



- **Experiment description (max. 4 slides)**
 - Concept and objectives
 - Background and motivation
 - Experiment set-up
- **Project results (max. 3 slides)**
 - Measurements
 - Lessons learned
- **Business impact (min. 4 slides)**
 - Impact on your business, .. how did Fed4FIRE+ helped you ?
 - Value perceived, .. why did you come to Fed4FIRE+ ?
- **Feedback (min. 4 slides)**
 - Used resources and tools
 - Added value of Fed4FIRE+





***CLONE: CLoudlet information
centric Networking Experiments***

2° Fed4Fire+ Open Call –

SME Cascaded Experiments

ANDRIANA IOANNOU

*ICN Expert Scientist at
Tara Hill National Park (THNP) Teo*

4° Fed4Fire+ Engineering Conference (FEC4)

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OUTLINE

- Experiment description
 - Concept & objectives
 - Background and motivation
 - Experiment set-up
- Project results
 - Measurements
 - Lessons Learned
- Business impact
 - THNP Background
 - Why Fed4Fire+
 - Impact of Fed4Fire+
- Feedback
 - Used resources & tools
 - Experience
 - Suggestions





discoverplaces

**Experiment
Description**



Concept & Objectives

- Improve QoE of end-users at remote tourist sites
- Enhance the performance of the Discover Places application, i.e. an Android guide application that aims to deliver both audio and video content to end-users
- Examine the advantages of the NDN architecture with regard to content delivery using the Discover Places application
- Utilize cloudlets, i.e. small repositories, located at the edge the network infrastructure, over NDN
- Compare NDN & NDN with cloudlets vs TCP/IP





Background & Motivation (1/2)

- Tourism is a particularly profitable sector for Ireland, i.e. a budget of 6.5 billion has been reported for 2017, by the Irish Tourism Industry Confederation
- Many of the tourist sites in Ireland currently have 2G mobile network coverage at best, i.e. high rate of service interruptions
- Almost 30% of the Irish people nationally encounter service interruptions with 3G/4G data coverage, according to the Irish telecommunications regulator ComReg
- International tourists, such as USA and Chinese citizens, experience high roaming charges





Background & Motivation (2/2)

- NDN is a hierarchically name-based Future Internet Architecture, that based on the publish-subscribe paradigm ensures time, space and synchronization decoupling between publishers and subscribers
- NDN can natively support operations such as multihoming, multi-path forwarding, and in-network caching
- In-network caching can be utilized at the edge of a network through the use of cloudlets, thus be able to locally satisfy subsequent requests that refer to the same content
- In-network caching increases the availability of content within a network, this reduces the chance of service interruptions occurring, and the propagation of requests further within the network infrastructure





Experiment Set-up

- Group of 8 end-users aim to retrieve an 659K audio file in close-in-time intervals
- Content located at either an Amazon EC2 node, or at the NDN cloudlet, in the form of 8K chunks
- **Architectures:** NDN, NDN with cloudlets, NDN multi-path, NDN with cloudlets one hop away
- **Technologies:** Commercial 2G/3G/4G, Iris LTE, Iris Wi-Fi
- **Equipment:** NDN C++, NDN Forwarding Daemon, NDN Repo, srsLTE eNodeB, srsLTE EPC with HSS, MME, SPGW, USRP X310 radio hardware, standard Wi-Fi 802.11 device



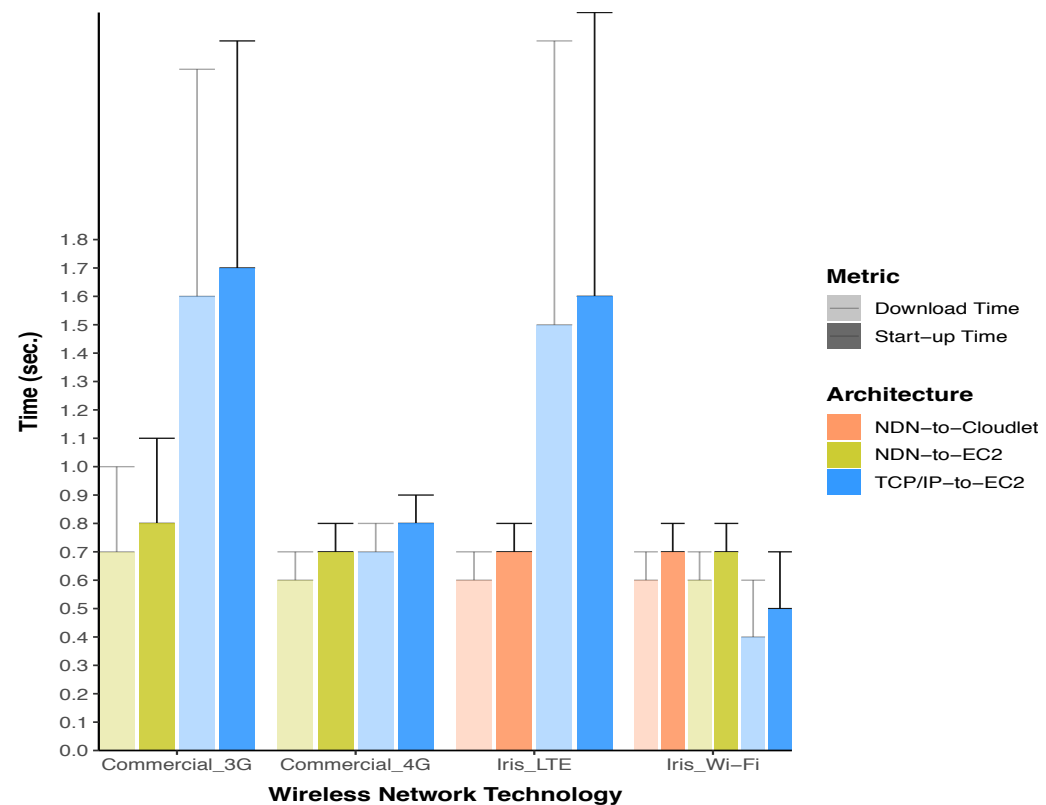


**Project
Results**

Measurements (1/2)

METRICS :

- Start-up time
- Buffer time
- Buffer ratio
- Download time
- Failure ratio
- Network traffic
- Server load



Each metrics refers to the execution of 100 experiments per end-user.





Measurements (2/2)

- Failure ratio for Commercial 2G is equal to 100%, regardless of the type of the architecture
- Failure ratio is higher for TCP/IP vs NDN & NDN with cloudlets, i.e. 0.125-2.175%
- Difference in buffer time, and buffer ratio, between the architectures is negligible, i.e. equal to 0.1 sec.
- Start-up and download times for NDN & NDN with cloudlets vs TCP/IP are lower for almost all technologies, i.e. 0.1-0.9 sec.
- Start-up and download times for TCP/IP vs NDN & NDN with cloudlets are lower **only** over Iris Wi-Fi, i.e. equal to 0.2 sec.

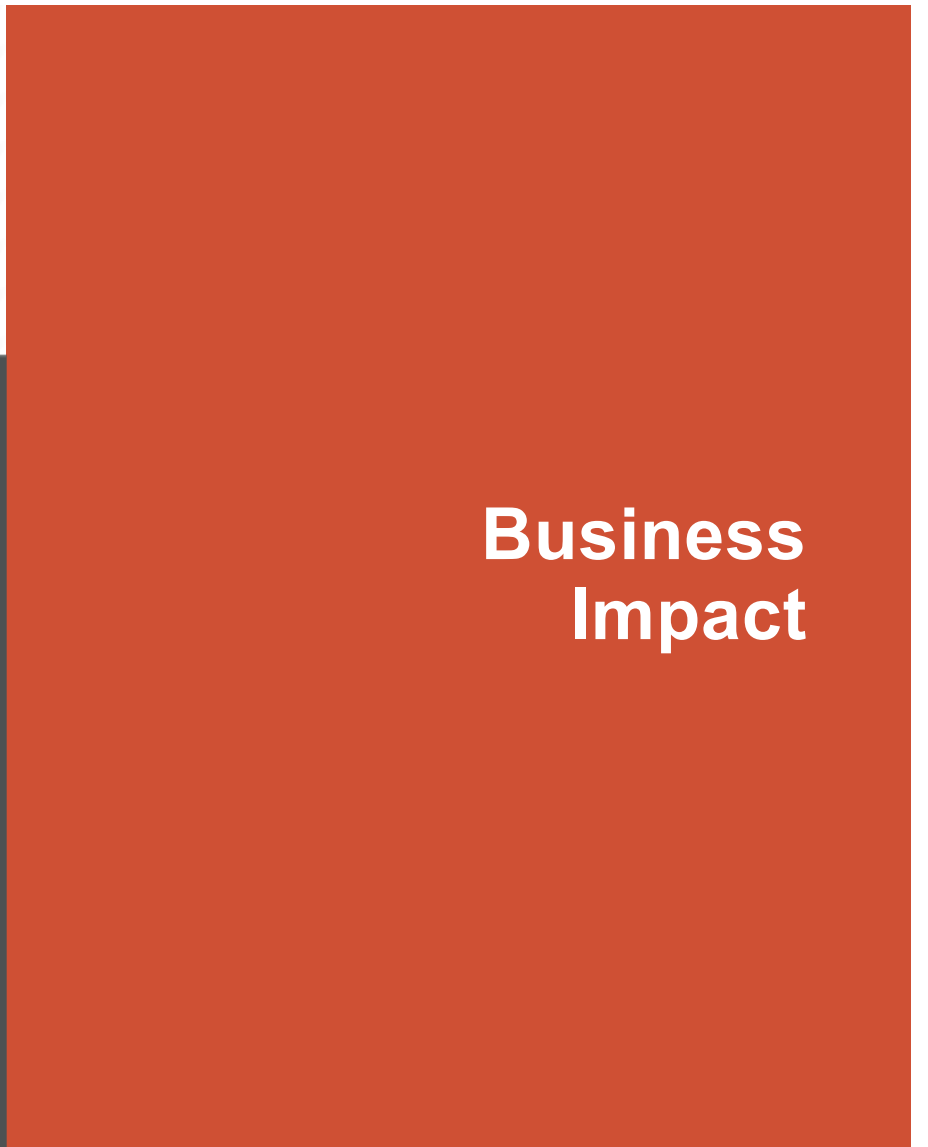




Lessons Learned

- NDN & NDN with cloudlets have been shown to outperform TCP/IP over a number of technologies
- Performance of NDN, & NDN with cloudlets is more consistent compared to TCP/IP, i.e. for the start-up and download time
- Superiority of NDN with cloudlets vs NDN is unclear, i.e. both conclude to the same results over Iris Wi-Fi technology
- Different network architectures may favour different wireless network technologies (investigation necessary)





**Business
Impact**



THNP Background

- THNP is a small Irish business that has been involved in the tourism, and software sectors for over 25 years
- THNP does did not have the required equipment or technical testbed cloud platform knowledge or resources to support the experiments proposed
- Without funding, THNP did not have the financial resources to dedicate staff to execute the experiments proposed





Why Fed4Fire+

- Fed4Fire+ acts as a legitimate source that provides a common mean for experimentation and cross-comparison between different experiments
- Fed4Fire+ provides a wide range of testbeds and technologies
- Fed4Fire+ provides an easy-to-use environment for the set-up and the execution of the experiments
- Fed4Fire+ provides a support service that guides the experimenters through the installation and configuration process related to the testbeds
- Fed4Fire+ supports experimenters with funding, that has allowed THNP to purchase both hardware and software equipment, and to employ expertise employees in the area of research and product development





Impact of Fed4Fire+ (1/2)

- Through the support of the CLONE project and the Fed4Fire+ federation THNP has been able to:
 - Evolve the company's thinking with regard to the future development and delivery of low-cost, high quality content to both domestic and international tourists
 - Evolve the company's knowledge with regard to new architectures and technologies by incorporating new equipment and staff expertise
 - Expand our team.



Impact of Fed4Fire+ (2/2)



- determine both the hardware and software requirements to support the NDN deployment on a real content distribution network through the use of the Discover Places application
- develop one of the first NDN-based applications for content delivery, working on real-environments
- enhance the company's esteem and profile through its participation to the Fed4Fire+ events and activities, and through the publication of the conclude results in prestige conferences, such as the *ACM ICN Conference '18*





Feedback



Used Resources & Tools

- Iris-testbed resources:
 - 2 X310 USRPs
 - 1 B200 mini
 - 2 virtual machine images: one representing the Evolved Packet Core (EPC), and one acting as the NDN cloudlet
 - a Wi-Fi node
- Fed4Fire+ tools:
 - Fed4fire+ portal
 - jFed tool





Experience (1/2)

- The timeframe given is reasonable to cover all necessary aspects of the project, including development and administration tasks
- The allocated budget is reasonable to cover the necessary equipment, and expertise staff for the execution of the experiments, and the administration tasks involved





Experience (2/2)

- The Iris testbed is publicly available, for researchers from both academia and industry alike, to access
- The support service provided by the Iris testbed support team is extremely helpful
- The environment provided is easy to follow, setting-up and configure new experiments is reasonably easy as well
- The environment provided is trustworthy and secure to run experiments
- The documentation provided – for the Iris testbed – is particularly detailed and thorough





Suggestions

- Provide the opportunity to experimenters to automate complex tasks
- Provide the opportunity to experimenters to obtain technical knowledge of the testbeds, through the use of online tutorials
- Provide the opportunity to experimenters to enhance their proposed experiments, and products, through continuous advice offered by a technical support team and/or a marketing team
- Provide the opportunity to experiments to obtain additional resources and research support through industrial co-operations





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