



Computer Network

Lecture 12

Make: Networking

2019. 03. 01

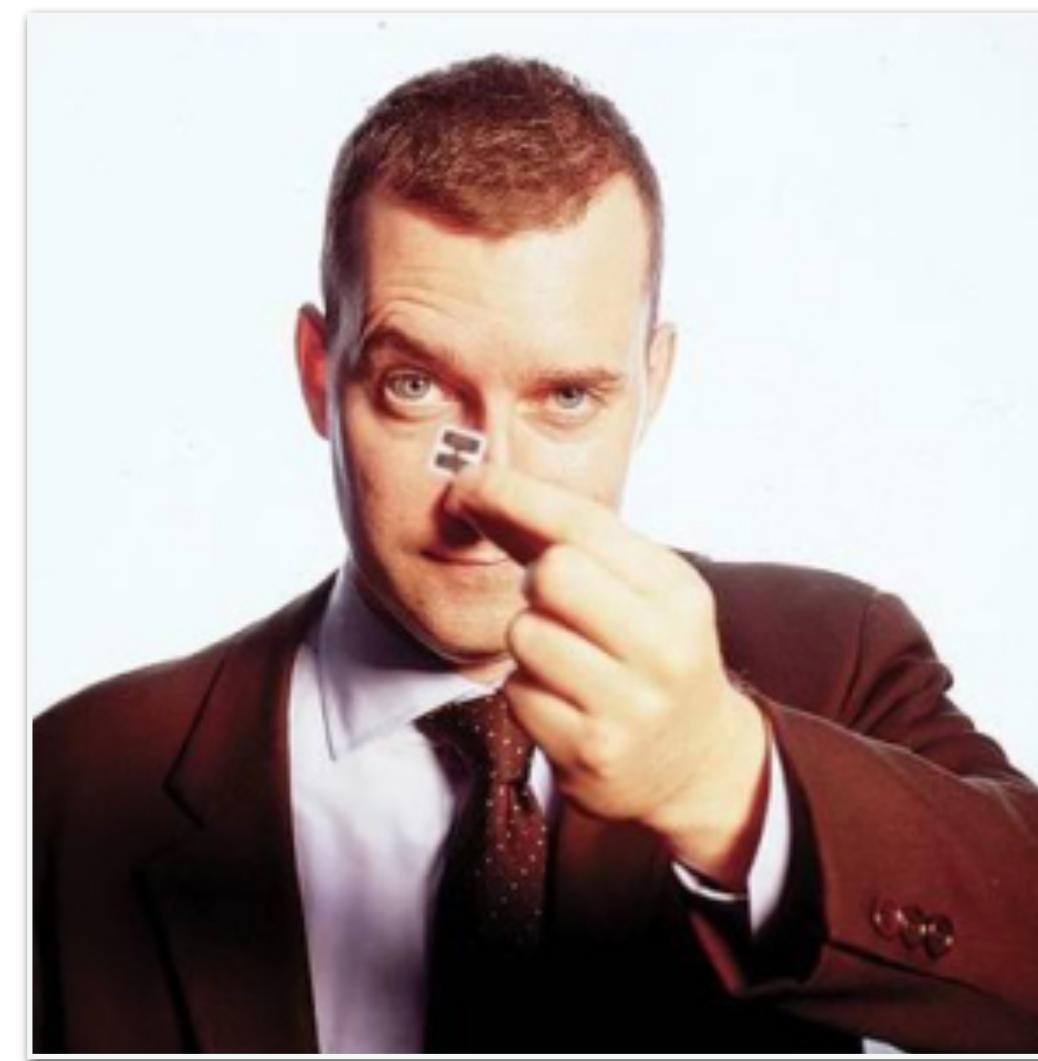
Sungwon Lee
Department of Software Convergence

Contents

- Internet of Thing (IoT)
- Physical Computing
- Cyber Physical System (CPS)
- Opensource DIY Networking
- Specialized OS for IoT
- OCP Telecom Infra Project
- Conclusion

Kevin Ashton





Today computers—and, therefore, the Internet—are almost wholly dependent on human beings for information. Nearly all of the roughly 50 petabytes (a petabyte is 1,024 terabytes) of data available on the Internet were first captured and created by human beings—by typing, pressing a record button, taking a digital picture, or scanning a bar code. Conventional diagrams of the Internet ... leave out the most numerous and important routers of all - people. The problem is, people have limited time, attention and accuracy—all of which means they are not very good at capturing data about things in the real world. And that's a big deal. We're physical, and so is our environment ... You can't eat bits, burn them to stay warm or put them in your gas tank. Ideas and information are important, but things matter much more. Yet today's information technology is so dependent on data originated by people that our computers know more about ideas than things. If we had computers that knew everything there was to know about things—using data they gathered without any help from us—we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best. The Internet of Things has the potential to change the world, just as the Internet did. Maybe even more so.^[19]

—Kevin Ashton, 'That 'Internet of Things' Thing', *RFID Journal*, July 22, 2009

Influential New IoT Products



Dropcam INFLUENCE SCORE: 183

Nest and Dropcam confirmed the acquisition, but did not specify the price tag.
- Source: Sharenet 06/21/2014



Kwikset Kevo E-Lock INFLUENCE SCORE: 20

Kevo will start to work right away, as the included fob works out of the box. Kwikset does, however, recommend that you calibrate the fob and any smartphones in order to enable the sensors built into the device.
- Source: iLounge 06/10/2014



Philips Hue Smart Bulb INFLUENCE SCORE: 19

Philips announced Hue Tap [kinetic energy] controller ... tapping the button generates all the energy to carry out a command.
- Source: Techno Buffalo 03/29/2014



Logitech Harmony Remote INFLUENCE SCORE: 45

Logitech announces an update to its Harmony Ultimate Remote.
- Source: CNBC 06/24/2014



Honeywell Lyric Thermostat INFLUENCE SCORE: 158

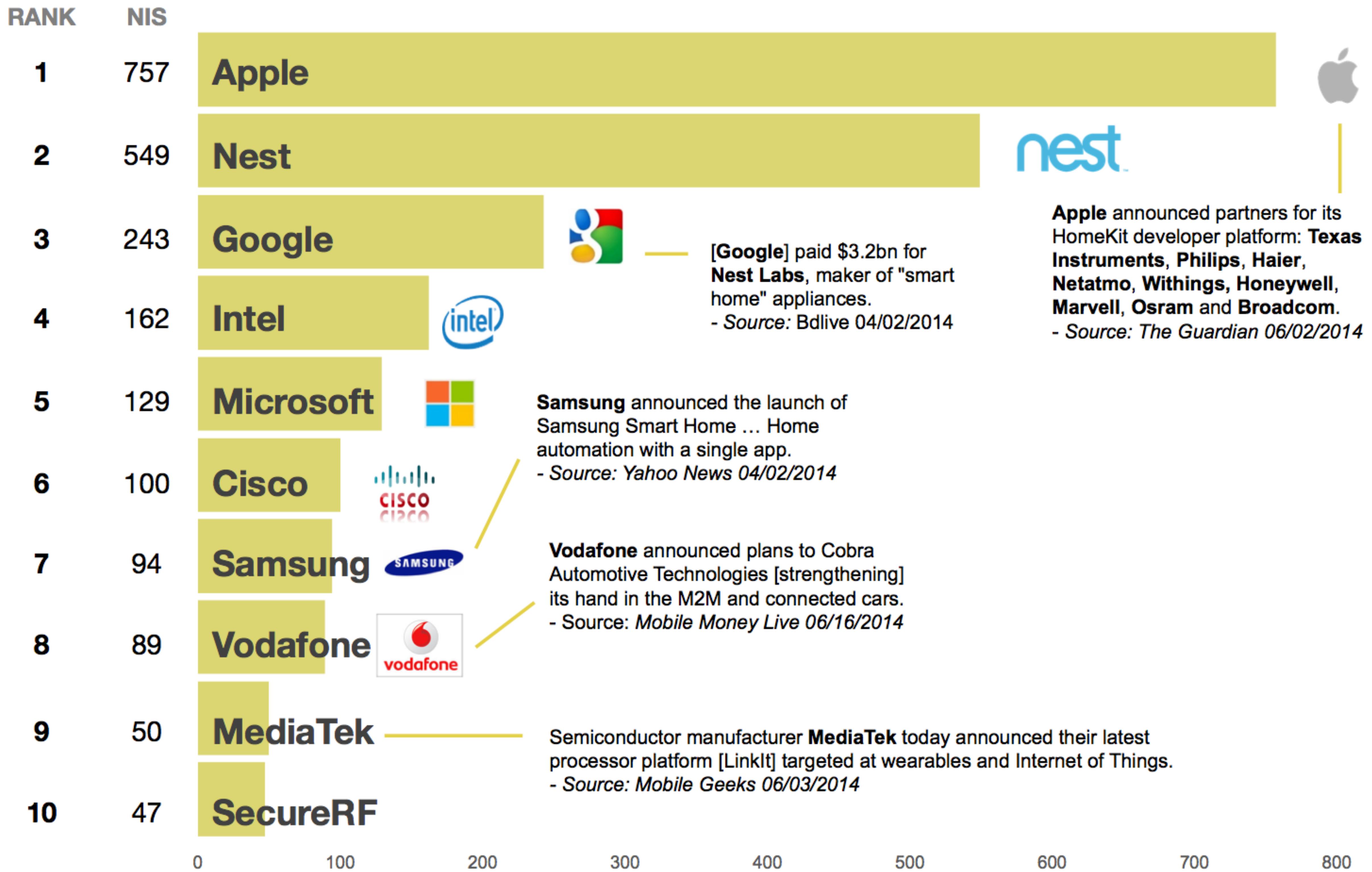
Honeywell has announced 'Lyric', a new [smart] thermostat to compete with Nest.
- Source: iClarified 06/10/2014



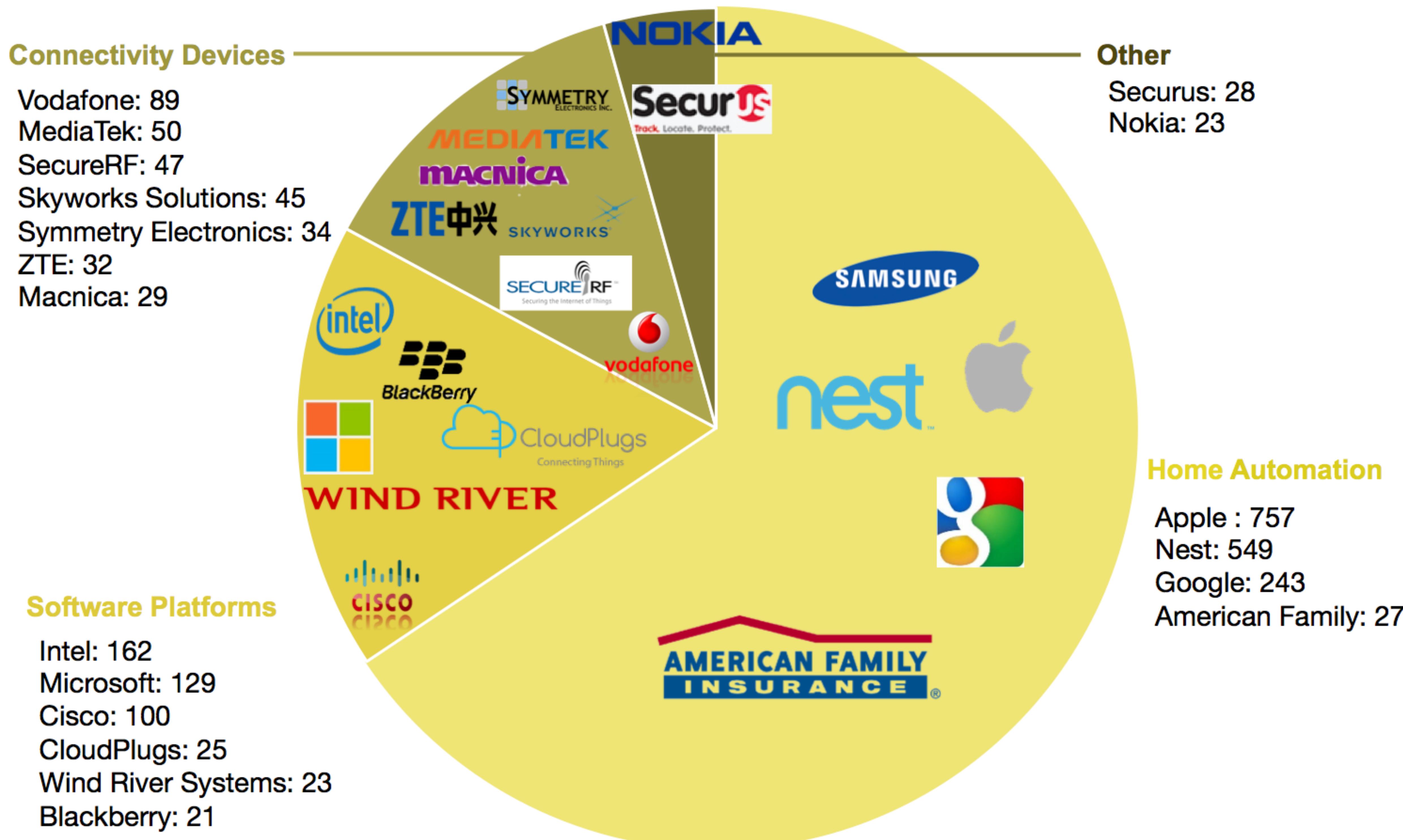
Belkin WeMo Home Controller INFLUENCE SCORE: 18

Belkin announced an updated version of its WeMo App for Android and iOS [with] new features for the WeMo Light Switch.
- Source: iClarified 04/17/2014

The 10 Most Influential Internet of Things Companies



Top 20 Influential Companies By Sectors



Contents

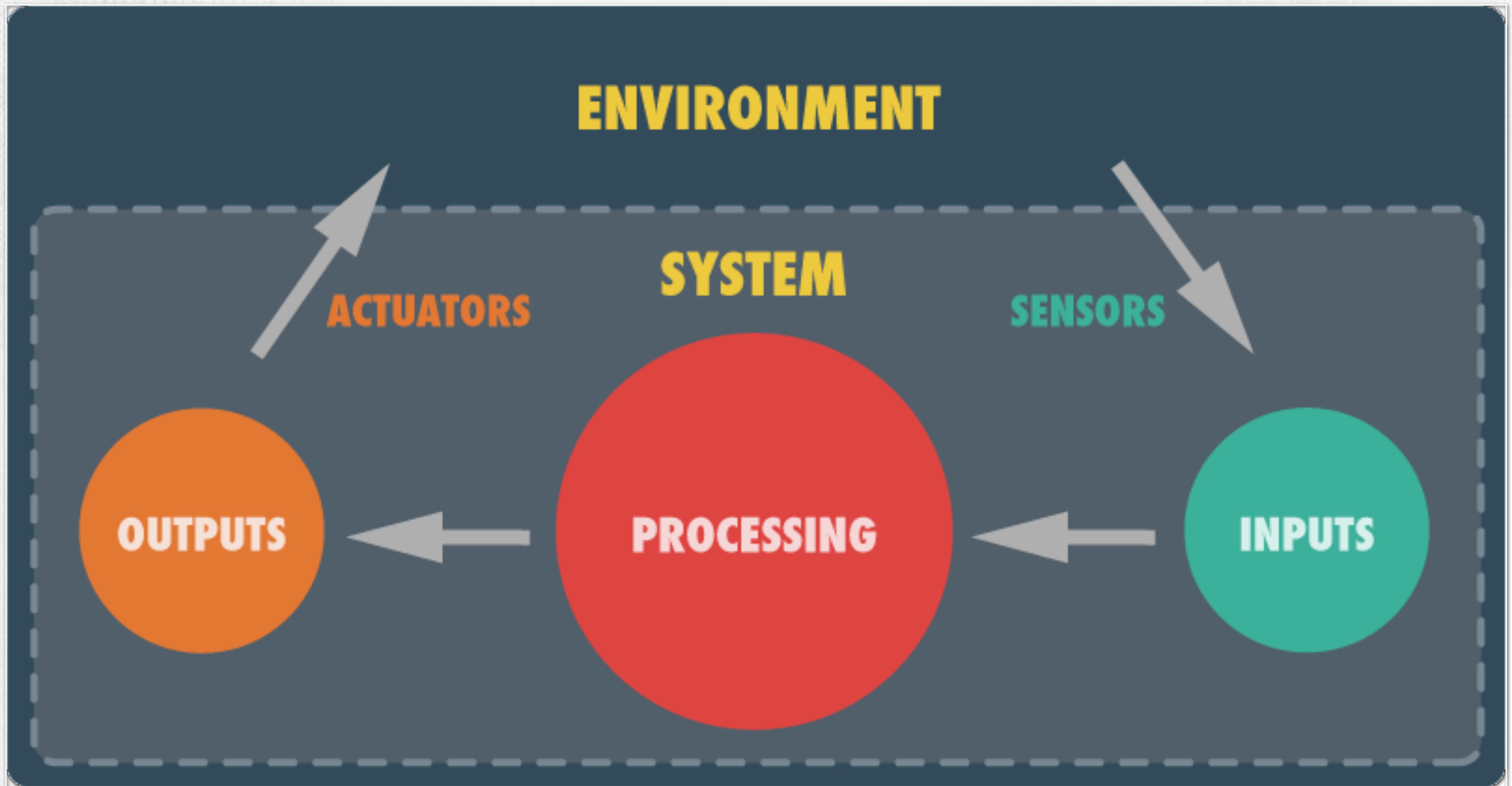
- Internet of Thing (IoT)
- **Physical Computing**
- Cyber Physical System (CPS)
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- OCP Telecom Infra Project
- Conclusion

Physical Computing

Term Definition

- Physical computing
 - means building ***interactive physical systems*** by the use of software and hardware that can ***sense and respond to the analog world***
 - most often describes handmade art, design or DIY hobby projects that use sensors and micro controllers to ***translate analog input to a software system, and/or control electro-mechanical devices such as motors, servos, lighting or other hardware.***
 - intersects the range of activities often referred to in academia and industry as ***electrical engineering, mechatronics, robotics, computer science, and especially embedded development.***

Physical Computing Concept



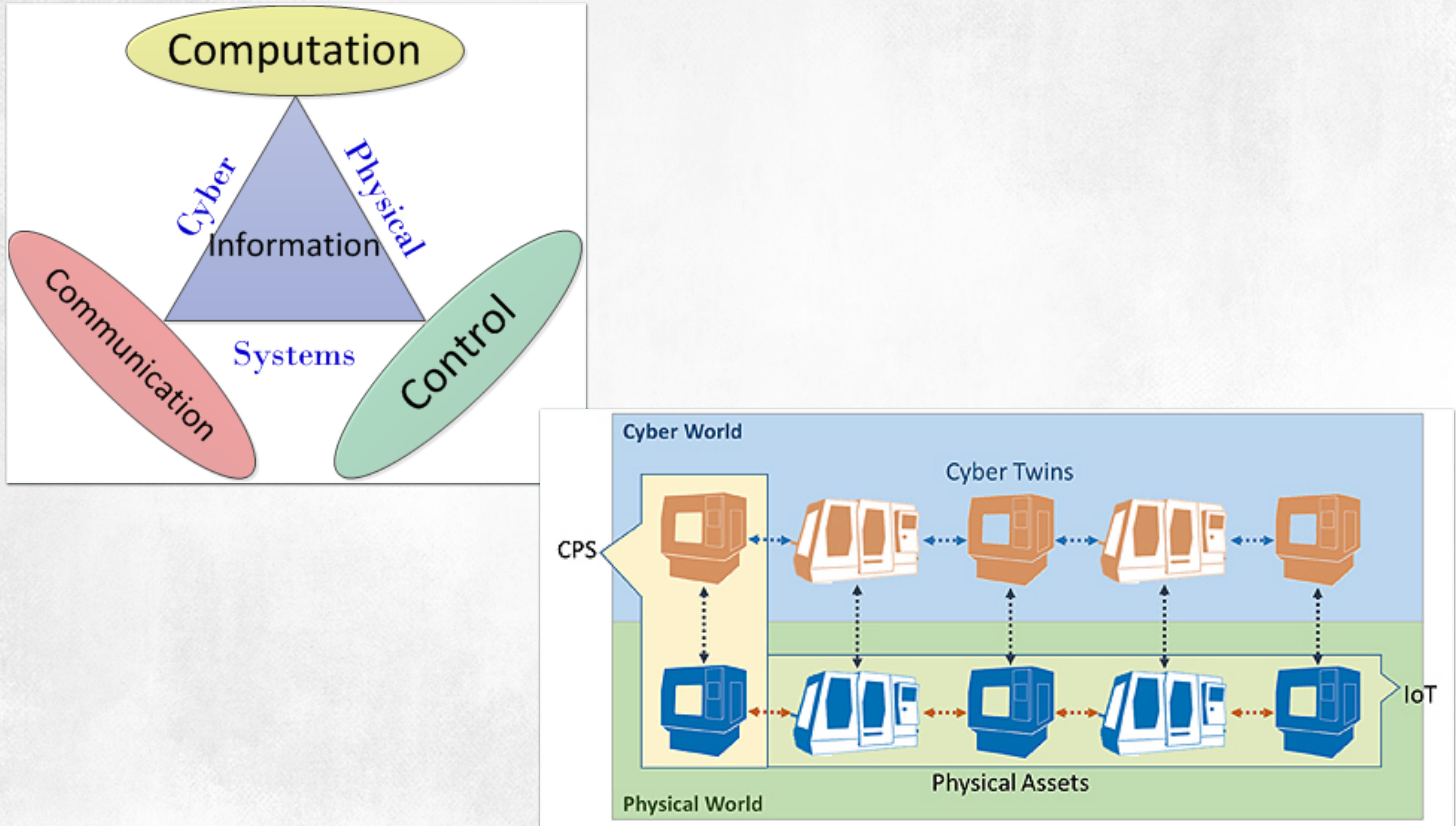
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Cyber-Physical System Concept

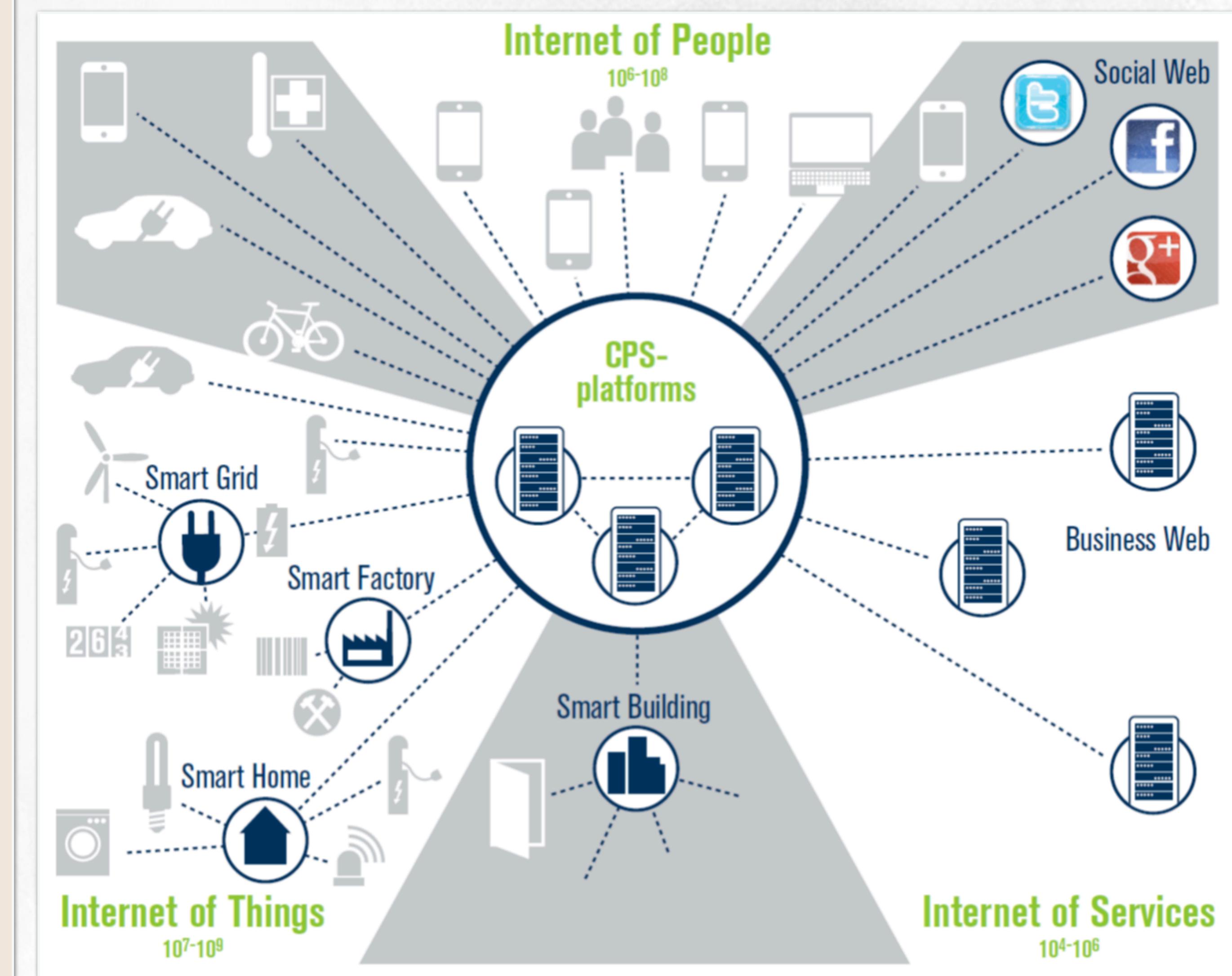
- Cyber-physical system (CPS)
 - is a mechanism that is ***controlled or monitored by computer-based algorithms, tightly integrated with the Internet*** and its users
 - include smart grid, autonomous automobile systems, medical monitoring, robotics systems, and automatic pilot avionics
 - involves ***trans-disciplinary approaches, merging theory of cybernetics, mechatronics, design and process science***
 - is also similar to the Internet of Things (IoT), sharing the same basic architecture; nevertheless, ***CPS presents a higher combination and coordination between physical and computational elements***

Cyber-Physical System Component



Cyber-Physical System

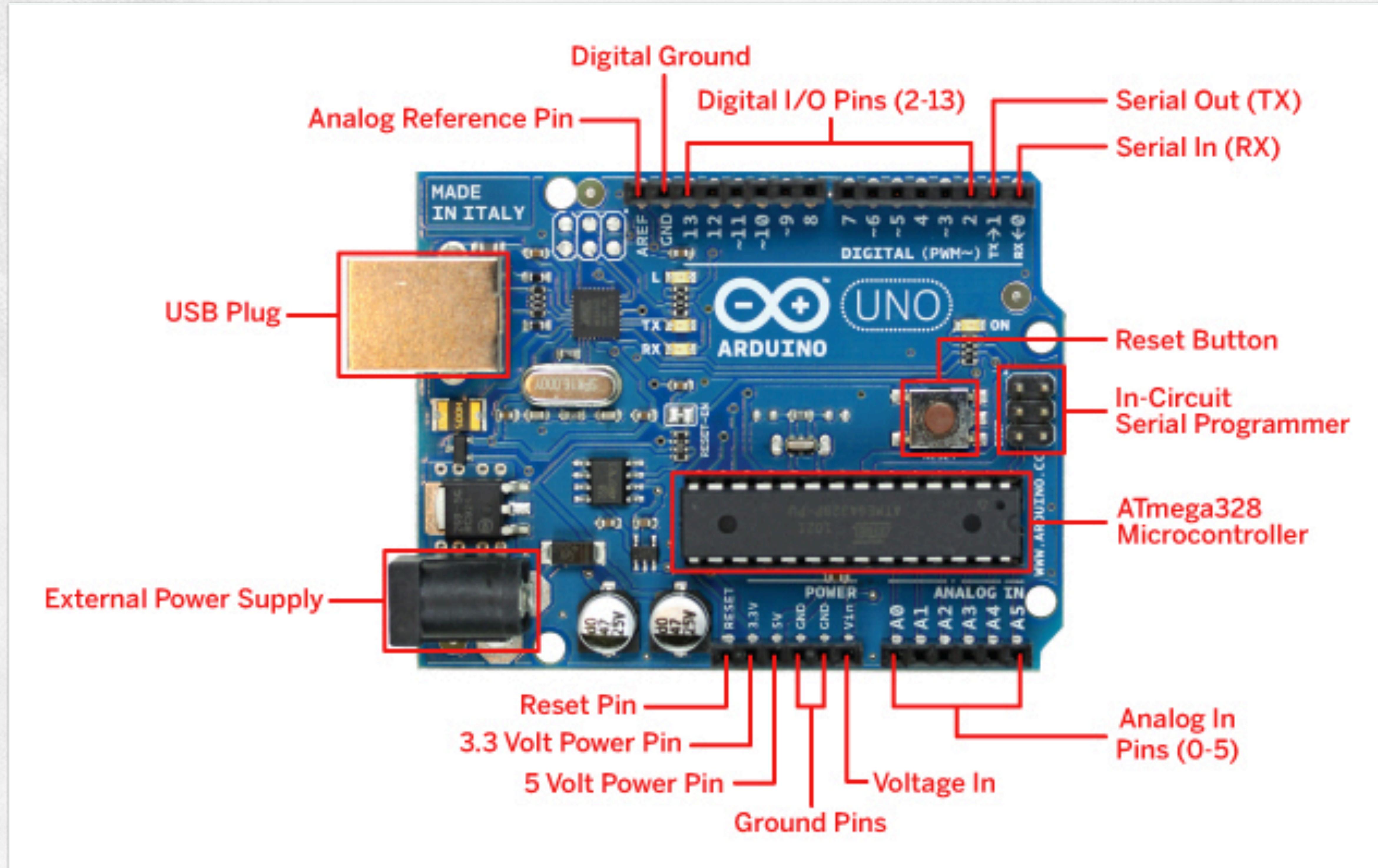
Industry 4.0



Contents

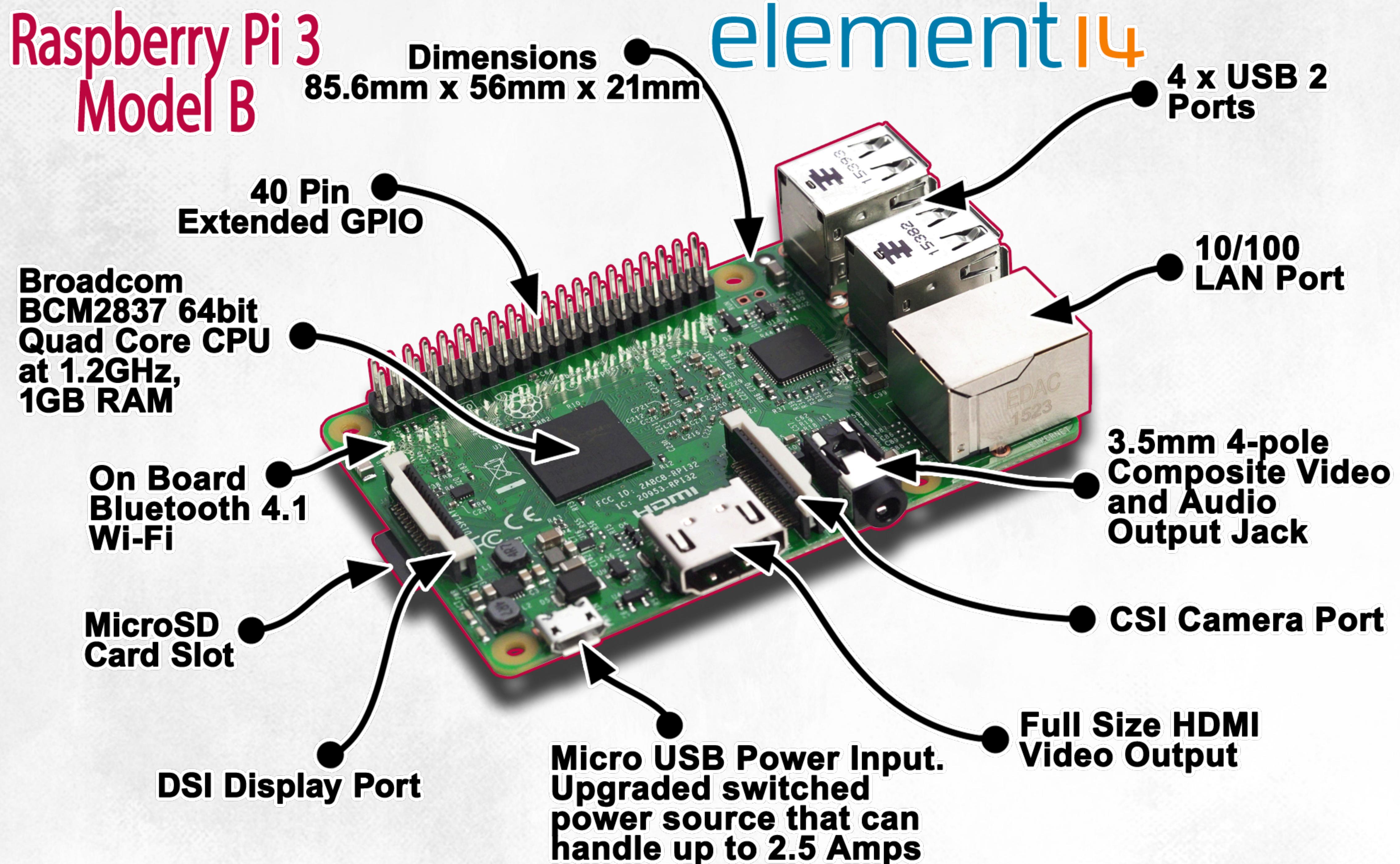
- Internet of Thing (IoT)
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Most Famous Opensource Hardware



RaspberryPi

Most Famous Single Board Computer



Raspberry Pi HQ

Your resource for Raspberry Pi Projects

[Home](#) [About](#) [Getting Started](#)

[Projects](#)

[Resources](#)

How-To: Turn a Raspberry Pi into a WiFi router

Do you want a separate WiFi network for your guests? or would you like to have network running an alternative DNS configuration in your house? You no longer have to buy a new WiFi router to do this – you can turn your Raspberry Pi into a WiFi router.



This post will guide you through the process of setting up your Raspberry Pi as a WiFi network.

PirateBox

PirateBox is a **DIY anonymous offline file-sharing and communications system** built with free software and inexpensive off-the-shelf hardware.

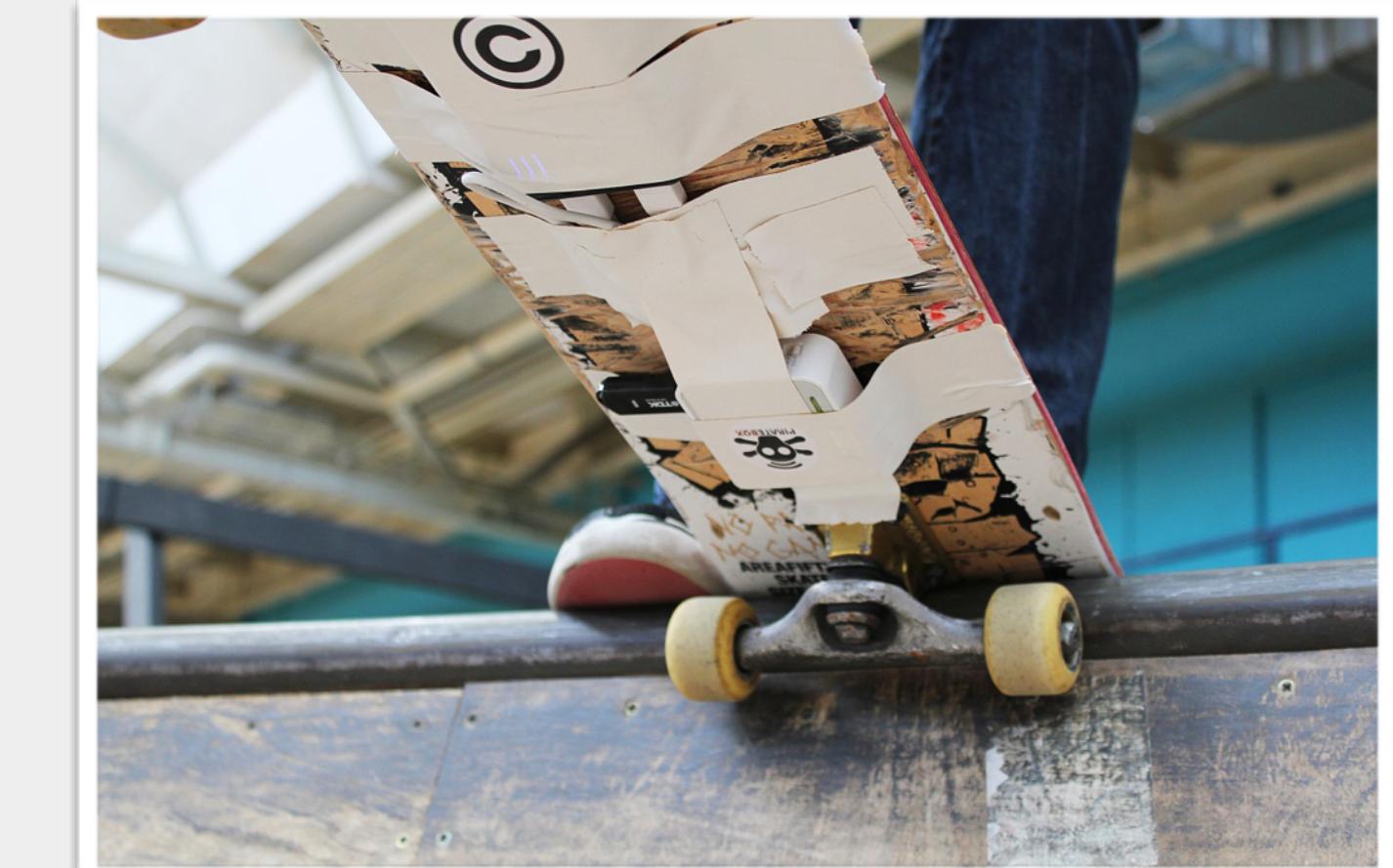
[Learn More...](#)[Build a PirateBox now!](#)

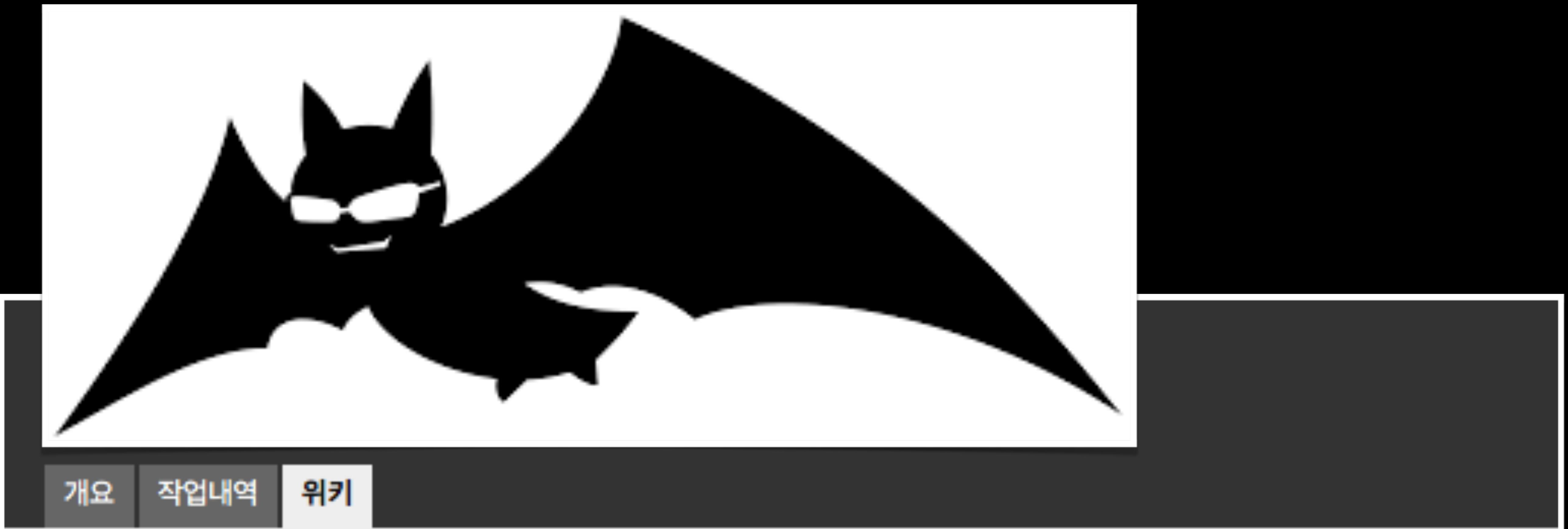
What is the PirateBox?

PirateBox creates offline wireless networks designed for **anonymous file sharing, chatting, message boarding, and media streaming**. You can think of it as your very own **portable offline Internet in a box!**

How does it work?

When users join the **PirateBox** wireless network and open a web browser, they are automatically redirected to the **PirateBox** welcome page. Users can anonymously chat, post images or comments on the bulletin board, watch or listen to streaming media, or upload and download files inside their web browser.





Welcome to Open Mesh

This page serves as development platform for a collection of tools to build free and open mesh networks.

B.A.T.M.A.N.

B.A.T.M.A.N. (better approach to mobile ad-hoc networking) is a routing protocol for multi-hop ad-hoc mesh networks. This is the main development website, we have source code, binary packages, documentation and further information available:

OpenFlow enabled OpenWRT

github.com/CPqD/ofsoftswitch13/wiki/OpenFlow-1.3-for-OpenWRT

The screenshot shows a GitHub wiki page for the repository CPqD/ofsoftswitch13. The page title is "OpenFlow 1.3 for OpenWRT". It contains text about the project, sections for "Pre-compiled image" and "Build instructions", and a sidebar with navigation links and clone options.

GitHub Header: GitHub, This repository, Search, Explore, Features, Enterprise, Blog, Sign up, Sign In

Repository Header: CPqD / ofsoftswitch13, Star 81, Fork 75

Page Title: OpenFlow 1.3 for OpenWRT

Text Content: srujan edited this page on Oct 11, 2013 · 4 revisions

Text Content (continued): Following the steps of Pantou, which turns OpenWrt router into OpenFlow switches, we developed a version using our OpenFlow 1.3 software switch, enabling to test the most recent version of the protocol on a real device, for a low cost.

We build images for the TP-LINK TL-WR1043ND. If you have interest on build for other devices and want to share it, please contact us, so we could keep an images repository.

Section: Pre-compiled image

If you do not want to build the code you can download pre-compiled images from

Section: Build instructions

Sidebar:

- Pages 5
 - Dpctl Documentation
 - Dpctl Flow Mod Cases
 - Home
 - OpenFlow 1.3 for OpenWRT
 - OpenFlow 1.3 Tutorial

Clone Options:

- Clone this wiki locally
 - <https://github.com/CPqD/ofsoftswitch13>
 - Clone in Desktop



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YOUR PHONE

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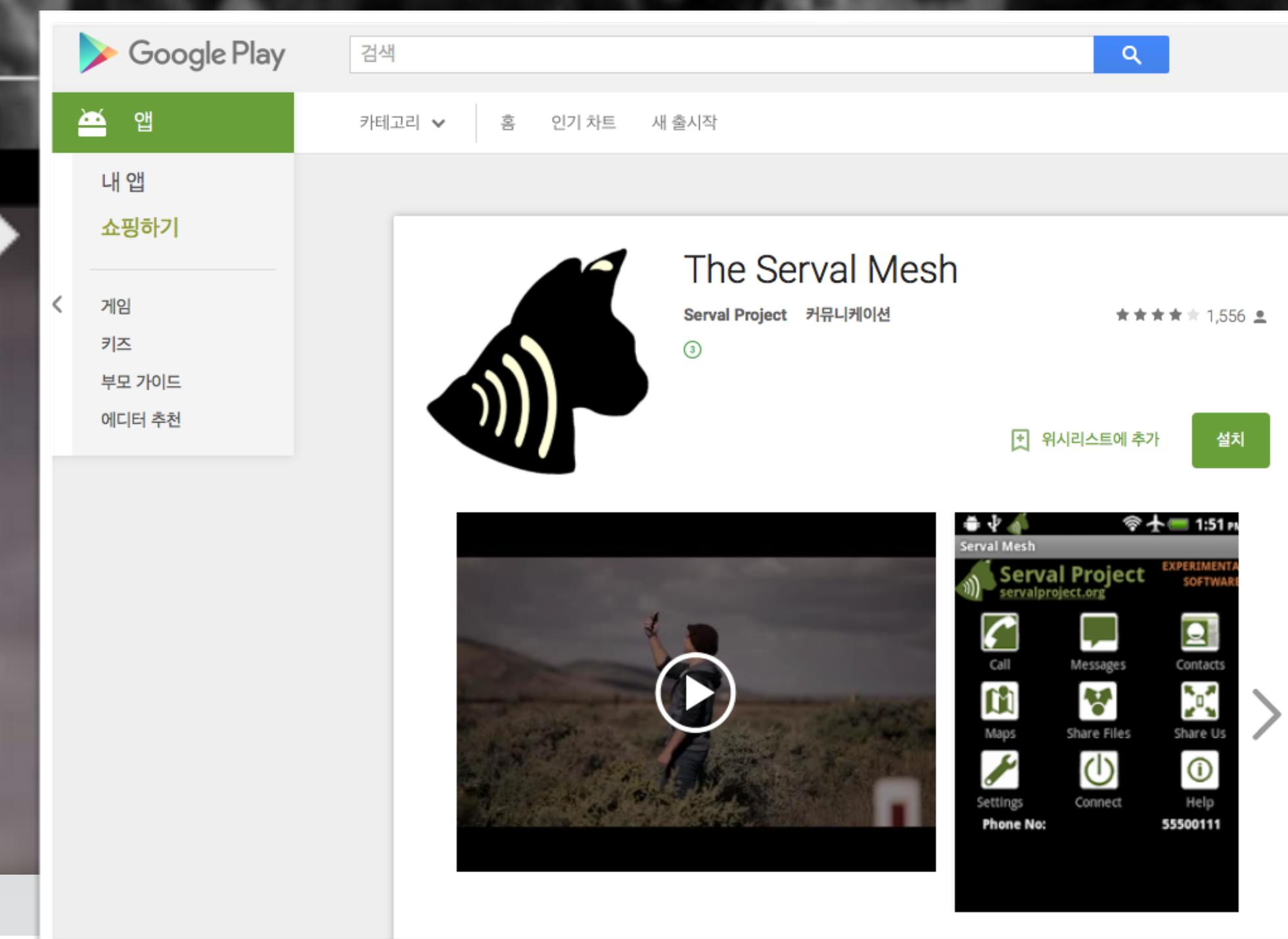
Donate

Developer

News

“Communications should not just be for the geographically, financially otherwise fortunate – for it is the unfortunate who need it most.”

Serval Mesh Extender - <http://igg.me/at/speakfreely>



Mobile phones normally can't be used when cellular networks fail, for example during a disaster. This means that millions of vulnerable people around the world are deprived of the ability to communicate, when they need it most.

We have spent the past four years working with the New Zealand Red Cross to create a solution. We call it the Serval Mesh, and it is free software that allows smart-phones to communicate, even in the face of catastrophic failure of cellular networks.

Google's Project Loon Gets 'Autolauncher,' Mesh Networking

BY DAVID MURPHY MAY 30, 2015 02:49PM EST 4 COMMENTS

Google's Internet-delivering stratospheric balloons now need far fewer ground controls.

734 SHARES 

At this rate, there may be more balloons in the sky than ever before, due to the latest update to the company's development tools in San Francisco this past week. The updates surrounding the program.

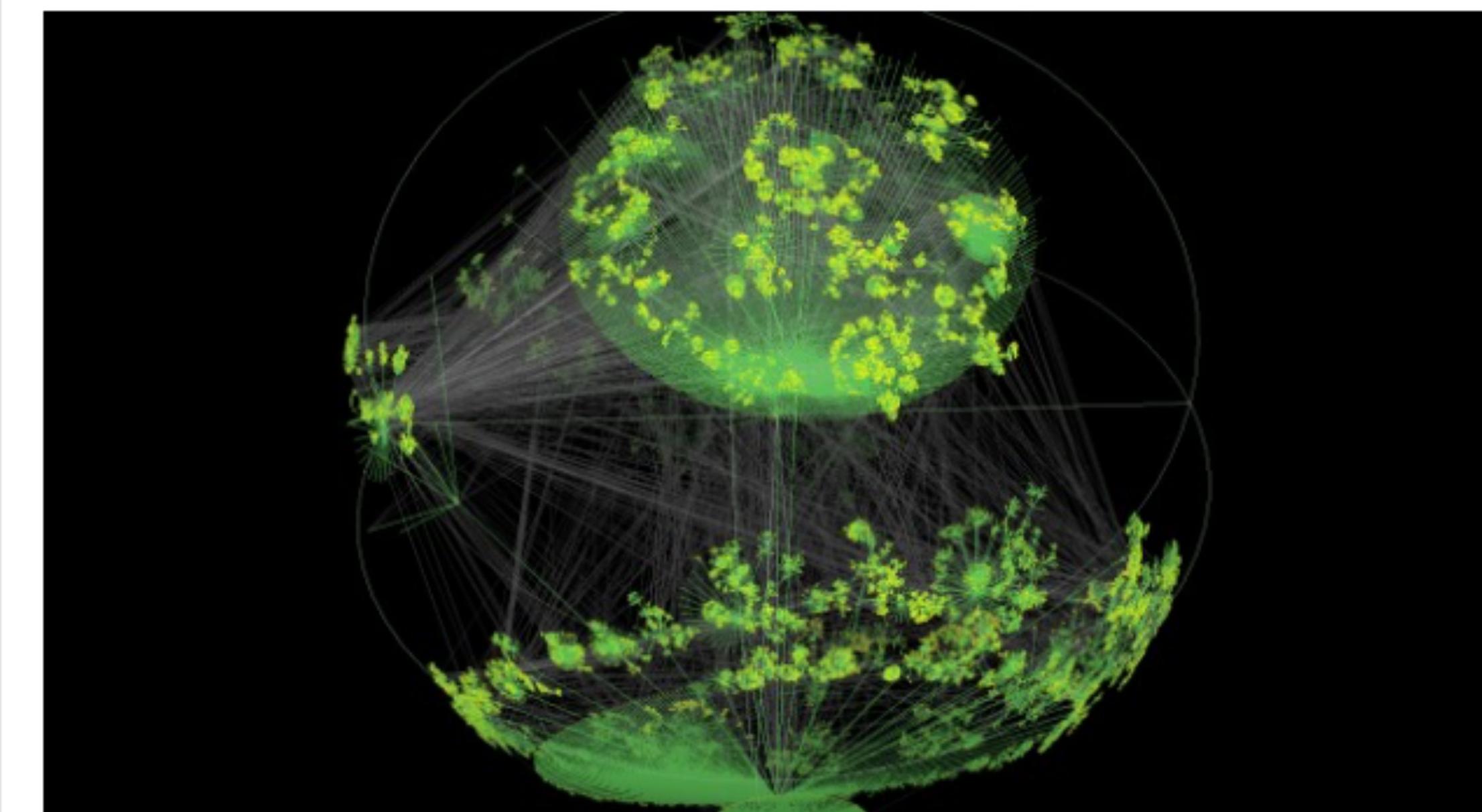
Project Loon, if you haven't heard, is designed to bring Internet connectivity to areas that wouldn't otherwise have it. The balloons—for lack of a better term—get launched into the stratosphere (about 20 miles above Earth's surface). The balloons themselves are designed to float in the air or so, and each one gives LTE connectivity to an area 50 kilometers wide.

Google's first major advancement, mentioned to Bloomberg by president Mike Cassidy, involves the way in which Google launches its balloons into the air to begin with. Previously, the process used to cost \$100,000 or so per balloon, and Google could only launch its balloons when the wind was six miles per hour or less.

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What is mesh networking, and why Apple's adoption in iOS 7 could change the world

By Sebastian Anthony on March 24, 2014 at 2:29 pm | 37 Comments



Share This Article



With iOS 7, Apple snuck in a very interesting feature that has mostly gone unnoticed: Mesh networking for both WiFi and Bluetooth. It also seems that Google is working to add mesh networking to Android, too. When it comes to ubiquitous connectivity, mobile computing, and the growing interest in the internet of things, it is not hyperbolic to say that mesh networking could change the fabric of society. But, I hear you ask, what is mesh networking? I'm glad you asked.

What's New?

There's a voice

There's a voice that keeps on calling me.
Down the road, that's where I'll always be.
...

Every stop I make

Every stop I make, I make a new friend.
Can't stay for long, just turn around and
I'm gone again. Maybe tomorrow, I'll want
to settle down, Until tomorrow, I'll just
keep moving on.

Our Downloads!

Yes we are moving fast! Antonio is working
on the Batman/Robin software using the
small boxes from Accton plus Ubiquiti
units. Please read on [More...](#)

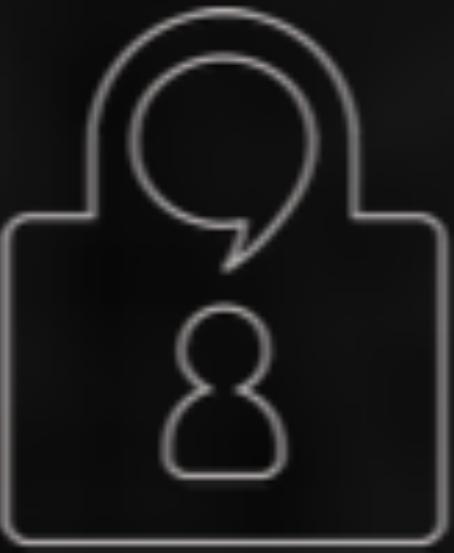
We are working hard on porting to all our
old compaq and dell! [Links](#) here with
info at our [Downloads](#) page or at [x86](#)
[section...](#)

- Enjoy!
- Be Happy!

Public chat 

OpenSourceMesh Chit Chat hosted by iansalmonsoffice.

[Join now](#)



TOX: A New Kind of Instant Messaging

With the rise of government monitoring programs, Tox provides an easy to use application that allows you to connect with friends and family without anyone else listening in. While other big-name services require you to pay for features, Tox is totally free and comes without advertising.

 Download Tox

Other clients & platforms

 Instant messaging Chat instantly across the globe with Tox's secure messages.	 Voice Keep in touch with friends and family using Tox's completely free and encrypted voice calls.	 Video Catch up face to face, over Tox's secure video calls.	 Screen sharing Share your desktop with your friends with Tox's screen sharing.	 File sharing Trade files, with no artificial limits or caps.	 Groups Chat, call, and share video and files with the whole gang in Tox's group chats.
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RADICAL/NETWORKS

October 24-25, 2015
NYU Poly, Brooklyn, NY

From mass surveillance to the over-commercialization of the Internet, the technology that we depend upon for community and connection is being compromised. The recent accessibility of networking technology through devices such as the Raspberry Pi and software such as BATMAN Adv has made it affordable and possible for everyday citizens to learn how to design their own web servers and networks.

GOALS

- To understand how the technology can be used as a method of control and how to subvert that.
- Teach people how to use networking technology for themselves.
- Encourage creative and social exploration with computer networks.

IDEALS

- Promoting free and open networks built with free and open hardware and software.
- Decentralizing the control of where networks exist and what and whom are served by them.
- Maintaining control of our own content, hardware, and means of deployment.
- Community and free expression first.

In Partnership with

**EYE
BEAM**

Hosted by



8th Floor, MAGNET
2 Metrotech Center
Brooklyn, NY 11201

TICKETS ON SALE NOW!



Open Source Basestation

“BTS = 2G Basestation”

OpenBTS.org

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Open Source GSM

Harvind Samra and David A. Burgess

2009 ~ 2010

o o

Open Source Basestation

“Evolving to 3G and Fuether”

OpenBTS.org

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07.22.2014

OpenBTS APIs & 5.0 Preview

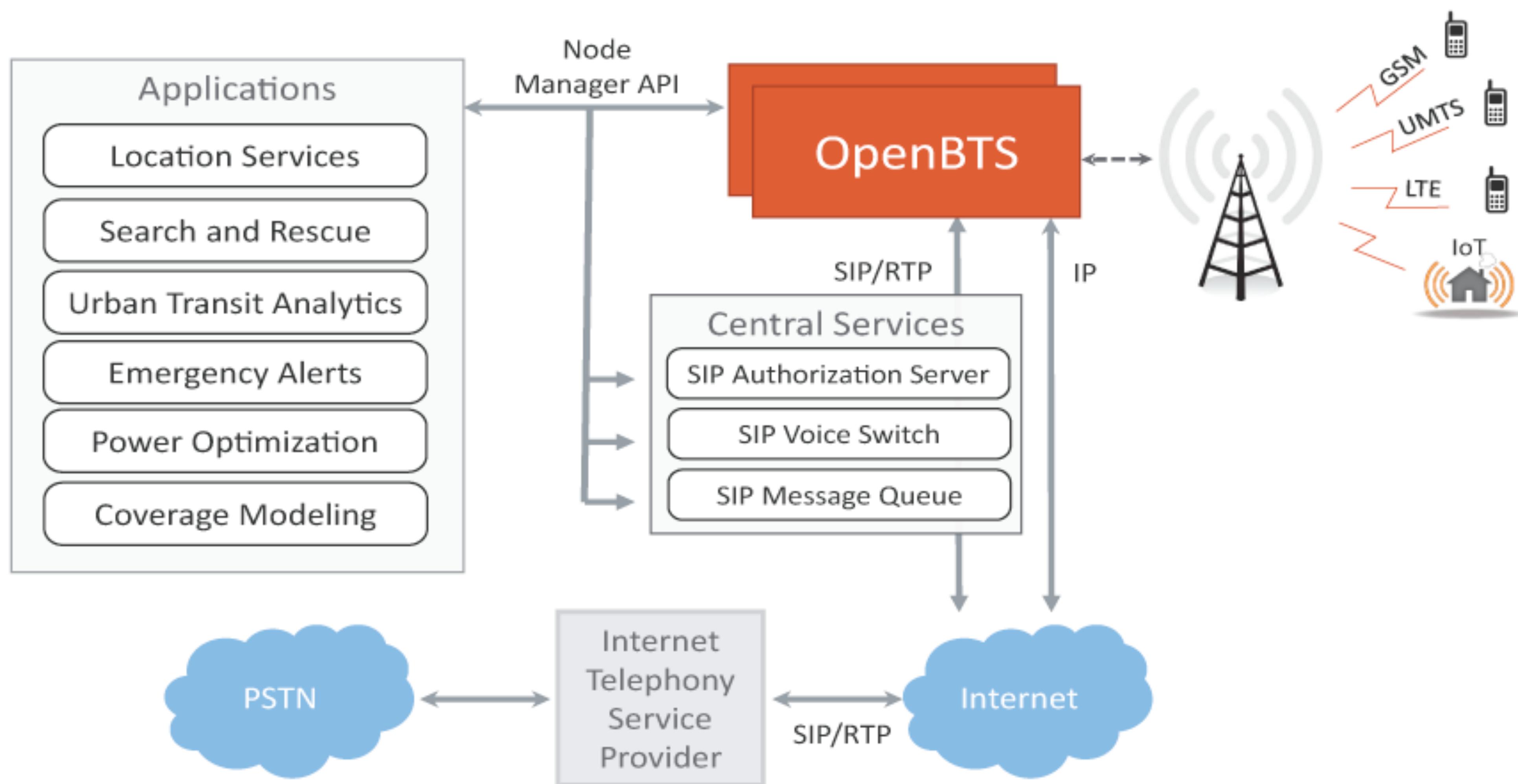
Now Available!

[Go Get 'Em!](#)

o o

OpenBTS Concept

“Single Box Cellular Network”





⌚ +1.415.778.8700 support contact

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**Cellular networks should be simple and flexible.
Now they are.**

We reimagined
cellular networking
equipment for:

Industries without
effective
communications

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OpenBTS Training

Next session May 7-9, 2014

Range Networks OpenBTS training presents a wonderful opportunity to learn about OpenBTS and to connect with colleagues from around the world.



[LEARN MORE ABOUT THIS TRAINING](#)



Professional Development Kit

Model: 2110-001-1



price: **\$4,722.00**

BAND:

Multi-Band

QUANTITY:

1 kit 2 kits 5 kits 10 kits

ADD TO CART

Radio Interface	Phase 2+ GSM
Services Supported	Speech/SMS + GPRS
Operating Bands	GSM850/GSM900/DCS1800/PCS1900
Call Capacity	7 concurrent full rate calls
Service Range	30m
Power Supply	12V 5A DC
Output Power	100mW. User may be required to obtain a radio transmission license to use this product.
Software	OpenBTS (Commercial "C" release), Asterisk, Ubuntu, subscriber registry, and SMS server
Network Interface Protocols	Speech: SIP/RTP, GSM-FR codec. SMS: SIP RFC-3428 page-mode
Network Interface	Ethernet / IP
Management Interfaces	HTTP, SSH console, CLI
Dimensions (Enclosure)	Width = 30.48 cm (12.0") Depth = 25.4 cm (10.0") Height = 4.44 cm (1.75")

Range Networks Enhances OpenBTS with 3G Data Capability

This 1.0 open source release marks the opening of the 3G stack to innovation, software-defined radio suppliers like Ettus Research and Nuand of bladeRF to support.

PORLAND, Ore., July 23, 2014 (OSCON, Oregon Convention Center, Booth #P3) – Range Networks, the leading provider of open source cellular systems and leader of the OpenBTS software project, today announced the public release of OpenBTS-UMTS 1.0, providing data capability for 3G networks. The new code is available to the OpenBTS community immediately as a free download.

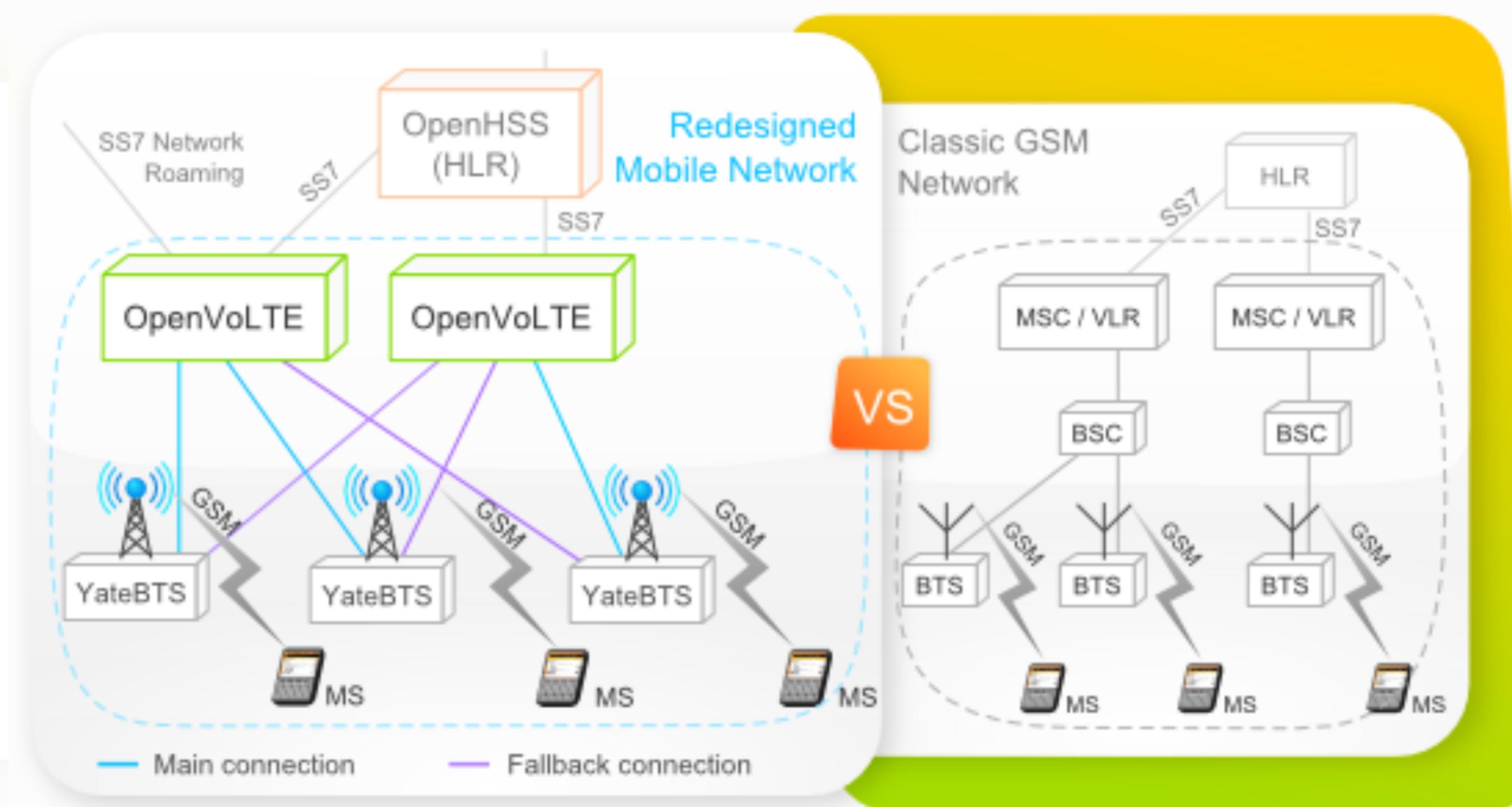
KEY FACTS:

- 3G stack now primed for innovation – This 1.0 release marks the opening of the 3G stack to innovation and makes OpenBTS the only open source project to support 3G networks.
- Meets 3GPP standards – OpenBTS-UMTS delivers an enhanced data speed of at least 384 kbits/s per user and in a lab environment can increase to 800 kbits/s download speeds per user. This enhancement enables Web access, streaming video and use of mobile applications on 3G-enabled handsets. It is 3GPP-compliant and operates on any of the 3GPP-defined UMTS frequencies.
- Ettus Research and Nuand endorse 3G open source – Industry leading software-defined radio (SDR) suppliers have shown support for the 3G release and plan to develop products that support OpenBTS-UMTS.
- New Contributor License Agreement (CLA) – Range Networks is also announcing changes in the open source CLA, designed to encourage greater community participation in the advancement of the mobile industry. OpenBTS.org now implements a Harmony CLA to strengthen the ownership and copyright claims of contributors.

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"YateBTS makes the impossible possible in terms of mobile networking by adding intelligence and features to the most important component of the radio network, the BTS."
Paul Chitescu, main developer of Yate at [Null Team SRL](#)

"YateBTS represents the next phase of what started with the OpenBTS® project."
David Burgess, original developer of OpenBTS® and CEO of [Legba, Inc.](#)

 [Watch the video](#)

YateBTS 1.0

10 Feb 2014

- 2G Mobile call
- SMS
- GPRS
- Javascript support
- NAT support
- Network in a Box
- Layer 2 filler and SACCH randomization

YateBTS 2.0

17 March 2014

- 2G/3G Authentication
- Network in a Box Web GUI
- USSD - commercial version

YateBTS 3

28 April 2014

- BladeRF support
- NIB fixes and improvements
- Forward calls, SMSs, registrations to external SIP server
- Voice Roaming - commercial version

YateBTS 4

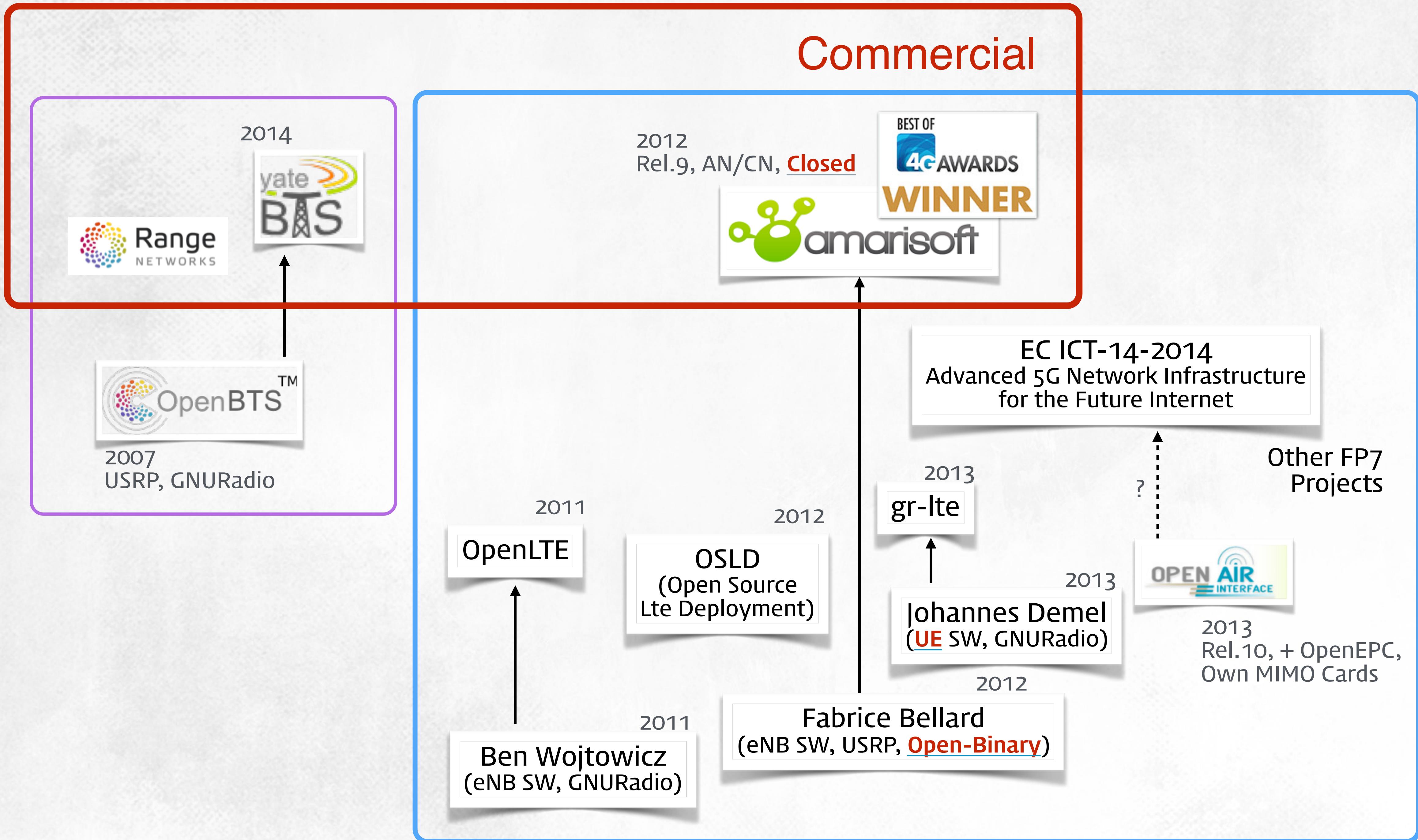
of both

Tell us
what you want



Open Source Cellular Network

“Open Source for 2G/3G and 4G”



Cellular's open source future is latched to tallest tree in the village

Open source tech that could reshape mobile connects a West Papua village to the world.

by Sean Gallagher - Feb 28 2014, 11:00am KST

DEVELOPMENT

NETWORKING

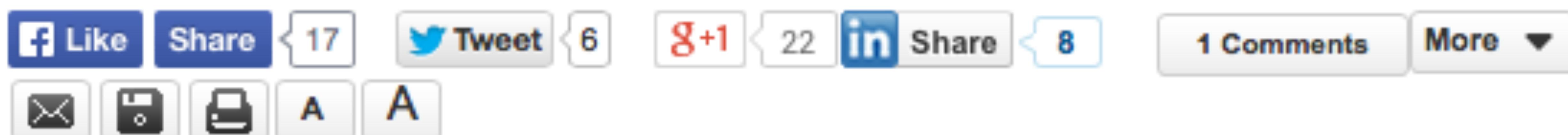
OPEN SOURCE

51



Antarctica to soon get cellphone service

IANS | Jun 10, 2014, 06.11 PM IST



The GSM service — network that carries voice calls and text messages elsewhere in the world — has been brought to Macquarie Island.

NEW YORK: How about planning your next vacation to Antarctica? No, this is not a joke as the southernmost continent, with bone-chilling weather, can now boast of a "cellphone service".

The GSM service — network that carries voice calls and text messages elsewhere in the world — has been brought to Macquarie Island, a small island just outside the Antarctic Circle, by the Australian government and California-based private company Range Networks.

The beauty of the technology is that although the network has a satellite up-link to connect to the world's telephone system, it is completely self-sufficient.



KYUNG HEE UNIVERSITY



balancing act

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- [Cell C could be in deep, deep trouble: report](#)



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TOP STORY

OpenBTS 4.0 offers new opportunities for Africa's mobile operators – Targeting remote locations and the transition to IP

Issue no 698 28th March 2014

Africa's mobile operators are faced with a number of network challenges that will have major commercial consequences. One of the key ones is the need to transition to IP for both voice and data to reduce costs and to be able to create a data network out of their legacy narrow pipe networks that is fit for purpose. A small start-up that is using OpenBTS to reach remote locations may have a contribution to make. Russell Southwood spoke to Paul Homburger, Range Network's Director of Sales.

OpenBTS has long been regarded as an outsider technology and something the mobile operators and equipment vendors do not give much credence to. Its advocates point to the fact that you can use it to build a network that can leverage standard Internet technology to build a core network.

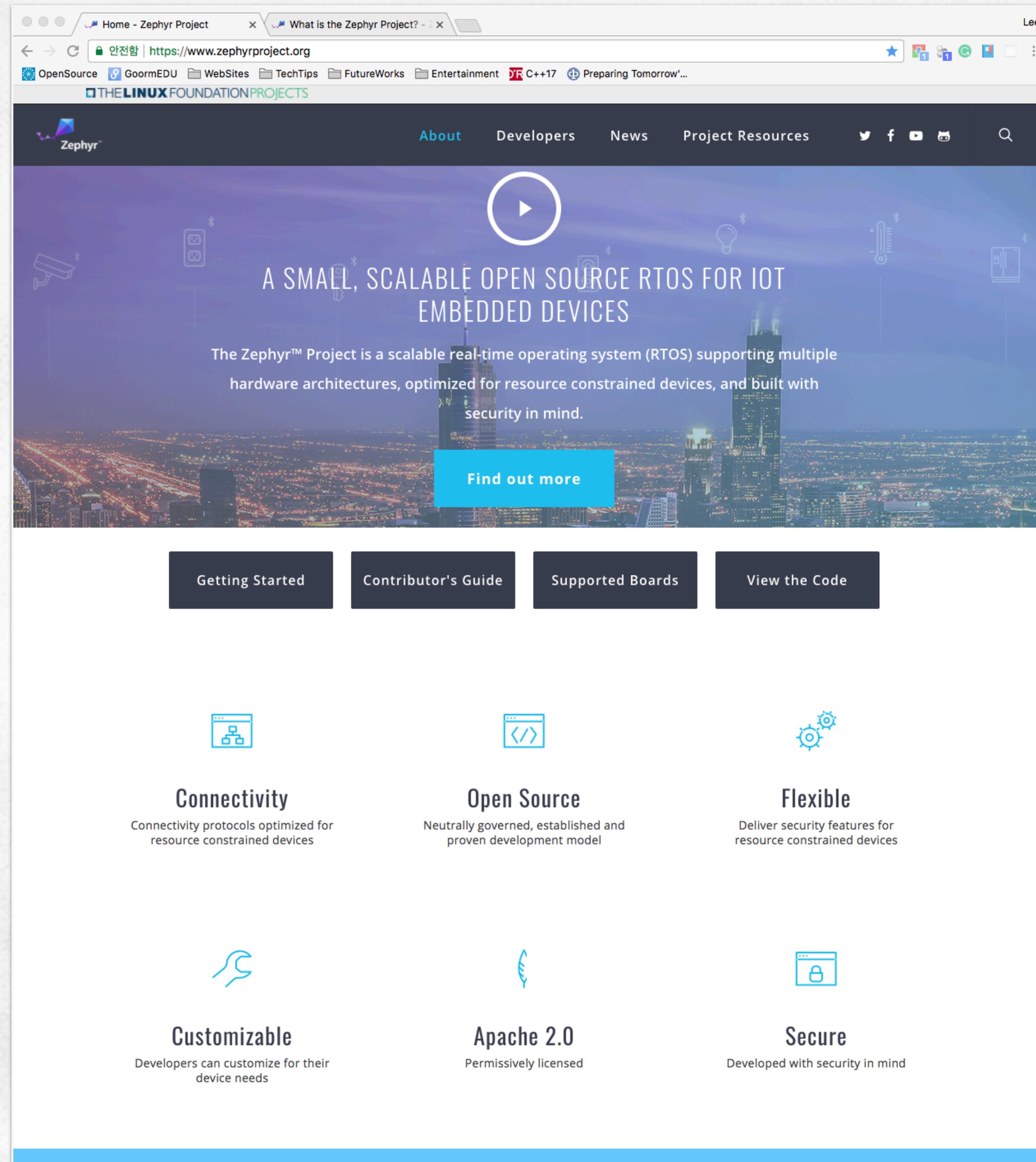
You can build out standard, low cost Wi-Networks alongside with low power equipment. It uses inexpensive software-defined radios for GSM calling that operate in the 700Mhz-2.4Ghz spectrum range. The network's intelligence can either be at the edge of the network or in the cloud or in a standalone system. Access to the GSM stack is software-

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New Comers

Zephyr Operating System



Zephyr Operating System

What makes Zephyr Project different?

Security

- ▶ Developed with security in mind
- ▶ Employs an in-depth security development lifecycle: security validation, fuzz and penetration testing, frequent code reviews, static code analysis, threat modeling and reviews to prevent backdoors in the code
- ▶ The project's governance includes the formation of a security working group and a delegated security maintainer
- ▶ The governance and its members have the responsibility to ensure that all aspects of the code are developed securely

Open Source

- ▶ Available through the Apache 2.0 open source license
- ▶ Free to use in commercial and non-commercial solutions
- ▶ Hosted as a collaborative project with the Linux Foundation, the project is neutrally governed employing a lightweight governance and development model
- ▶ From professional makers to large industrial and commercial vendors, the Zephyr Project strives to deliver a universally adoptable solution for the Internet of Things.

Modular

- ▶ Zephyr Project provides developers with feature-rich software optimized for memory constrained devices.
- ▶ Runs on systems as small as 8 kB of memory all the way up to 512 kB
- ▶ Complete freedom – use the RTOS as-is or tailor a solution by enabling/disabling nearly every feature using Kconfig
- ▶ Developers can use their tool suite of choice by supporting custom toolchains and compiler optimizations

Connected

- ▶ Optimized for low-powered, small memory footprint devices
- ▶ Supports Bluetooth®, Bluetooth® Low Energy, Wi-Fi*, 802.15.4
- ▶ Supports standards like 6Lowpan, CoAP, IPv4, IPv6, and NFC
- ▶ Refined and enhanced functionality through community-driven development

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Open Compute Project

Opensource Hardware meets IT & Telcos

The screenshot shows the homepage of the Open Compute Project (OCP) website. The header features the OCP logo (a green circular icon with arrows) and the text "OPEN Compute Project". The navigation menu includes links for About, Learn, Buy, Participate, Projects, News, Contact, Sign In, and a search icon. The main content area has a background image of a server room. On the left, there's a section titled "About OCP" with the following text:

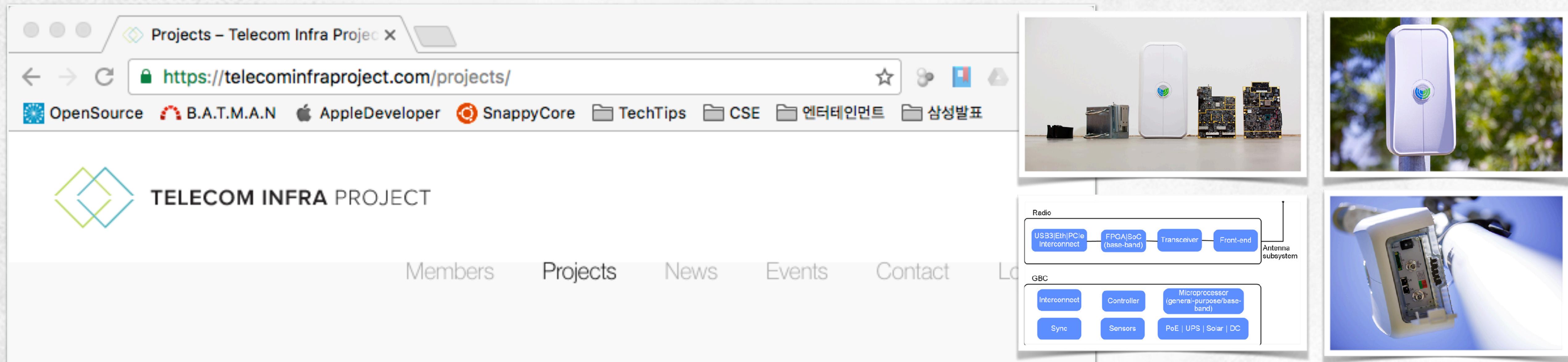
The Open Compute Project (OCP) is a collaborative community focused on redesigning hardware technology to efficiently support the growing demands on compute infrastructure.

On the right, there are two circular callouts: one dark grey circle containing the text "Hundreds of active members" and a larger light green circle containing the text "Collaborating to improve infrastructure design". To the right of these circles is a sidebar titled "Projects" with a list of categories: Storage, Networking, Server Design, Open Rack, Certification, Hardware Management, and Data Center.



Open Source Telecom

OCP TIP for Mobile Networking



The screenshot shows the Telecom Infra Project website at <https://telecominfraproject.com/projects/>. The page features a navigation bar with links for Members, Projects, News, Events, Contact, and a search bar. On the right side, there are three images of network hardware: a white outdoor access point, a close-up of its PCB, and a white indoor access point mounted on a pole. Below these images is a diagram of a base station's internal architecture, divided into Radio and GBC (General Baseband) sections.

Projects

The project groups were created to support three strategic network areas: Access, Backhaul and Core & Management. Within each area, the initial set of project groups will address some of the most pressing industry needs including connecting the unconnected or underserved populations, and augmenting the development of powerful new technologies like 5G that will pave the way for better connectivity and richer services. Specifications and designs are contributed to TIP through the TIP project groups.

This project group will deliver recipes for services/applications in the radio core network, leveraging open cloud architecture, libraries, software stacks and APIs. The group will provide a framework to enable disaggregated cloud scale computing for Radio Core Network (RCN) applications and services, such as IMS, P-Gateway, S-Gateway, EPC, etc. The scope also includes 5G & IOT infrastructure.

Open Source Telecom

OCP TIP: Open Source Hardware and Software for Telco Networking

- **Artificial Intelligence and applied Machine Learning** : will focus on using machine learning and automation to help carriers keep pace with the growth in network size, traffic volume, and service complexity. It will also work to accelerate deployment of new over-the-top services, autonomous vehicles, drones, and augmented reality/virtual reality.
- **End-to-End Network Slicing (E2E-NS)** : aims to create multiple networks that share the same physical infrastructure. That would allow operators to dedicate a portion of their network to a certain functionality and should make it easier for them to deploy 5G-enabled applications.
- **openRAN**: will develop RAN technologies based on General Purpose Processing Platforms (GPPP) and disaggregated software.

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OCP TIP: Open Source Hardware and Software for Telco Networking

- Several WGs follows:
 - ✿ **Open Optical Packet Transport:** This project group will define Dense Wavelength Division Multiplexing (DWDM) open packet transport architecture that triggers new innovation and avoids implementation lock-ins. Open DWDM systems include open line system & control, transponder & network management and packet-switch and router technologies.
 - ✿ **System Integration and Site Optimization:** The Working Group is focused on enabling carriers to more efficiently deliver new services and applications by using mobile edge computing (MEC) to turn the RAN network edge (mobile, fixed, licensed and unlicensed spectrum) into an open media and service hub.

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OCP TIP: Open Source Hardware and Software for Telco Networking

- Several WGs follows:
 - ✿ **vRAN Fronthaul:** The project is pioneering a virtualized RAN (VRAN) solution comprised of low-cost remote radio units that can be managed and dynamically reconfigured by a centralized infrastructure over non-ideal transport.
 - ✿ **Solutions Integration:** This project group will develop an open RAN architecture by defining open interfaces between internal components and focusing on the lab activity with various companies for multi-vendor interoperability. The goal is to broaden the mobile ecosystem of related technology companies to drive a faster pace of innovation.

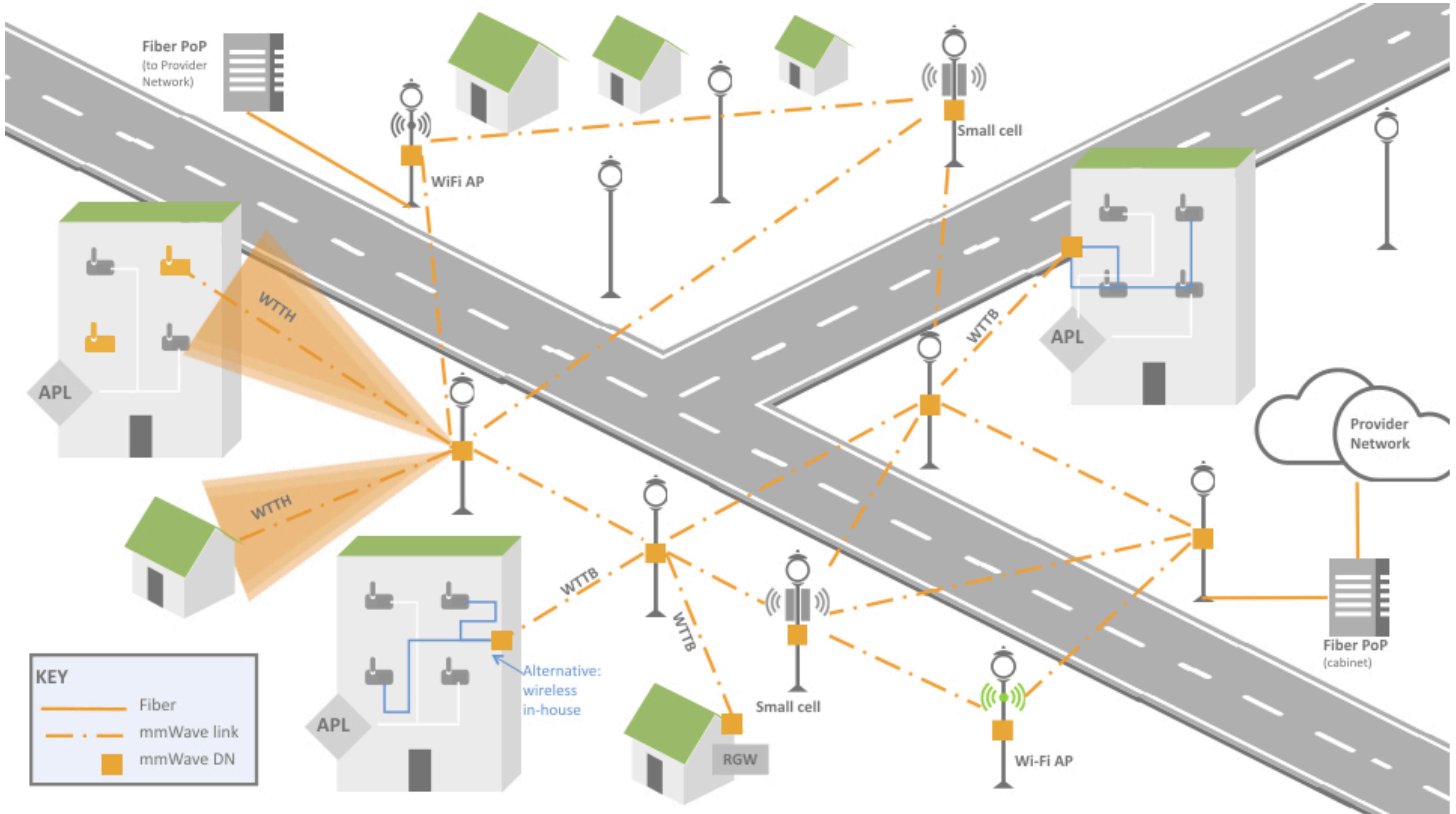
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OCP TIP: Open Source Hardware and Software for Telco Networking

- Several WGs follows:
 - ✿ **Edge Computing:** This group is addressing system integration requirements with innovative, cost-effective and efficient end-to-end solutions that serve rural and urban regions in optimal and profitable ways.
 - ✿ **mmWave Network:** This group is pioneering a 60GHz wireless networking system to deliver gigabits of capacity in dense, urban environments more quickly, easily and at a lower cost than deploying fiber. A contribution was made to IEEE 802.11ay task force this year on use cases for mmW backhaul.

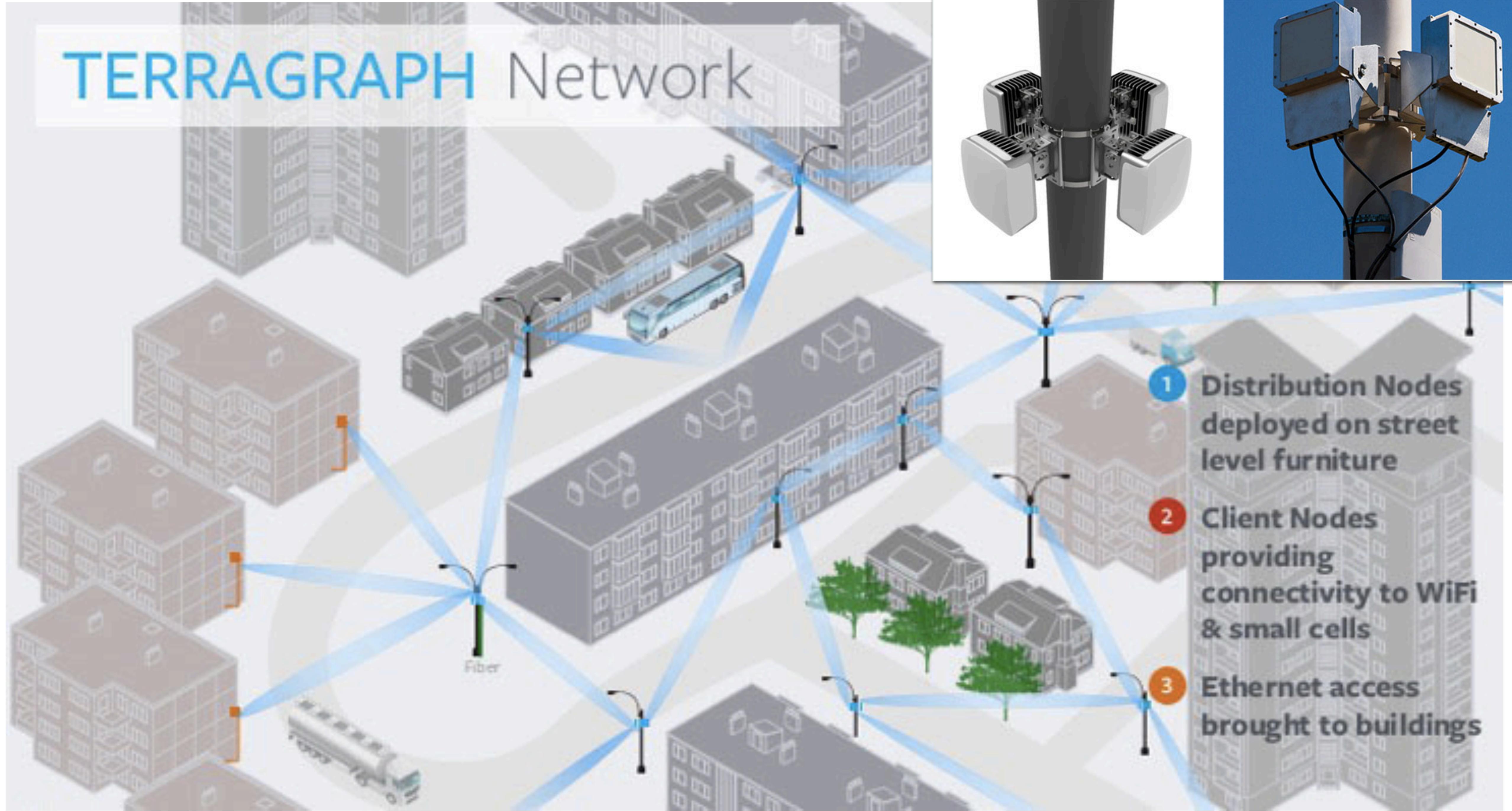
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OCP TIP mmWave Network Group



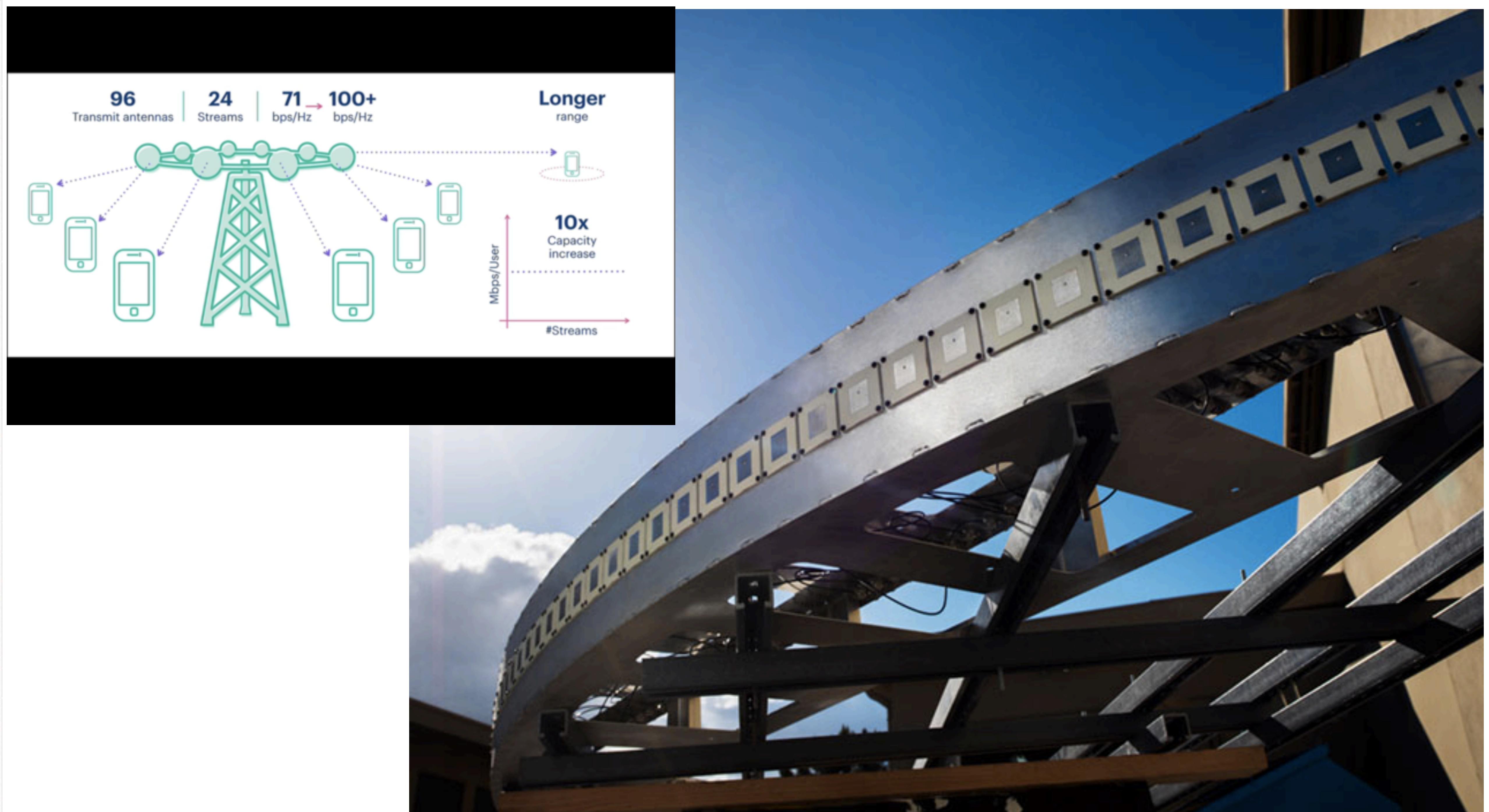
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Facebook's TERRAGRAPH (60 GHz, Multi-Node Wireless System)



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Facebook's ARIES (96 Antenna Massive MIMO System)



Why Open/R?

As more people come online and consume richer content, the complexity of the networks underlying the flow of information also grows. While traditional routing protocols have worked well over the past 30 years, it can be challenging and time-consuming to quickly push extensions or entirely new protocols into networking devices. New advances in routing often require carefully extending an existing protocol or designing new overlay extensions. Further, most protocols were initially designed based on constrained hardware and software environment assumptions from decades ago. **To continue delivering rich, real-time, and highly engaging user experiences over networks**, it's important to accelerate innovation in the routing domain. It was straightforward to add more applications on top of routing, such as link utilization measurement, shaping weight computation for bandwidth fairness, and MPLS label allocation for segment routing purposes. **Also, contrary to other approaches that focus on removing intelligence from the network and placing it in a central controller, we believe that autonomous network functions play an important role.**

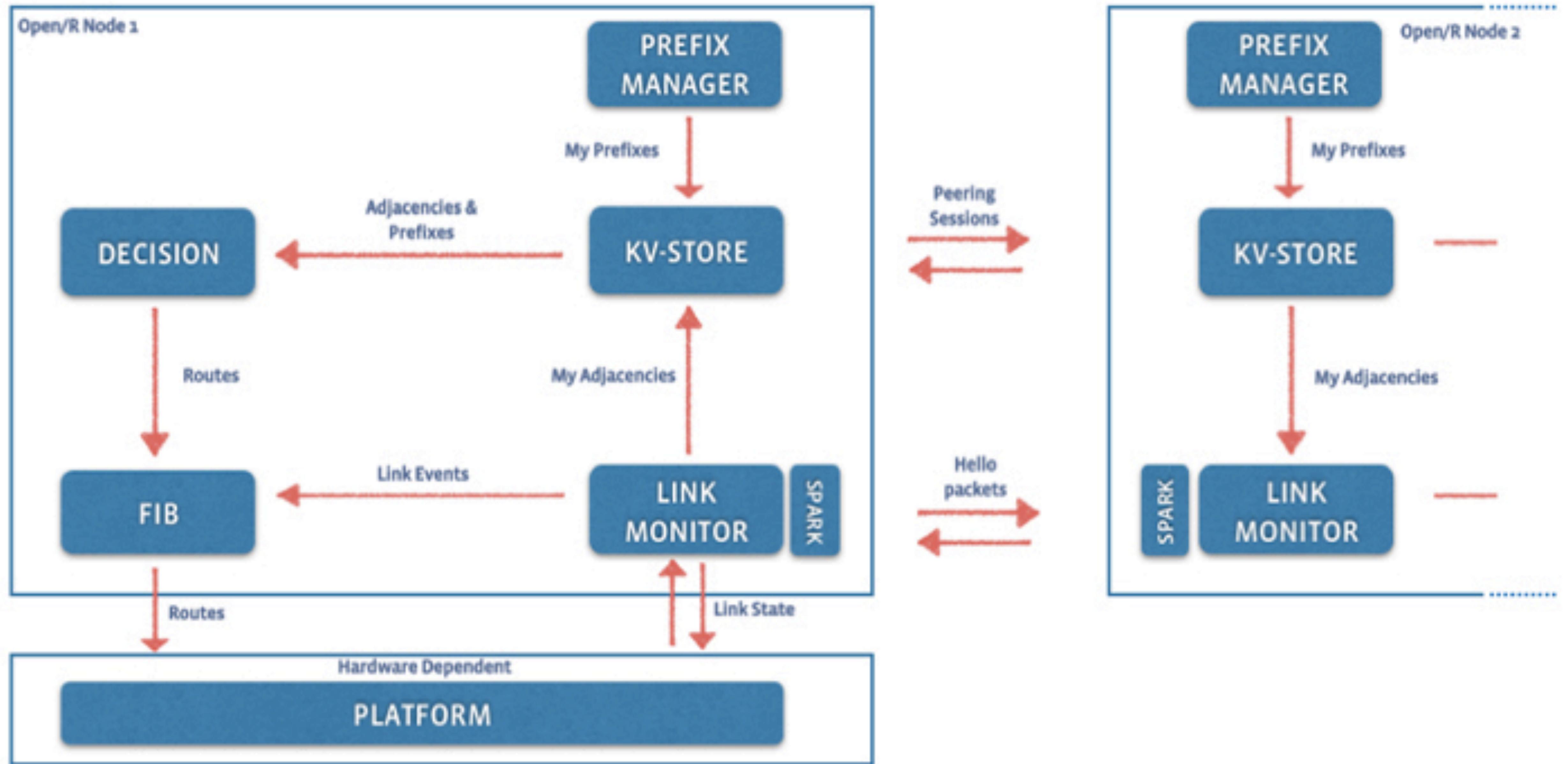
What is Open/R? (1/2)

- We are open-sourcing Open/R, an extensible network routing platform that enables rapid innovation in network functions and applications.
- Open/R is being used in Facebook's backbone and data center networks.
- The platform supports different network topologies (such as WANs, data center fabrics, and wireless meshes) as well as multiple underlying hardware and software systems (FBOSS, Arista EOS, Juniper JunOS, Linux routing, etc.).
- Open/R provides a platform to disseminate state across the network and allows new applications to be built on top of it. It also provides northbound interfaces to allow integration with external controllers.

What is Open/R? (2/2)

- Open/R supports features like automatic IP prefix allocation, RTT-based cost metrics, graceful restart, fast convergence, and drain/undrain operations.
- We have been working with external partners and operators to support and use Open/R, and we invite more operators, ISPs, vendors, systems integrators, and researchers to leverage Open/R as a platform for implementing new network routing ideas and applications.

High Level Architecture of Open/R (1/2)



High Level Architecture of Open/R (2/2)

- **KV-STORE**: functions as a replicated key-value store that enables distributed communications and state replication.
- **Spark**: performs neighbor discovery on interfaces using Link-Local Multicast, and reports neighbor activities.
- **LinkMonitor**: monitors system interfaces via Platform, manages Spark sessions on those, and advertises discovered neighbors in KV-STORE.
- **PrefixManager**: performs automatic prefix suballocation for ad hoc configuration.
- **Decision**: computes routing information based on the topological information learned via KV-STORE.
- **FIB**: serves as a proxy for programming computed routes via Platform, maintains forwarding state (computed routes).
- **Platform**: implements route programming and interface discovery logic for the target hardware platform.

“Don't reinvent the wheel”

- Open/R leverages existing open source codebases for two core functions.
 - First, the encoding and decoding of control plane data structures is done using [Thrift](#).
 - Second, the logic to exchange data between network nodes is implemented using [ZeroMQ](#).
- This design choice helped us eliminate a lot of technical overhead and develop Open/R quickly, concentrating on higher-level features rather than on the low-level plumbing.
- Open/R implements many features similar to those found in traditional protocols like IS-IS and OSPF, **it also introduces a few unique features of its own.**

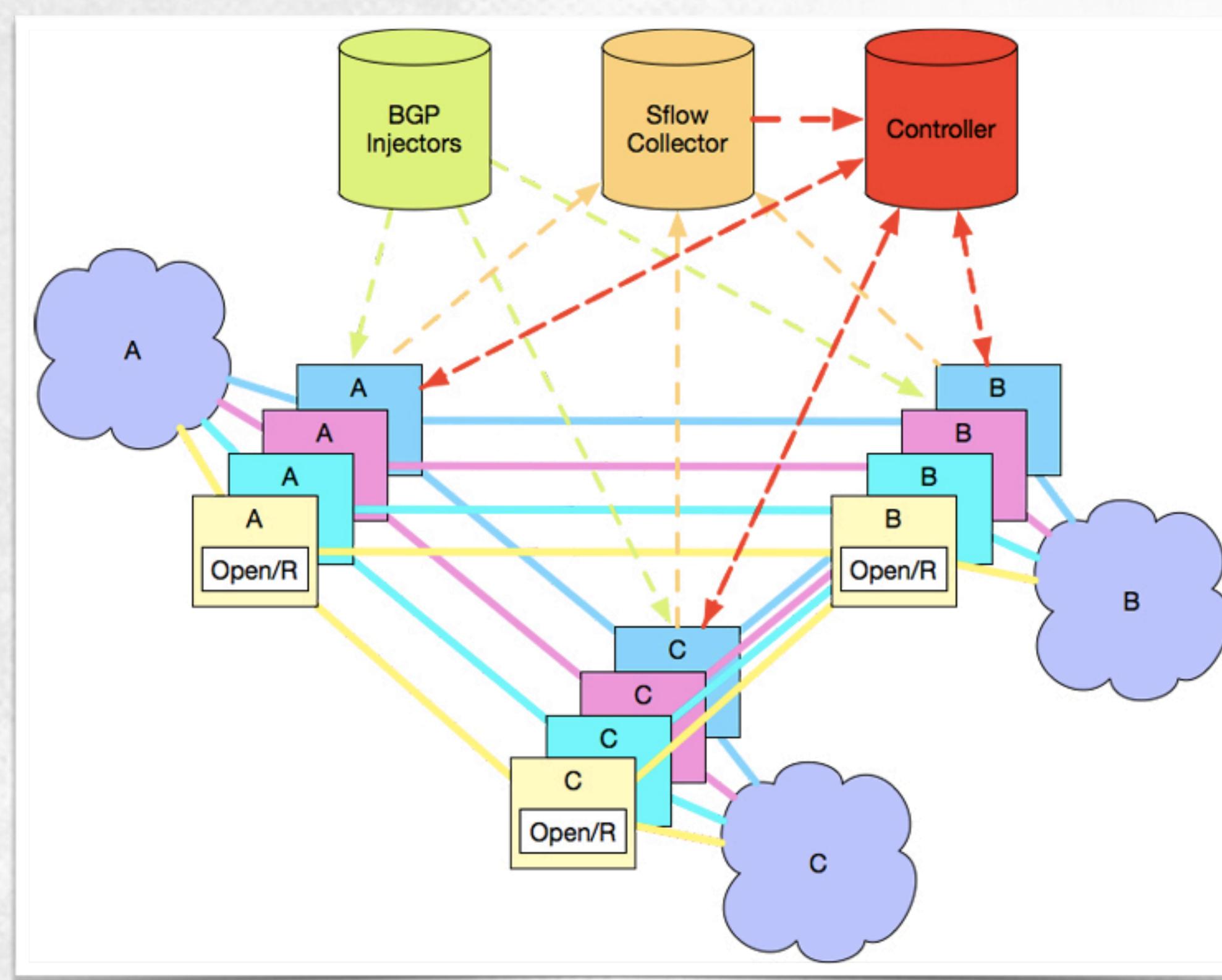
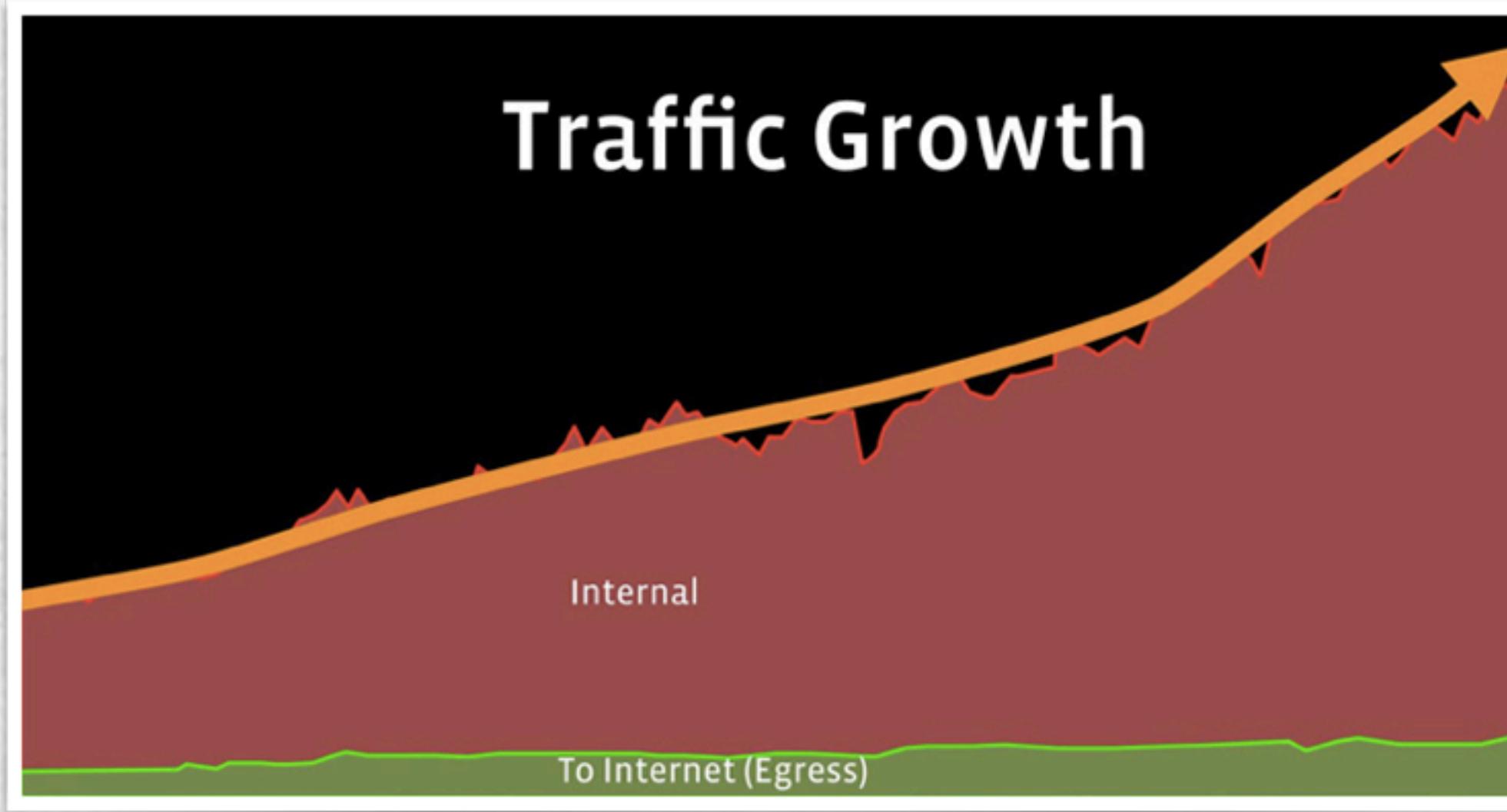
Unique Features of Open/R (1/2)

- IPv6 first, leveraging IPv6 link-local addresses to achieve zero-touch configuration. No special network configuration is required.
- Support for native IPv4 routing when needed.
- Ad hoc network prefix allocation and IP configuration for nodes in the network from a larger aggregate prefix.
- A graceful restart that enables live software updates without disrupting traffic forwarding.
- Support for draining and undraining for nodes and links.
- Dynamic link RTT metrics computed and smoothed out from active probes.
- The ability to set custom metric values, statically or dynamically.

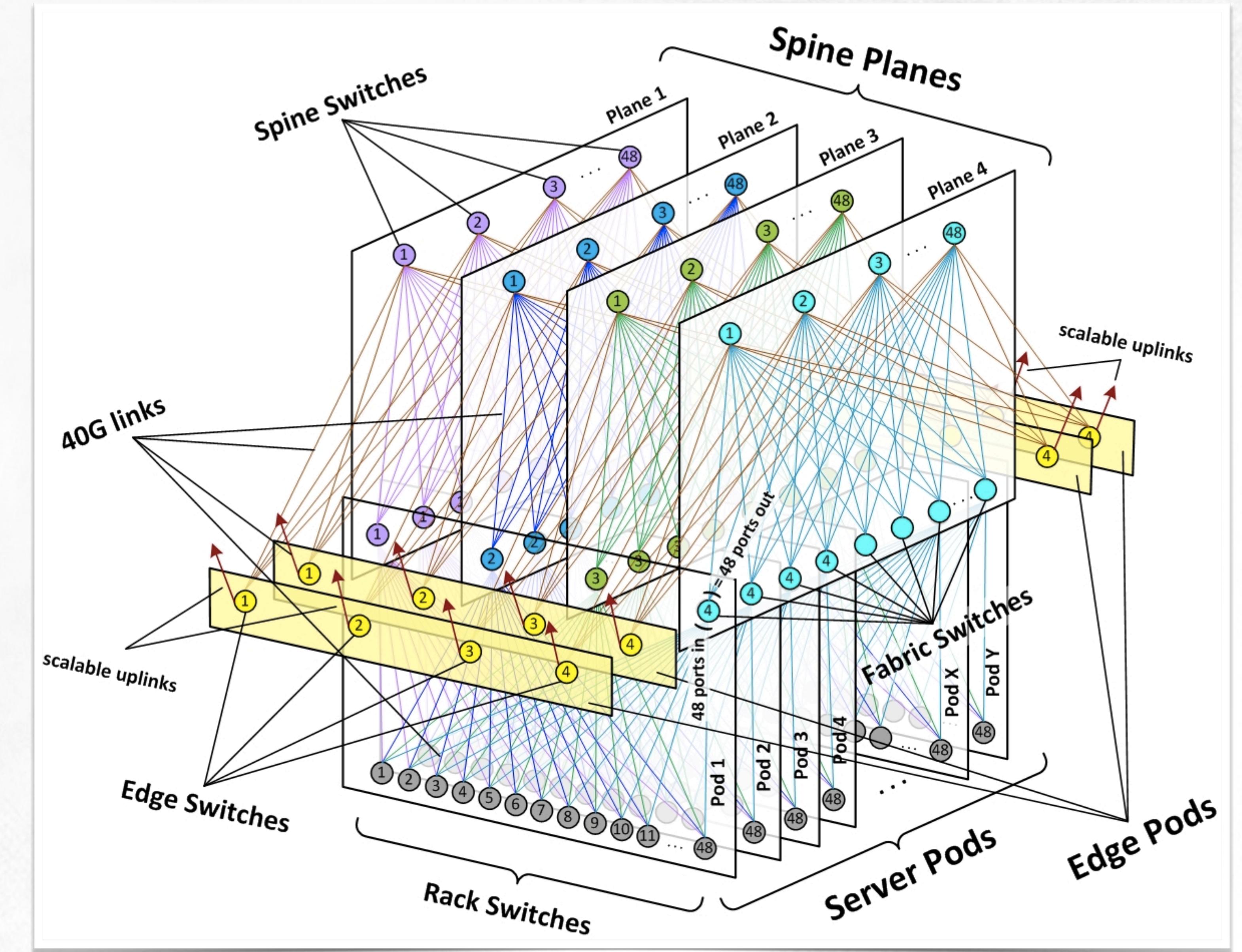
Unique Features of Open/R (2/2)

- Fast network convergence with smart back-off timers for link or node failures.
- Continuous health checking of the network through live reachability probing.
- An API for integration with centralized controllers.
- A Python library to interact with all the main Open/R processes.
- The ability to extend the platform to disseminate all sorts of additional information, and even to introduce enhancements or variations to the path computation logic.

Wireless Mesh to Backbone & Datacenter



Simplified three-site backbone topology example



Schematic of Facebook data center fabric network topology

Contents

- Internet of Thing (IoT)
- Physical Computing
- Cyber Physical System (CPS)
- Opensource DIY Networking
- Specialized OS for IoT
- OCP Telecom Infra Project
- Conclusion

“what's your impression?”



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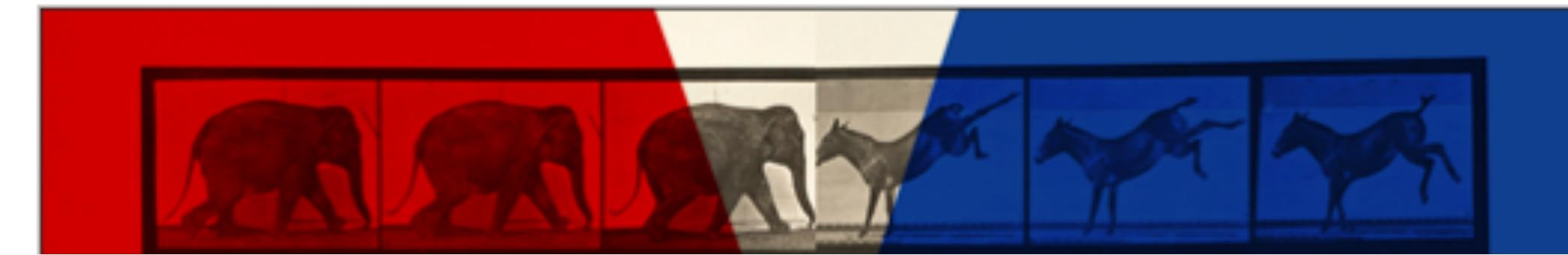
Ubuntu Linux 'Bash' command line comes to Windows 10, this could cross technologies for the benefit of all end users. Image credit: Canonical

The Little Black Book of Billions

NY bill would provide tax credit for open source contributors

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Project is a small, scalable real-time operating system for in resource-constrained systems supporting multiple cores. Developers are able to tailor their optimal solution. Due open source project, the community can evolve the project to support new hardware, developer tools, sensor drivers. Advancements in security, device management features, connectivity stacks and file systems can be easily implemented.

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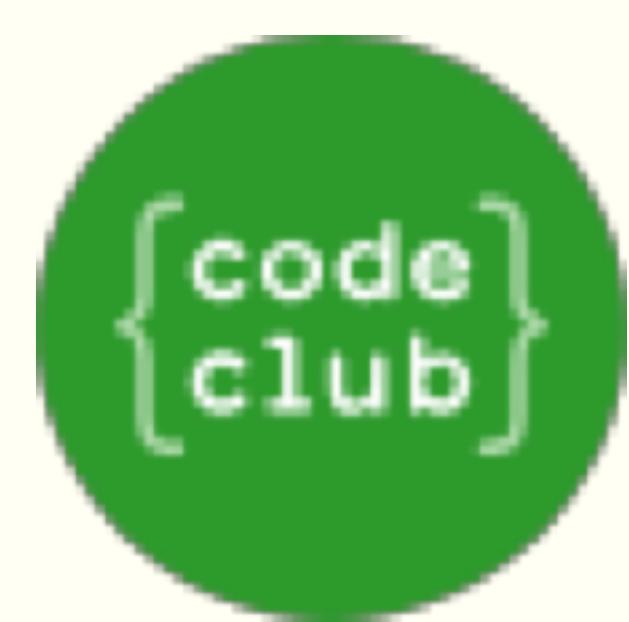


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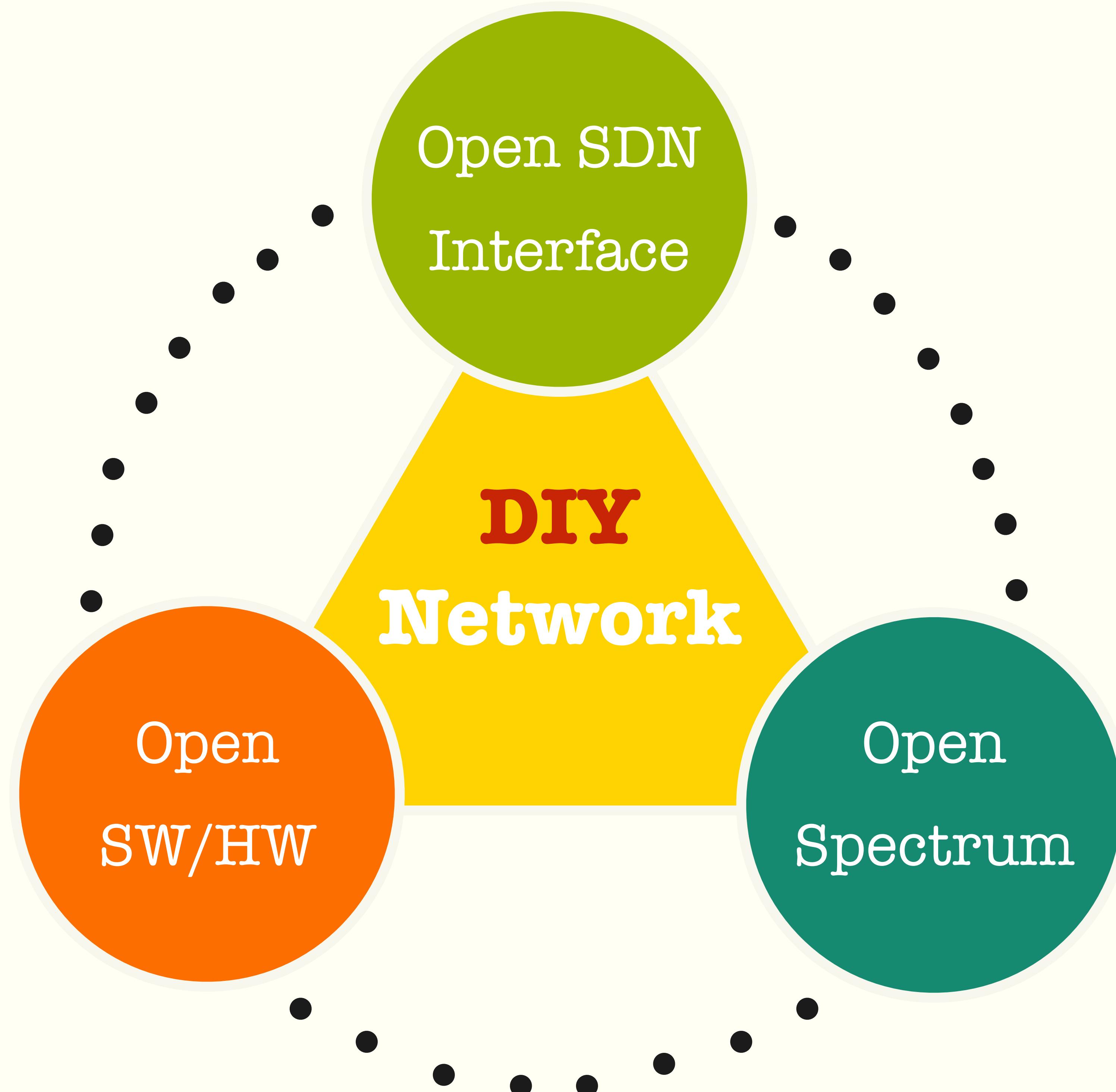
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