NOKIA Bell Labs

Nokia Bell Labs

Internships @ Nokia Paris Saclay – UPMC master RES (M2)

- Ludovic Noirie + NBLF colleagues
- Nokia Bell Labs
- 20-10-2021

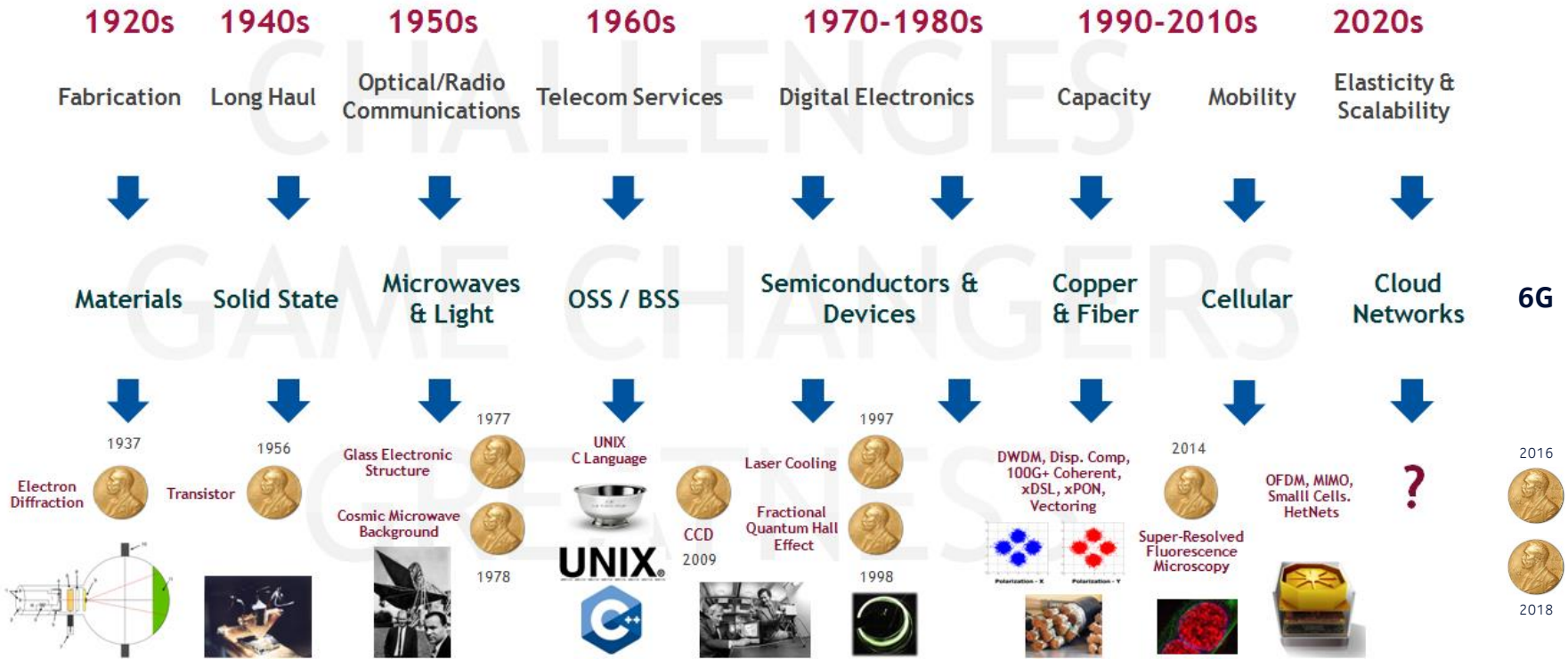
Nokia Bell Labs: Research @ Nokia

"As the renowned industrial research arm of Nokia, we solve the needs of future humans."

https://www.bell-labs.com/

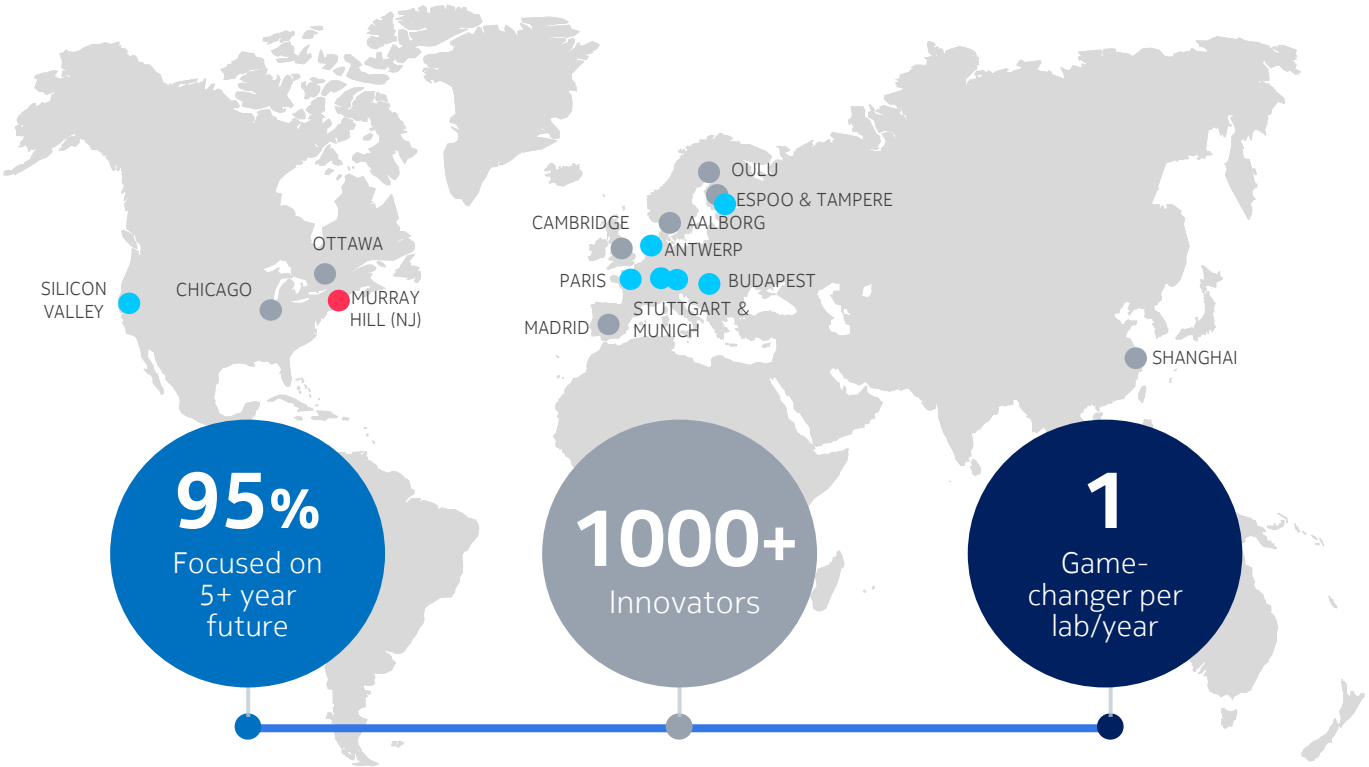
Nokia Bell Labs – General presentation

Bell Labs History: Unparalleled disruptive innovation



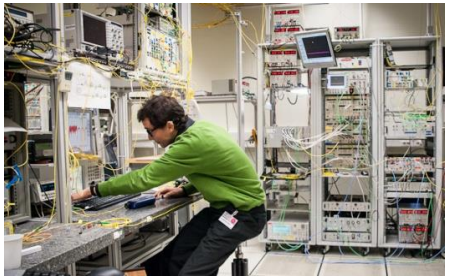
Nokia Bell Labs – General presentation

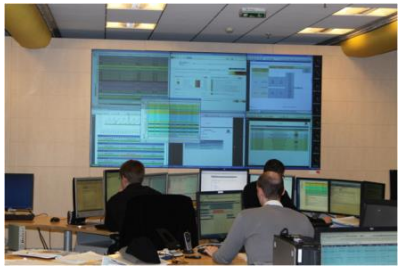
Bell Labs Scope & Scale: A global innovation engine



Nokia Bell Labs – General presentation
Nokia Paris-Saclay

- **Nokia Paris-Saclay location**
  - 20 km south of Paris, Nozay, Essonne (Paris-Saclay agglomeration) https://goo.gl/maps/AfCFvq8nTjx
- **Research activities**
  - **Network**
  - **Algorithms**
  - Analytics
  - **IoT Control**
  - Security
  - III-V devices
  - Optical networking & transmission
  - Radio & end-to-end mobile networks





Past internships with Sorbonne Université (ex-UPMC) students
Examples in IoT-Control department

- **Kahina Aberkane (2015)**
  - D. T. Bui and K. Aberkane, *A generic interface for Open vSwitch*, NetSoft 2016, https://doi.org/10.1109/NETSOFT.2016.7502442
- **Nesrine Ammar (2016)**
  - N. Ammar, M. Le Pallec and L. Noirie, *Algorithme de Caractérisation des Services IoT: Évaluation des Performances*, ALGOTEL 2017, https://hal.archives-ouvertes.fr/hal-01515597
  - PhD thesis with us on “Autonomous IoT device type identification” (defended in March 2020)
- **Pooneh Mokariasl (2020)**
  - P. Mokariasl, L. Noirie and R. Varloot, *Monitoring as a service for IoT networks*, see presentation at LINCS https://www.lincs.fr/events/interns-talks-1-monitoring-as-a-service-for-iot-networks-and-2-structured-and-interactive-summarization-provisional-title/
  - **Covid19 lockdown conditions…**

Who to contact?
Internships in Nokia Bell Labs @ Paris Saclay

- **How to know about Nokia internships ?**
  - Nokia web site:
    - https://www.nokia.com/about-us/careers/student-and-graduate-opportunities/
  - Internship contacts:
    - See next slides (for IoT-Control department) and next Nokia Bell Labs presentations
  - And your professors…
    - They have contacts with several Nokia Bell Labs researchers…

Topic #1: Multi-Access Edge Computing (MEC) Slicing
Context of 5G/5G+

Low-Latency Pillar

- Low-Latency concerns are part of 5G system designed: URLLC, very small TTI (down to 125 us), etc.
- **MEC[1]** allows for bringing Cloud resources next to the end-users for improving latency and ease 5G core bandwidth
- Low-latency applications: VR, AR, Industry 4.0, V2X, etc.

Network Slicing Pillar

- Network Slice: an isolated logical partition of a 5G infrastructure
- Allows for sharing a 5G infrastructure with different usages => cost reduction

Problem = MEC Slicing Architecture

- 3GPP Network Slicing Architecture does not cover the MEC
- E2E latency SLA requires an E2E Network Slicing architecture

[1] https://www.etsi.org/deliver/etsi_gs/MEC/001_099/003/02.02.01_60/gs_MEC003v020201p.pdf

Topic #1: Multi-Access Edge Computing (MEC) Slicing
Internship content

- **The intern will participate in this research study with Nokia Bell Labs researchers. She/He will:**
  - Contribute to the conception and the design of MEC slicing architecture and orchestration (possibly in interaction with 5G Core);
  - Setup and implement a MEC Slicing POC;
  - Benchmark (performance test) the different design choices;
  - Help present and showcase the implemented platform.
- **Recommended skills:**
  - Systems/Software: Linux, Docker containers, Kubernetes, Helm, Swagger
  - Programming: Go, Bash/Shell script, Python
  - Networking: LAN, IP network protocol stack, SDN, NFV
  - Knowledges in ETSI MEC and 3GPP 5G architecture is a plus
- **Contact: dinh_thai.bui@nokia-bell-labs.com**

Topic #2: Generalized SDN
Context / Main objective

- The Software-Defined Network (SDN) principle makes network elements programmable.
- This programmability, however, has some limitations, especially in terms of frame format, imposed by the standard and "hard coded" in the components.
- The purpose of this internship is to push the limits of the SDN principle by making possible the encoding / decoding of any frame format sent / received by the network element.

Topic #2: Generalized SDN
Internship content

- **The intern will participate in this research study with Nokia Bell Labs researchers. She/He will:**
  - Contribute to the conception and the design of a targeted software architecture (possibly based on OVS and OpenFlow);
  - Implement a first prototype of the proposed software architecture;
  - Benchmark the different design choices;
  - Help present and showcase the implemented platform.
- **Recommended skills:**
  - Systems/Software: Linux
  - Programming: C, Bash/Shell script
  - Networking: LAN, IP network protocol stack, SDN
  - Knowledges in OpenFlow/OVS or P4 can be an advantage
- **Contact: richard.douville@nokia-bell-labs.com**

Topic #3: Participating in Proof-of-Concept platform development

Context of advanced Fog computing

- Multi-tenant, Fog computing and IoT ecosystems are the key aspects that 6G intends to tackle.
- Distributed software architecture that aims to coordinate the resources of different users, giving each user a personal view to interact with the system named Personal OS.
- The purpose of this internship is to experiment and learn the practical aspects of research and its prototyping. The intern will study techniques of service orchestration in Fog computing, and the challenges related to IoT ecosystem.

Topic #3: Participating in Proof-of-Concept platform development
Internship content

- **The intern will participate in the PoC preparation with Nokia Bell Labs researchers. Depending on the advancement of the platform development, she/he will tackle a subject built out of these items:**
  - Design and deploy tools around platform (Platform Monitoring, Self-generated documentation of APIs, Security Hardening)
  - Support the implementation of demonstrators about FOG computing orchestration over IoT ecosystem (UI devs, constrained devices, Workflow definitions & associated software design/implementation)
  - Study discovery mechanisms and description of embedded resources in IoT; experiment alternatives to containers in order to run arbitrary code on constrained devices
- **Recommended skills (depending on the subject definition):**
  - Systems/Software: Linux, Docker, Kubernetes, Helm, Swagger & Open API, RaspberryPI, OpenWRT
  - Programming: JS, D3.js / React, Java, Python, Rust, Web Assembly
  - Familiar with networking concepts and tools
- **Contact: pierre.peloso@nokia-bell-labs.com**

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NOKIA Bell Labs

Inventing the Future X Network

The Creation of Nokia Bell Labs
The engineering departments of the American Telephone and Telegraph Company (AT&T) and Western Electric were consolidated in Bell Telephone Laboratories. Their mission was to research and design communication technologies for the rapidly expanding telephone network and to explore fundamental areas of science that could shape the future of the industry. Over the years, many cornerstone technologies of modern society have been invented at Bell Labs and 9 Nobel Prizes have been awarded to its researchers.

1925

1930's

1937 Electron Diffraction
NOBEL PRIZE
Demonstrating wave nature of matter

1950 Theseus
Claude Shannon creates a robotic mouse that "learns" to run a maze

1952 Audrey
The first voice recognition system. Capable of recognizing the numbers 1-9

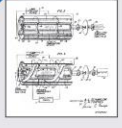
1940's

1948 "A Mathematical Theory of Communications"
By showing that all communications channels - of any type - have a fundamental capacity limit, Claude Shannon founded the field of information theory

1950's

1954 Solar Cells
The Bell Labs solar battery was the first successful device to convert the sun's energy directly and efficiently into substantial amounts of electricity

1956 Transistor
NOBEL PRIZE
To replace the vacuum tube, Bardeen, Brattain and Shockley created a working point-contact transistor. The basic building block for all digital products is the foundation for our information society



1958 LASER
In their 1958 paper, Schawlow and his brother-in-law Townes described in detail a proof of concept for the LASER. The laser enables a wide variety of applications: fiber-optic communications, digital storage, barcode scanners, precision surgery and industrial cutting tools

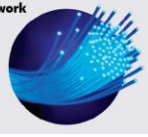
1960's

1962 Telstar
Transatlantic live TV broadcast via satellite

1970's

1973 UNIX and C Language
Thompson and Ritchie's elegant designs were an immediate hit with the programming community when they were released in the 1970s. UNIX would eventually become the Internet's foundation

1976 Fiber Optic Network
First demonstration of 45 Mbit/s transmission



1977 Electronic Structure of Magnets & Glasses
NOBEL PRIZE
Fundamental theoretical investigations of the electronic structure of magnetic and disordered systems leading to an improved understanding of symmetry breaking, localization of electrons, magnetism and superconductivity

1978 Cosmic Microwave Background Radiation
NOBEL PRIZE
Pioneering work on radio communications using the Holmdel Horn Antenna provides support for the Big Bang Theory

1978 Commercial Cellular Network
Invention of the cellular concept and creation of the first commercial network

1980's

1985 Belle
The first computer built specifically to play chess. Creators Condon & Thompson

1980 Demonstration of DSP
Large-scale integration circuit for digital signal processing

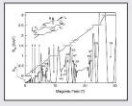
1995 Commercial DWDM
Pioneering work on wavelength multiplexing in optical fibers

1988 Applied Convolutional Neural Networks
(CNN) to the task of recognizing handwritten characters

1995 LeNet
The first improved CNN that recognized handwritten digits with speed and accuracy

1995 Integrated ADSL Chip
After co-inventing ADSL technology, follow-up innovations like vectoring continued to generate world records for high-speed data transfer over copper telephone lines, fueling the Internet

1998 Wireless MIMO Spatial Multiplexing
Invention of wireless transmission based on multiple spatial paths



1998 Fractional Quantum Hall Effect
NOBEL PRIZE
Discovery of a novel collective quantum fluid state of matter

1990's

1997 Laser-Based Cooling and Trapping of Atoms
NOBEL PRIZE
To understand the fundamental limits of materials and matter

2006 Software Defined Routing
Predecessors of Software Defined Networks (SDN)

2009 CCD
NOBEL PRIZE
Boyle and Smith's Picturephone research realized the enormous potential of the Charge Coupled Device as an imaging device, leading to the invention of the digital photo, video cameras, scanners, satellite surveillance and ultra-sensitive astronomical telescopes

2009 Coherent 100G Optics
Invention of the future of high speed optical communications with coherent processing

2000's

2008 Massive MIMO
Key enabler of 5G technology providing 50X or > spectral efficiency improvements over 4G technology. Massive MIMO is scalable to any degree with respect to the number of service antennas

2009 World's first standard compliant LTE call
The first LTE call made via base stations with fully compliant software to the 3GPP LTE standard

2011 lightRadio Cube
First demonstration of building block of future small cell wireless networks

2010's

2014 Fluorescent Microscopy
NOBEL PRIZE
Ground-breaking work on sub-wavelength optical microscopy leads to super-resolution microscopy at cellular level

2014 XG-FAST
First demonstration of 10 Gbps over copper telephone wires

2015 GreenTouch
GreenTouch
International consortium delivers new technologies to improve energy efficiency in wireless networks by more than 10,000X

2015 The Future X Network: A Nokia Bell Labs Perspective
First Nokia Bell Labs book written

2016 5G Massive Connectivity
First demonstration of 1M simultaneous, ultra-low latency connections in a single cell for 5G and IoT

2017 Probabilistic Constellation Shaping
New wavelength modulation technique pushing optical wavelength performance up against the Shannon limit

2018 Optical Tweezers
NOBEL PRIZE
Optical tweezers can trap microscopic and nanoscopic objects and living things using lasers, without damage, affording an unprecedented ability to study cells, bacteria, viruses , DNA, and other molecules that constitute the basis of life

The Future

Nokia Bell Labs continues to solve the great industry challenges, producing disruptive innovations for the next phase of human existence