

The following section will deal with a detailed overview of WT clone services business cases.
Exploitation related to the WT business case 1: Clone as an IaaS

As a CSP, WT is interested in providing a Mobile Clone Service to complete its offer and catalogue for one of its key clients: communications operators. This business case gives the Communications Operators the business opportunity to foster the provision of this service to their clients and to keep their infrastructure up-to-date. This service is aligned with WT’s strategy as a CSP, becoming a key product in order to define a penetrating commercial strategy towards Communications Operators, see Table 1.

**Table 2: Business Case 1: Clone as an Infrastructure.**

<table>
<thead>
<tr>
<th>Product</th>
<th>IaaS. Clone as an Infrastructure.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business model</td>
<td>B2BC</td>
</tr>
<tr>
<td>Final user</td>
<td>Mobile customers</td>
</tr>
<tr>
<td>Target client</td>
<td>Communications Operator</td>
</tr>
<tr>
<td>Marketing channels</td>
<td>Operator channels</td>
</tr>
<tr>
<td>Sales channels</td>
<td>WT channels: the operator is more than a client, a key partner to reach final user</td>
</tr>
</tbody>
</table>

**Main advantages for the client**

- Distinctiveness: value added for final users (battery life and storage of multimedia content). Improved loyalty policies.
- Cost reduction: efficient usage of bandwidth.
- Optimization of resources for processing tasks.
- Adaptation to new solutions and trends: mobile clones may progressively become a commodity, required by final users.

**Revenue Streams**

- 4G and 4.5G that adopts the 5G
- Customers who offloads applications to the cloud

**Differential value proposition**

Compared with an alternative approach, such as Mobile Bank-end as a Service, iCIRRUS clone-based solution is enriched by the implementation of an intelligent system in the cloud, able to perform a real-time analysis of traffic and load. Indeed, iCIRRUS solution provides an offloading task as a controlled, intelligent process, designed to improve the performance of the system, without causing any disturbance.

Exploitation related to the WT business case 2: Corporate Mobile Clone

The second business case focuses on a solution for corporate environments. “Corporate Mobile Clone” is a new service for those companies that want to improve their Enterprise Mobility Management (EMM). Our proposal is based on the concept BYOM: the employees are invited to use their own mobile devices at work, by means of a partition aimed at host all the corporate information and tools. In this way, all the corporate content is contained in the mobile clone, while the employee can access it through his or her own mobile device by the use of corporate tools. This corporate content is kept safe in the cloud, easily deployed in a new mobile device and rapidly updated and maintained without the
need to perform any action on every mobile device. Additionally the content could be removed or anonymized (clone disassociated from the device) when the employee leaves the enterprise.

This service perfectly fits into WT’s commercial offer. In fact, Wellness Telecom already provides a specific service aimed at preserving organizations’ data, by means of back-up copies conveniently saved and protected, as knowledge and information is a key resource for any company. With this new service, WT will provide a global, on-trend solution, aimed at satisfying the new needs born from mobility trends, as it is based on cutting-edge, sustainable technologies, with a promising evolution within the following years. The business exploitation plan can be seen in Table 3.

Table 3: Business Case 2: Corporative Mobile Clones.

<table>
<thead>
<tr>
<th>Product</th>
<th>Corporative Mobile clone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business model</td>
<td>B2B</td>
</tr>
<tr>
<td>Final user</td>
<td>Employee using his own mobile device</td>
</tr>
<tr>
<td>Target client</td>
<td>Companies interested in Enterprise Mobility Management:</td>
</tr>
<tr>
<td></td>
<td>• MDM: mobile device management</td>
</tr>
<tr>
<td></td>
<td>• BYOD: Bring your own device</td>
</tr>
<tr>
<td></td>
<td>• EMM: Enterprise mobility management (e.g. IBM)</td>
</tr>
<tr>
<td>Marketing channels</td>
<td>WT channels</td>
</tr>
<tr>
<td>Sales channels</td>
<td>WT channels</td>
</tr>
<tr>
<td>Main advantages for the client</td>
<td>• Control of corporate resources</td>
</tr>
<tr>
<td></td>
<td>• Security</td>
</tr>
<tr>
<td></td>
<td>• Productivity: easy deployment of corporative tools in every new device.</td>
</tr>
<tr>
<td></td>
<td>• Employee’s satisfaction: the company does not impose the use of a specific device.</td>
</tr>
<tr>
<td>Revenue Stream</td>
<td>• 4G and 4.5G that adopts the 5G</td>
</tr>
<tr>
<td></td>
<td>• Company interested in bringing its data to the Cloud</td>
</tr>
<tr>
<td>iCIRRUS exploitation</td>
<td>Expansion of the iCIRRUS results</td>
</tr>
<tr>
<td></td>
<td>• Adaptation of current functionality for corporative purposes</td>
</tr>
<tr>
<td></td>
<td>• Need to add IT security functionality, developed by WT, in order to protect corporative resources.</td>
</tr>
</tbody>
</table>

**Differential value proposition**

Based on the previous analysis, we consider that virtualization tools applied to corporate environments are direct competitors for this business case, as they come to solve the same specific need, from a functional point of view. However, our clone-based solution includes an additional intelligence, as the system will evaluate and analyse the suitability of offloading a certain task. In addition to that, it does not only observe the situation of the device or the characteristics of the specific task, also the situation of the network and servers that are supposed to support the process. Therefore, our solution can guarantee efficiency and a good user experience, as it considers the network.
5.1.2. ADVA Optical Networking SE (ADVA)

The business exploitation plan of ADVA is summarised in Table 4 utilising the lean business canvas. The table provides the technological advances to be offered by ADVA, the target clients and how they will benefit from this and the revenue streams for the company.

Table 4 ADVA’s business exploitation summary using the lean business canvas.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 5G driven by diverse set of services (eMBB, uRLLC, mMTC)</td>
<td>• Converged x-haul solution for 5G and legacy services</td>
</tr>
<tr>
<td>• 1000x capacity &amp; devices. 1/5x latency, 5 nines reliability</td>
<td>• Time-sensitive Ethernet, precision timing &amp; open SDN control</td>
</tr>
<tr>
<td>• Today’s x-haul networks lack capacity and do not scale</td>
<td>• Network probes for assured delivery of data, control &amp; timing</td>
</tr>
<tr>
<td>• Different technologies in fronthaul &amp; backhaul</td>
<td>information</td>
</tr>
<tr>
<td>• Missing tools for operation &amp; optimization</td>
<td>• Edge computing option for NFV</td>
</tr>
<tr>
<td>Problem</td>
<td>Alternative Solution</td>
</tr>
<tr>
<td>• #1 in Ethernet access devices</td>
<td>• Live with bottlenecks</td>
</tr>
<tr>
<td>• #2 in precision timing solutions</td>
<td>• Deploy dedicated point solutions where necessary</td>
</tr>
<tr>
<td>• Cross-selling opportunities to 250 operators and 10,000 enterprises</td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td>Key Metrics</td>
</tr>
<tr>
<td>• Market share</td>
<td>• Market share</td>
</tr>
<tr>
<td>• Revenue &amp; profit</td>
<td>• Revenue &amp; profit</td>
</tr>
<tr>
<td>• # of customers</td>
<td>• # of customers</td>
</tr>
<tr>
<td>Competitive advantage</td>
<td>Business model</td>
</tr>
<tr>
<td>• One zero-touch network solution for all fiber-based x-haul deployments</td>
<td>• B2C</td>
</tr>
<tr>
<td>• High resource efficiency at low operational costs</td>
<td>• B2B</td>
</tr>
<tr>
<td>• Flexible adaptation to changing traffic patterns and services</td>
<td></td>
</tr>
<tr>
<td>• Additional monetization opportunities by service assurance &amp;</td>
<td></td>
</tr>
<tr>
<td>optimization</td>
<td></td>
</tr>
<tr>
<td>Main advantages for the client</td>
<td>Target client</td>
</tr>
<tr>
<td>• One zero-touch network solution for all fiber-based x-haul deployments</td>
<td>• Service providers</td>
</tr>
<tr>
<td>• High resource efficiency at low operational costs</td>
<td>• Mobile equipment vendors</td>
</tr>
<tr>
<td>• Flexible adaptation to changing traffic patterns and services</td>
<td>• System integrators</td>
</tr>
<tr>
<td>• Additional monetization opportunities by service assurance &amp;</td>
<td>• Enterprises</td>
</tr>
<tr>
<td>optimization</td>
<td></td>
</tr>
<tr>
<td>Revenue Streams</td>
<td>Channels</td>
</tr>
<tr>
<td>• Equipment</td>
<td>• Direct sales</td>
</tr>
<tr>
<td>• Software licenses</td>
<td>• OEM partners</td>
</tr>
<tr>
<td>• Customer services</td>
<td>• Value added resellers</td>
</tr>
</tbody>
</table>

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
5.1.3. Orange S.A. (Orange)

Orange’s rollout of FTTH is ramping up. Our ducts are more and more filled with optical fibers. 5G is coming with phase 1 and phase 2 trials. If the 5G promise is a “fiber-like mobile user experience”, massively, new antenna sites will require a fiber connectivity. 5G is making disruptive evolution for fixed access network:

- on technologies: keeping backhaul plus fronthaul high and low layer split
- traffic: throughput, latency,…
- topology densification: number of antennas in macro cells and small cells scenarios

The standardization process for 5G is ongoing at 3GPPP. A working supplement document on fixed access technologies standardization was initiated at FSAN, ITU SG15 and BBF. NTT, China mobile, Vodafone, SKT, China Telecom, are active on this topic in standardization.

For Orange, I-Cirrus project is the opportunity to update and challenge our analysis based on technical features. Here, in this project, the opportunity to used Ethernet for either low or high layer split over a 100GEth line rate fixed optical interface. We also use the opportunity of this project to involve in standardization program. Orange has also in parallel of this project, launched internal lab and field trials with our RAN vendors of 4G+ and 5G with or without virtualization features in different countries and cities. I-Cirrus lessons help us to focus the technical specifications for transport of our internal trials.

5.1.4. Telekom Slovenije, d.d. (TS)

The business exploitation plan of Telekom Solenjie is summarised in Table 5 utilising the lean business canvas. The table provides the technological advances to be offered by TS, the target clients and how they will benefit from this and the revenue streams for the company.

Table 5: TS’s business exploitation summary using the lean business canvas.
### Solution
- Next Generation of more flexible mobile network 5G
- Improved resource management
- Adaptive network technology – pay as you grow/need
- Improved, adaptive coverage (SON)
- IoT support
- Added value services

### Alternative Solution
4.5G

### Key Metrics
- Traffic/device
- Price/bits
- New services annual growth (e.g. IoT, security, reliability)

### Business model
- B2C
- B2B
- Prepaid nad postpaid users
- Professional users

### Target client
- Advanced consumers
- Innovative industry

### Channels
- Customer service department
- Industry partners
- Marketing department

### Main advantages for the client
- Best mobile network services
- Integration to the fixed network
- Established and running business environment

### Revenue Streams
- Restructuring the infrastructure
- Deployment costs
- Marketing costs
- Customer service
- Employee training

### Cost Structure
- Revenues from existing/4G, fixed network and new that adopt the 5G
- New plans for 5G usage

### 5.1.5. PrimeTel PLC (PTL)

The business exploitation plan of PrimeTel is summarised in Table 6 utilising the lean business canvas. The table provides the technological advances to be offered by PTL, the target clients and how they will benefit from this and the revenue streams for the company.

*Table 6: PTL’s business exploitation summary using the lean business canvas.*

### Problem
- Technology (3G obsolete, 4G can’t response Need for faster telecommunication to upcoming/growing needs)
- Bad resource distribution & management
- More and more mobile devices are used
- IoT
- More real-time apps are used

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
<table>
<thead>
<tr>
<th>Mobile data usage growth</th>
<th>Next Generation telecommunications technology 5G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited coverage</td>
<td>Hundreds of thousands of simultaneous connections to be supported</td>
</tr>
<tr>
<td></td>
<td>Improved resource management</td>
</tr>
<tr>
<td></td>
<td>Spectral &amp; signaling enhanced efficiency</td>
</tr>
<tr>
<td></td>
<td>Higher data rates</td>
</tr>
<tr>
<td></td>
<td>Improved coverage</td>
</tr>
<tr>
<td>Solution</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Alternative Solution    | 4.5G                                           |
|                         |                                               |

| Key Metrics             | # customers interested/1 month |
|                         | # customers that adopt 5G/3 months |
|                         | # of new customers               |
|                         |                                               |

| Unfair Advantage        | Offers 4G, 4.5G and own optical network         |
|                         | If it’s offered by PTL first in Cyprus. Technology knowhow |
|                         | Very well established customer base             |
|                         |                                               |

| Business model          | B2C                                           |
|                         |                                               |

| Target client           | PTL’s mobile customers (40k)                   |
|                         | Other’s mobile providers customers due to improved service |
|                         |                                               |

| Channels                | Customer service department (directly through shops, etc.) |
|                         | Upgrade plans for PTL’s existing customers (3G & 4G)       |
|                         | Marketing Department                                      |
|                         |                                               |

| Main advantages for the client | Best mobile network services |
|                               | (Fastest, Best coverage, More throughput, Better resource utilization, Uninterrupted) |
|                               |                                               |

| Revenue Streams            | Revenues from (existing/4G and new) that adopt the 5G |
|                           | New Plans for 5G usage                           |
|                           |                                               |

| Cost Structure            | Restructuring the infrastructure                |
|                           | Deployment costs                                 |
|                           | Marketing costs                                  |
|                           | Customer service employee training               |
|                           |                                               |

5.1.6. **Viavi Solutions (VIAVI)**

The business exploitation plan of PrimeTel is summarised in Table 7 utilising the lean business canvas. The table provides the technological advances to be offered by PTL, the target clients and how they will benefit from this and the revenue streams for the company.
Table 7: VIAVI’s business exploitation summary using the lean business canvas.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Explosion in mobile data demand, collapse in revenue/bit</td>
<td>• Split RAN, to enable scalable architecture &amp; increased of COTS h/w</td>
</tr>
<tr>
<td>• Net neutrality v paid-for access</td>
<td>• TSN to enable Ethernet to support split RAN</td>
</tr>
<tr>
<td>• IoT</td>
<td>• Ethernet transport: for resilience &amp; lower cost</td>
</tr>
<tr>
<td>• More and more mobile devices are used</td>
<td>• Standardized open interfaces to increase competitive pressure</td>
</tr>
<tr>
<td>• Poor resilience</td>
<td>• Joint RAN + transport automation /SON</td>
</tr>
<tr>
<td>• High CAPEX and OPEX</td>
<td>• Network slicing</td>
</tr>
<tr>
<td>• Vast range of service QoS requirements</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternative Solution</th>
<th>Key Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increase cell density</td>
<td>• # operators interested/12 months</td>
</tr>
<tr>
<td>• Add WiFi</td>
<td>• # operators adopt Lab/Field test 18 months</td>
</tr>
<tr>
<td>• Accept degradation of user experience</td>
<td>• # operators adopt joint optimisation 24 months</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sustainable Advantage</th>
<th>Customer segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Established relationship with operators</td>
<td>• Lab test (equipment vendor or operator</td>
</tr>
<tr>
<td>• Established relationship with n/w vendors</td>
<td>• Field deployment (operator)</td>
</tr>
<tr>
<td>• Best in class geolocation</td>
<td>• Network optimisation (operator or network manager)</td>
</tr>
<tr>
<td>• Best in class assurance</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Early adopters</th>
<th>Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Existing vendors with 4G Lab/Field test</td>
<td>• Equipment resellers/rental &amp; direct sales for Lab/Field test</td>
</tr>
<tr>
<td>• Existing operators with 4G optimisation</td>
<td>• Direct optimisation sales</td>
</tr>
<tr>
<td></td>
<td>• Indirect optimisation sales via managed service providers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unique value proposition</th>
<th>Revenue Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Lab/Field test:</td>
<td>• Equipment sales to developers and integrators of virtualized/functional split RAN and TSN transport (Lab-test and field)</td>
</tr>
<tr>
<td>• Most flexible split RAN test solution, early to market</td>
<td>• * Product/service to Operators for optimisation (or managed service providers).</td>
</tr>
<tr>
<td>• Joint optimisation:</td>
<td>• Sales infrastructure as a service (IaaS) suppliers</td>
</tr>
<tr>
<td>• Best geolocation, best joint optimisation solution, with big data analytics</td>
<td></td>
</tr>
<tr>
<td>• Integration with virtualisation and automation solutions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost Structure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Analytics virtualisation infrastructure</td>
<td></td>
</tr>
</tbody>
</table>
The Network and Business Service Enablement unit (NSE) that is leading VIAVI engagement with iCIRRUS supplies products and solutions help service providers and IT organisations optimise and maintain complex networks. Supporting them with solutions for test and measurements, service activation and assurance, and performance management. Customers include mobile network operators, telecommunication network equipment vendors, service providers, enterprises, and cloud providers.

Our customers’ success depends on their ability to manage their future. 5G, NFV, and virtualisation are arriving – to be successful they need to manage complex networks, simplify the skillset of their workforce, reduce CAPEX and do more with fewer people. NSE helps our customers conquer these challenges by delivering integrated solutions that provide reliable real-time intelligence.

Viavi solves performance visibility challenges for its customers; for service providers this involves visibility solutions for fibre to the antenna, ethernet mobile backhaul, 1G to the home, and assurance of customer experience; for network equipment manufacturers this involves managed services, platforms to support NFV/SDN, and visibility to small cells; for the enterprise this involves migration to the cloud, app performance, distributed antenna, small cell and WIFI access, convergence of communications and IT, and security; for cloud providers this involves scale and WAN connectivity, compute and storage assurance, bring your own device, and software as a service.

This visibility is delivered by three complimentary product portfolios adapted to the scale and business life-cycle of each opportunity; the respectively customer segments are “field and lab instruments,” “assurance solutions,” and “enterprise and cloud performance management.”

As a provider of field and lab test instruments VIAVI is interested in providing instruments with capabilities tailored to meet the emerging needs of network equipment vendors and operators as Ethernet based fronthaul is introduced into 5G and even 4.5G network deployments. This offering is aligned with VIAVI’s strategy to service this potential market that is dependent on the standards that are defined and their market traction.

Table 8 Ethernet fronthaul field and lab instrument business case

<table>
<thead>
<tr>
<th>Product</th>
<th>Ethernet fronthaul field and lab instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business model</td>
<td>B2B</td>
</tr>
<tr>
<td>Final user</td>
<td>Cellular Network Managers, Network equipment vendors</td>
</tr>
<tr>
<td>Target client</td>
<td>Cellular Network Managers, Network equipment vendors</td>
</tr>
<tr>
<td>Marketing channels</td>
<td>VIAVI, reseller/rental partner</td>
</tr>
</tbody>
</table>

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
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<table>
<thead>
<tr>
<th>Sales channels</th>
<th>VIAVI, reseller/rental partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main advantages for the client</td>
<td>• Cost reduction and risk control: Flexible split RAN test solution, reduce cost and risk of development and deployment</td>
</tr>
<tr>
<td>Revenue Streams</td>
<td>• Equipment sales to developers of virtualized/functional split RAN and TSN transport</td>
</tr>
<tr>
<td>iCIRRUS exploitation</td>
<td>iCIRRUS results provides a 6-12-month head start in the technology analysis phase, giving readiness and awareness of pitfalls if, for example, the market were to select TSN, TWDM etc, for Ethernet fronthaul.</td>
</tr>
</tbody>
</table>

The field and lab instrument portfolio addresses laboratory development of products, their deployment to the field and, trouble-shooting; examples are illustrated in Figure 9. The products used in iCIRRUS from this portfolio were the MTS 5800 to provide and analyse CPRI test vectors and precise timing for PTP and TSN testing; the ONT to provide test vectors for the 100G FH aggregation; and CellAdvisor to trouble shoot LTE s/w radio deployment.

As a provider of assurance and optimisation solutions for cellular networks VIAVI is interested in providing solutions with capabilities tailored to meet the emerging needs of network equipment vendors and operators as Ethernet based fronthaul is introduced into 5G and even 4.5G network deployments. This offering is aligned with VIAV’s strategy to service this potential market that is dependent on standards, as they become defined, and subsequent market traction.

Table 9 Ethernet fronthaul field and lab instrument business case

| Product | Joint Ethernet fronthaul and RAN assurance/optimisation solutions |

Figure 10 Field test and Measurement

The field and lab instrument portfolio addresses laboratory development of products, their deployment to the field and, trouble-shooting; examples are illustrated in Figure 9. The products used in iCIRRUS from this portfolio were the MTS 5800 to provide and analyse CPRI test vectors and precise timing for PTP and TSN testing; the ONT to provide test vectors for the 100G FH aggregation; and CellAdvisor to trouble shoot LTE s/w radio deployment.

As a provider of assurance and optimisation solutions for cellular networks VIAVI is interested in providing solutions with capabilities tailored to meet the emerging needs of network equipment vendors and operators as Ethernet based fronthaul is introduced into 5G and even 4.5G network deployments. This offering is aligned with VIAV’s strategy to service this potential market that is dependent on standards, as they become defined, and subsequent market traction.

Table 9 Ethernet fronthaul field and lab instrument business case

| Product | Joint Ethernet fronthaul and RAN assurance/optimisation solutions |

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
Business model | B2B
---|---
Final user | Network optimizer, marketeer
Target client | Network Operator, Managed service provider
Marketing channels | VIAVI, Managed network service provider, Assurance partners
Sales channels | VIAVI, Managed network service provider, Assurance partners
Main advantages for the client | • Cost reduction and risk control: Joint visualisation of FH and RAN performance and joint optimisation, reduce cost and risk of network operation, and provide accurate performance monitoring
• Differentiated service: 5G assisted bulk geo-location
Revenue Streams | • Product and service sales of joint FH & RAN optimisation
• Sales of FH enriched geolocated data feeds to marketeers
iCIRRUS exploitation | iCIRRUS results provides a 6-12-month head start in the optimisation scenario discovery phase, giving readiness and awareness of pitfalls if, for example, joint FH + RAN optimisation became a critical requirement.

The assurance solution portfolio addresses performance management and root cause analysis and solution of network issues on an on-going basis the portfolio addresses performance measurement, visualisation and optimisation of mobile networks; example products are illustrated in Figure 10. The product deployed in iCIRRUS from this portfolio was packet portal measurement probe. Additionally, the potential use cases for joint FH and RAN optimisation using enhanced versions of ariesoGEO was investigated in depth considering different FH architectures and RAN configuration.

![xSIGHT](image1.png)
![ariesoGEO](image2.png)
![PacketPortal](image3.png)

*Figure 11 Assurance Solutions*
Moreover Viavi has filed an additional two patents that are:

“Enhancing network topology information for a self-organising network,” which is aimed at expanding the optimisation of a mobile radio network to include optimisation of the “network topology.” Briefly, the invention relates to enhancing network topology information for a self-organizing network. A device may obtain network topology information that identifies a set of nodes of a network and one or more physical links between nodes of the set of nodes. The set of nodes may include one or more base stations, one or more mobile devices, and one or more network resources. The device may provide the network performance information to cause a change in the network. This represents a potential new product with and new market with an estimated size of 100-250M Euro.

“Packet colouring for data stream monitoring,” which is aimed at enabling performance KPIs to be measured using the actual user data packets rather than by sporadic insertion of operations and maintenance packets. Briefly, the invention relates to being able to generate colouring on an individual packet stream to perform monitoring and ability to effectively determine various set of parameters of the traffic such as latency, packet loss and delay with high accuracy and low effort. Can be utilized for a range of use cases in SON, Performance management and Troubleshooting. This represents a potential new product and new market with an estimated size of 25-100M Euro.

5.1.7. IAF GmbH Future Radio Technology (IAF)

The company IAF is a developer of system solutions for future wireless standards. Our main fields of work are hardware development, digital signal processing algorithm development and system integration.

Within iCIRRUS the work of IAF includes the hardware development and production of the iCIRRUS FPGA platform and the development and implementation of signal processing algorithms for the Ethernet based fronthaul.

The iCIRRUS FPGA hardware platform has been used together with the partners ADVA, TS, HHI and UniKent for realisation of their testbeds.

The exploitation of the research and development within the iCIRRUS project (Table 11) finally leads to the following industrial product:

**Hardware Product: F-PU-5G - 5G Development and Prototyping Platform**

The 5G development platform with embedded ComExpress computer mainboard is most suitable for many applications in the area of 5G mobile communication:

- Low latency CPRI /Ethernet conversion based on synchronized Ethernet technology
- Software defined base station development with 5G enhancements like new fronthaul via Ethernet with functional split
- Software Defined Radio Head development for 5G mobile communication
- Media conversion 10G Ethernet/100 G Ethernet / CPRI
- Open air interface implementation with FPGA-driven hardware acceleration
- Cloud RAN
- Synchronized Ethernet, PtP based time synchronisation
- 100 Gb Ethernet aggregation
- High Bandwidth Phy and MAC Signal Processing (60 GHz Radio Access)

The 5G development platform combines Xilinx Ultrascale FPGA with embedded COMExpress processor boards and 100G Ethernet connectivity.
The platform has been created for development and prototyping of 5G key technologies like 'Cloud RAN', 'Ethernet fronthaul', '100Gb Sync Ethernet' and 'Software Defined Base Station Development'.

The unique value proposition is based on the following properties:

The F-PU-5G enables to use one Prototype Solution for implementation of several 5G related technologies. The platform combines high performance hardware and software processing and is most suitable for realization of flexible and scalable prototype solutions.

The market is characterized by low volume but high quality. Customers will use the platform for a long time period and for several projects and applications.

Marketing channels are:

- Research projects like iCIRRUS
- Direct marketing via IAF Internet website
- Demonstrations and Exhibitions

Table 10: IAF’s business exploitation summary using the lean business canvas.

| Problem | • Development of Prototype Solutions for 5G related technologies  
|         | • Research results have to be tested and verified under real conditions  
|         | • Development effort and time has to be reduced |
| Solution | • 5G Development platform |

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
### Alternative Solution
- High Processing Power
- Flexible Configuration
- Handling high transmission data rate in realtime
- Reuse of existing IP

### Key Metrics
- Handle data rate of 100 GBPS
- Ethernet Fronthaul
- Sync Ethernet

### Unfair Advantage
- Established in research community
- High complexity requires particular knowledge

### Business model
- B2B

### Target client
- Research Institutes and Universities
- Equipment Manufacturer

### Early adopters
- Research Institute which needs to test and verify results in practice

### Channels
- Research projects
- Internet website
- Demonstrations and Exhibitions

### Main advantages for the client
- One Prototype Solution for implementation of several 5G related technologies
- Platform combines high performance hardware and software processing
- Flexible and scalable solution

### Revenue Streams
- Hardware platform sale
- Development of customized solutions

### Cost Structure
- Hardware and software development cost
- Customer support costs
### 5.1.8. InterDigital Europe LTD (IDCC)

The business exploitation plan of InterDigital is summarised in utilising the lean business canvas. The table provides the technological advances to be offered by PTL, the target clients and how they will benefit from this and the revenue streams for the company.

*Table 11 Interdigital’s business exploitation summary using the lean business canvas.*

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Incapability of conventional core networks to carry out ultra-high speed and low-latency communications</td>
<td></td>
</tr>
<tr>
<td>• Existing end user address based communications, e.g. cloud controlled IP based communications, not being scalable due to explosion in the content</td>
<td></td>
</tr>
<tr>
<td>• Substantial decrease in revenue per bit</td>
<td></td>
</tr>
<tr>
<td>• Difficulty of mobility management for the small cells</td>
<td></td>
</tr>
<tr>
<td>• Monolithic architecture of end-user devices, e.g. mobile phones</td>
<td></td>
</tr>
<tr>
<td>• Difficulty of incorporating end-user devices into the virtual fabric of infrastructure systems</td>
<td></td>
</tr>
<tr>
<td>• Migrate the high complexity functionality of core networks to edge nodes</td>
<td></td>
</tr>
<tr>
<td>• Enable content based packet trafficking, instead of address based transport</td>
<td></td>
</tr>
<tr>
<td>• Integrate end-user devices into to edge and core network virtualization fabrics</td>
<td></td>
</tr>
<tr>
<td>• Introduce end-user device clones in the edge networks in order to reduce access network traffic and improve security</td>
<td></td>
</tr>
<tr>
<td>• Enable multi-purpose hardware and operating system paradigm at the end user devices</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternative Solution</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Move from micro-cells towards nano-cells</td>
<td></td>
</tr>
<tr>
<td>• Introduce operating-system only virtualization technology to majority of mobile devices</td>
<td></td>
</tr>
<tr>
<td>• Impose new revenue models for the usage of edge network resources</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key Metrics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• # of mobile devices with virtualization capability/36 months</td>
<td></td>
</tr>
<tr>
<td>• Virtual mobile devices licensing revenue/ 60 months</td>
<td></td>
</tr>
<tr>
<td>• Revenue/bit</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sustainable Advantage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Leading technology provider in standards</td>
<td></td>
</tr>
<tr>
<td>• Established licensing relationship with all major vendors</td>
<td></td>
</tr>
<tr>
<td>• Solid existing patent portfolio</td>
<td></td>
</tr>
<tr>
<td>• Strong position in contributing to future technology directions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Customer segments</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• End-user terminal suppliers</td>
<td></td>
</tr>
<tr>
<td>• Network vendors</td>
<td></td>
</tr>
<tr>
<td>• Operators</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Early adopters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Existing terminal suppliers</td>
<td></td>
</tr>
</tbody>
</table>

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
• Existing vendors with 5G facilities

| Channels       | • Standard contributions  
|               | • Direct communications with the hardware and operating system suppliers  
|               | • Technology fairs

| Main advantages for the client | • Novel revenue models  
|                               | • Seamless integration of network and end-user terminal devices for novel applications  
|                               | • Improved maintenance of end user services

| Revenue Streams | • Technology licensing  
|                | • IP module sales

| Cost Structure | • R&D cost  
|               | • HW and SW virtualization testing platforms  
|               | • Industry fair participation costs  
|               | • marketing costs

5.2. Academic Exploitation

5.2.1. University of Kent (UniKent)

In iCIRRUS, the University of Kent has developed an advanced laboratory testbed for Ethernet fronthaul/xhaul with SDN control, if necessary, and with probing for accurate packet delay/delay variation measurements, together with analytics. It has also advanced algorithmic work for cellular-assisted device-to-device operation and produced novel analyses for C-RAN energy efficiency and low-complexity beam allocation for massive MIMO. As a research-led teaching institution, the University exploits this work through:

- Involving PhD students in the work being undertaken: two PhD students, in particular, have been closely linked with the iCIRRUS work, although not funded by it: Mr M K Al-Hares and Mr Y Kai.
- Involving project students (3rd year, 4th year undergraduate and MSc) in the work being undertaken, giving them an opportunity to interact with researchers and better understand how research laboratories operate. In total, 3 4th year project groups (12 students), and around 4 undergraduate students and 4 MSc students have benefited from this, during iCIRRUS.
- More generally, creating awareness among the student cohort of the research being undertaken, and of the progress in 5G research, standardisation and trials. This has been done in lectures, particularly at the more advanced level, by the academic staff involved in iCIRRUS, and by seminars given by external speakers.
The work carried out in iCIRRUS will also be exploited in future projects. The results and knowledge of iCIRRUS have been exploited for the joint major project, just funded by Chinese government, entitled “Smart and dynamic self-organizing networks for emergency communications”, in which there are six partners, including UniKent as an international partner. Funding applications have been/are being submitted for UK funding (from the Department of Media, Culture and Sport), and to EU 5G PPP infrastructure calls. It is envisaged that our current testbed will be upgraded with 5G waveform capabilities in the coming year in its contribution to these projects. Approaches from industry for direct funding of future work are also being explored. We will continue to look for industry partners who can commercially exploit our work and use the business outreach unit at the University of Kent to help us with this.

5.2.2. Fraunhofer Heinrich-Hertz- Institute (HHI)

Fraunhofer HHI has had significant outcomes from the iCIRRUS project. Those are for example:

- The development of a real-time fronthaul system using a new functional split, based on Ethernet. This included the development of the respective node, namely: central unit (CU), distributed unit (DU) and end user device (UE). The UE has been connected to the DU using 60GHz mmW links using transmitter and receiver boards from iCIRRUS partner UEssex.
- The CU is based on a Kintex FPGA, 10G Ethernet backhaul and fronthaul connectivity using SFP+ modules. The DSP performs the following main functions, reception of standard Ethernet frames, FEC, mapping, framing and transmission of fronthaul frames.
- The DU is also based on a Kintex FPGA together with a 10G-fronthaul interface (SFP+). The baseband signal are provided by means of 2.5GSa/s ADC and DAC subsystems.
- The UE was based on an old (existing) design using Virtex6 FPGAs, which was adapted to the requirements of the new functional split.
- Further, HHI has experimentally investigated high-speed data transmission for optical fronthaul on backhaul links using the multiplex of different OFDM signals. Here, data rates of 150 Gb/s and more could be reached.
- HHI compared the transmission of analogue and digital fronthaul signal over optical fibres.
- Fraunhofer has participated in IEEE 802.15.7r1 standardisation, covering VLC-based fronthaul links.

The exploitation of the achievements in the project covers the following items:

- Fraunhofer HHI is currently discussing, if general purpose IP cores can be marketed via our partner MLE over the Xilinx website, similar to existing IP core products.
- HHI plans to use the know-how and the outcomes of the project to acquire new projects with industrial and research partners.
- The results have been published at major conferences and there has been a master thesis on the comparison of analogue and digital fronthaul.
- Fraunhofer HHI has participated in the final demo at TS labs
- Fraunhofer HHI plans to setup a 5G demo site and testbed in Berlin, together with industrial and research partners

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526
These activities follow the innovation and exploitation strategy that the outcome of research projects is used to strengthen relation with industrial partners and to increase the portfolio of advanced solutions that can be brought to the market.

5.2.3. University of Essex (UEssex)

In the iCIRRUS project, the University of Essex has acted as a partner involving two laboratories, and developed a mobile cloud computing/network testbed and a 60 GHz device-to-device (D2D) communication testbed. The mobile cloud testbed incorporates the demonstrators of task offloading and video streaming to illustrate the benefits for the mobile phone users and mobile network operators. Several theoretical works have also been conducted to propose the advanced algorithms to optimise resource allocation and energy efficiency in the C-RAN. As a research-led teaching institution, the University has exploited this work through:

- The iCIRRUS testbed that was demonstrated in the Open Day of the University of Essex.
- Involving PhD students in the work being undertaken: one PhD student, Mr C. Magurawalage, has been closely linked with the iCIRRUS work, although not funded by it.
- Involving MSc students in the work being undertaken, giving them an opportunity to interact with researchers and gain a better understanding of how research laboratories operate.

As an institute of academic learning, UEssex performs the role of teaching of fundamental and new knowledge to the next generation of researchers, who will go on to apply the latest knowledge and know-how as gained from iCIRRUS into new products and techniques at their places of work to transform the knowledge into commercially successful products. It is also to be expected a proportion of these next-generation of researchers will continue the basic innovation process, either through their PhD or post-doctoral research, or within industrial research laboratories.

From the work emerging from the iCIRRUS project, UEssex has included the important outputs into their Bachelor of Engineering (BEng) courses, and also to postgraduates in their Master of Engineering (MEng) taught and research courses. In particular, the lecture courses on Telecommunications and Network Principles have benefited from the knowledge accrued during iCIRRUS. Results from iCIRRUS have also been deployed in various final undergraduate and masters (MEng) research projects. There has been a successful PhD thesis written by D. Terry Quinlan on “Microwave Antenna Modelling” based on much of the wireless (microwave and millimetre wave) antenna research undertaken at UEssex during iCIRRUS. As part of its PhD award programme, UEssex is also joining with British Telecom to bid for as a UK Doctoral Training Centre specialising in 5G telecommunications and networking technologies.

UEssex has extensive relationships with network equipment suppliers both nationally and across Europe, and so the participation of UEssex in iCIRRUS has led to improved relationships with external suppliers such as Siklu, and ARC Basildon, which provides secure network recovery functionalities (e.g. for London, by storing and updating an digital image of London, and offering a network recovery time of only 10 seconds).
UEssex is also exploiting its participation in iCIRRUS to form the basis of future projects and proposals. For example, UEssex is closely involved in UK-based Knowledge Transfer Partnerships (KTPs) with local businesses (e.g. LPA Connect Ltd., and ABER Ltd. who are developing RF engineering products) in order to assist the incorporation of the emerging 5G technologies into commercially available products, e.g. in particular within the railway industry for intelligent transport systems. In addition, project proposals investigating new intelligent outdoor signage technologies exploiting millimetre wave (mmW) technologies have been submitted. The UK government via the Dept. of Culture, Media, Sport and Digital (DCMS) is also now funding through the InnovateUK agency a programme to support 5G Testbeds & Trials in cities throughout the UK, and UEssex has been collaborating with Colchester Borough Council as well as British Telecom and local SME businesses to submit a suitable 5G testbed proposal.
6. Conclusion

In D6.4 the dissemination, communication, standardisation and exploitation activities of Year have been summarised. With regards to dissemination the iCIRRUS consortium published the project’s research outcomes and findings in top tier Journals and Magazines including two papers at IEEE/OSA Journal of Lightwave Technology, three at IEEE Wireless Communications Magazine, and three at IEEE/OSA Journal of Optical Communications and Networking and one in IEEE Transactions on Wireless Communications.

A large number of conference papers and invited talk presentations also took place in Year 3 at events including ECOC 2017, OFC 2017, Globecom 2017, ICC 2017, VTC 2017, ICTON 2017, EUCNC 2017 and ICDCS 2017, ISWCS 2017. At the EUCNC the iCIRRUS team contributed to a joint workshop together with H2020 5g-Xhaul and H2020 5G-Crosshaul projects. A pairing of key technologies between and 5G-Xhaul where also demonstrated at the BT innovation week in June 2017. Other events participated in 2017 by the consortium and promoting the iCIRRUS technologies included the Nordic Edge Expo in Norway, Smart City Expo in Barcelona and the 5G World Expo in London.

In general, the research and technological outcomes included advancements in a number of research areas including mobile fronthaul, MIMO-CRAN, D2D communication, mobile cloud offloading which provided performance and energy optimisations in the iCIRRUS architecture and consequently the future 5G Ethernet-based Fronthaul Architecture.

Moreover the consortium continued its ongoing activities and associated contributions to the various standardisation bodies of interest including FSAN/ITU-T SG15Q2, 3GPP, IEEE1904.3 (RoE)/IEEE1914(NGFI), IEEE 802.1, ITU-T Q13, IEEE 1588, and IETF 100. Continues feedback from the standardisation bodies ensured alignment of iCIRRUS with the ongoing standardisation work.

Finally, the last section of the deliverable summarises the business exploitation plans of each partner where in the case of the industrial partners the lean business canvas was used as a guide to derive the exploitation items of interest.
List of Figures

Figure 1 Demonstrating a pairing of iCIRRUS (converged Ethernet) and 5G-Xhaul technologies (agile WDM) at BT’s Innovation weekl ____________________________ 12
Figure 2 iCirrus Website ongoing updates ________________________________________________________________________________________ 14
Figure 3 Example Twit during the ISWCS conference ___________________________________________________________________________________ 15
Figure 4 iCIRRUS promoted on Wellness Telecom Website _______________________________________________________________________________ 16
Figure 5 iCIRRUS participation at the Nordic Edge Expo with Microsoft Azure in Norway in September 2017 ___________________________________________________________________________________________ 16
Figure 6 iCIRRUS booth at the 5G World EXPO, London, UK, 13-15 June 2017. ______________________________________________________________ 17
Figure 7 iCIRRUS booth at EUCNC 2017, Oulu, Finland. ___________________________________________________________________________ 17
Figure 8 Lean Business Canvas used to derive to a common exploitation plan format for all industrial partners. _____________________________________________________________________________________________ 23
Figure 9 Field test and Measurement _______________________________________________________________________________________________ 33
Figure 10 Assurance Solutions ______________________________________________________________________________________________________ 34
Figure 11 Hardware Product: F-PU-5G - 5G Development and Prototyping Platform ________________________________ 36

List of Tables

Table 1 iCirrus Dissemination Activities Summary ................................................................................................................................. 8
Table 2: Business Case 1: Clone as an Infrastructure. ......................................................................................................................... 25
Table 3: Business Case 2: Corporative Mobile Clones. ....................................................................................................................... 26
Table 4 ADVA’s business exploitation summary using the lean business canvas. ................................................................. 27
Table 5: TS’s business exploitation summary using the lean business canvas. ................................................................................. 28
Table 6: PTL’s business exploitation summary using the lean business canvas. ................................................................................ 29
Table 7: VIAVI’s business exploitation summary using the lean business canvas. ............................................................................. 31
Table 8 Ethernet fronthaul field and lab instrument business case .................................................................................... 32
Table 9 Ethernet fronthaul field and lab instrument business case .................................................................................... 33
Table 10: IAF’s business exploitation summary using the lean business canvas. ............................................................................. 36
Table 12 Interdigital’s business exploitation summary using the lean business canvas. ........................................................... 38
Appendix I

Effects of Contention and Delay in a Switched Ethernet Evolved Fronthaul for Future Cloud-RAN Applications

Philippopoulos, Dimitrios, Gurtov S. Birin, Nathan J. Gomes

1. Introduction

Fronthaul is evolving. New technology like 5G and multi-access edge computing (MEC) demand for new fronthaul solutions. The current solutions are based on packet switching, which is not suitable for real-time traffic. New technologies like 5G are emerging, which need a new fronthaul solution. This paper proposes a new fronthaul solution based on switched Ethernet.

2. Functional Split for the Evolved Fronthaul

The functional split for the evolved fronthaul is defined as follows: The user plane is split between the radio network and the core network. The control plane is split between the radio network and the core network. The split is based on the QoS requirements of the traffic.

3. Evolved Fronthaul Testbed

The testbed is based on a 40 Gbps Ethernet interface and uses 40 Gbps Ethernet links for backhaul and fronthaul. The testbed is used to test the performance of the evolved fronthaul solution.

4. Testbed Results

The testbed results show that the evolved fronthaul solution is able to handle high traffic loads and can be used for real-time traffic.

5. Conclusions

The evolved fronthaul solution is a promising solution for future cloud-RAN applications. The solution is able to handle high traffic loads and can be used for real-time traffic.

6. Bibliography

ICIRRUS project
The project ICIRRUS proposes an intelligent Cloud-Radio Access Network (C-RAN) as a combined cloud and radio access solution, focusing on the use of low-cost, but highly flexible Ethernet technology and targeting more efficient use of the spectrum resource in access networks.

Wellness Telecom Contribution to ICIRRUS
Wellness Telecom is one of the partners of ICIRRUS consortium and the leader of the implementation of clone concept and the mobile cloud networking including clone-to-clone (C2C) communication.

Approach
market driver: apart from functional improvements, smartphone users can also benefit from the power available in clouds, ranging from enhancements of compute power and battery life through computation and communication offloading to the improvement of data services.

Mobile Cloud Networking architecture implemented by Wellness Telecom.
In ICIRRUS project, the clone is “Android 4.4 VM” and the targeted task is an offloading task.

On-going study of a new tariff for a cloud clone-based service
WT is carrying out experiments on the clones to monitor the features of the virtual machine by adapting VMware monitoring tool for profiling power usage, data transfer and storage. The results will help to establish a new tariff taking into account energy minimization and power usage.

Cloud Services Business Cases
WT is implementing a mobile cloud clone as an IaaS, with the following purposes: 1) increase User Equipment (UE)’s battery life, optimizing power consumption; 2) augment processing capacity of the UE, thanks to the offloading of heavy tasks to its cloud clone; 3) Optimize UE’s memory usage, as multimedia content can be stored in the mobile clone.

“clone service” as an additional service of an operator offer

Product IaaS, Clone as an Infrastructure
Final User Citizen using mobile device
Target Client Operator
Main expected advantages for the client Better commercial offer (distinctiveness), enhance loyalty, client program, decrease cost (less data traffic at user side)

“clone back-up service” to protect the corporate resources of an enterprise

Product clone as employee mobile back-up, clone as infrastructure
Final User Employee using mobile device
Target Client Enterprise with interest in:
  ➢ MDM: mobile device management
  ➢ BYOD: Bring your own device
  ➢ EMM: Enterprise mobility management (e.g. IBM)
Main expected advantages for the client Productivity, empowerment and, security and control of corporate resources.
Appendix II
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 644526 (iCIRRUS)
Duration: 36 months (January 2015 – December 2017)

Project Coordinator: University of Kent
Key Contact: N.J.Gomes@kent.ac.uk

For more information, visit the project website: http://www.icirrus-5gnet.eu/

https://www.facebook.com/pages/Icirrus-5G/748941148509013
https://www.twitter.com/Icirrus5g
https://www.linkedin.com/groups/iCIRRUS-5G-H2020-project-6930274/about
iCIRRU proposes an intelligent virtualised Radio Access Network (vRAN) which brings together optical fibre technology, highly flexible and low cost Ethernet networking, wireless resource management for device-to-device (D2D) communication and introduces a mobile cloud with clone-to-clone (C2C) technology to enhance spectrum utilization and energy efficiency.

**System Concept**
- Low cost optical Ethernet in an evolved fronthaul.
- Intelligent operation brought to fronthaul
- Added intelligence for D2D operation
- Centralised functions available to mobile cloud processing

The project is moving towards the validation of key concepts through integrated testing and demonstration in the consortium’s research labs. Dedicated hardware has been developed to facilitate the fronthaul verification.

The evolved Ethernet fronthaul can transport sampled waveforms (generic IQ or CPRI-type) and next generation fronthaul interface (NGFI) split point data, for different split points. The same Ethernet network can transport backhaul, midhaul and fixed access traffic. Probe-based, real-time monitoring enables optimisation of the performance of the fronthaul and Radio Access Network. In the future, full virtualisation of the RAN, will enable the monitoring to be used in orchestration of NFV and SDN.

The mobile cloud functions can be moved closer to the user – in the above at the radio cloud centre/base station pool. Clone-to-clone communication offloads traffic from the mobile network and RAN.

The novel feature of iCIRRUS is to enable a converged 5G access network, that also supports legacy mobile and fixed line services based on Ethernet transport and intelligent monitoring.

D2D communication and mesh networking, under control of the mobile network also offloads traffic. Localisation through remote radio units leads to a reduction in signalling complexity and overhead.