



ITU Kaleidoscope 2016
ICTs for a Sustainable World

5G IN RURAL AND LOW-INCOME AREAS: ARE WE READY?

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Join Work

- Introduction
- Key Questions
- Our Contributions
- Challenges
- Main Pillars
- Architecture vision
- Conclusions and Future Work



Introduction

- 69% of the world population is covered by the third generation (3G) network.
- The Internet penetration rate in North America is above 80%.

BUT...

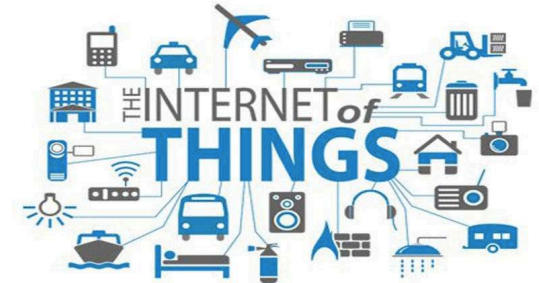
At least two billion people are currently experiencing a complete lack of wireless cellular coverage!



The connectivity divide

- The lack of connectivity is experienced by people living in rural and low-income areas
- Telecommunication networks are widely deployed in urban zones rather than in rural and low-income ones.
- Urban zones are covered by “first class” networks, like the forthcoming 5G technology.

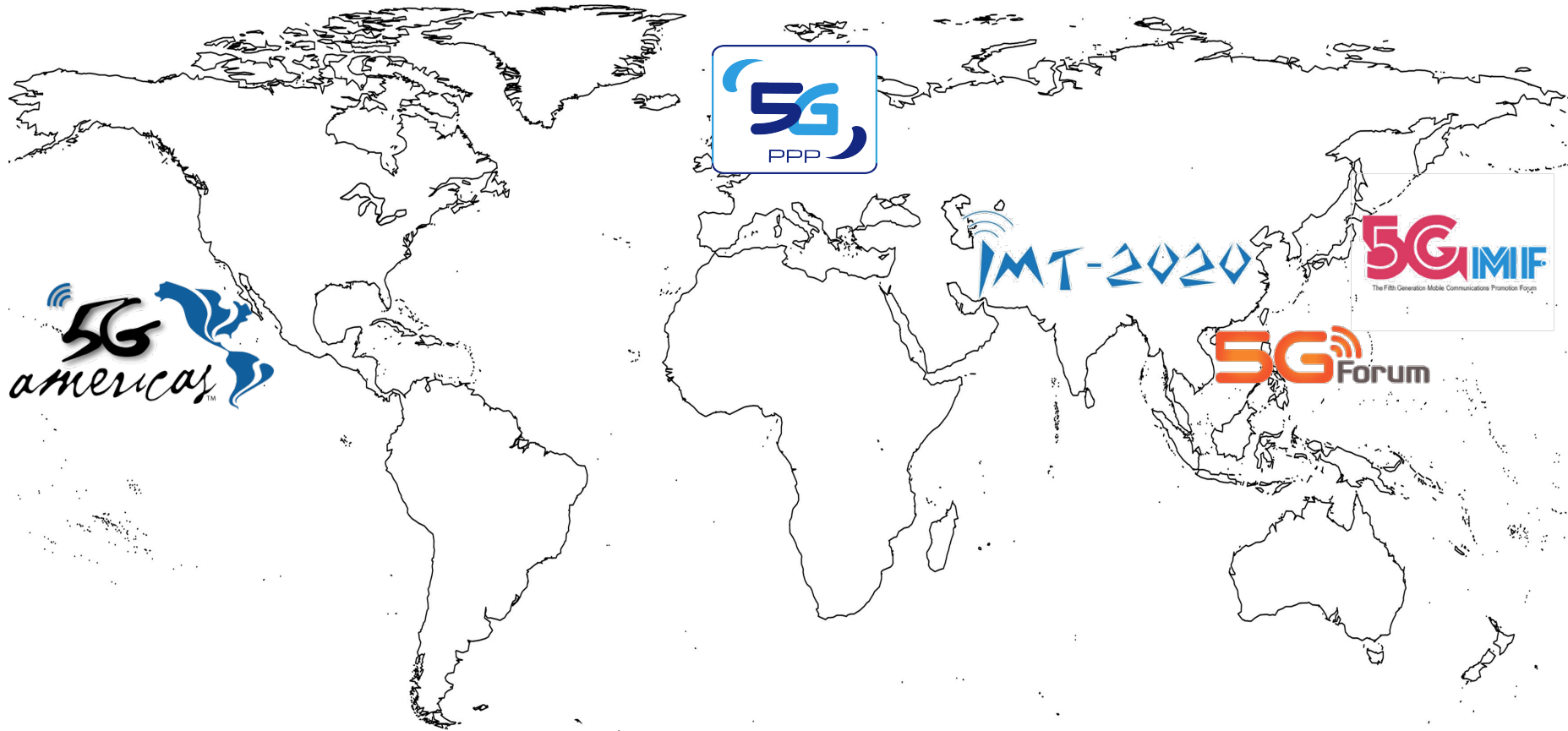
5G Services



- Tactile Internet
- Internet of Things
- Virtual Reality
- Very High Definition Videos
- e-Health



5G Research and Standardization Activities



- 5G is being investigated by a variety of organizations, including partnerships, research projects and international events

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5G Technology Advantages

- High level of flexibility
 - deploy services and network resources where and when they are really needed
- Exploitation of commodity hardware
 - development of software solutions implementing networking functions
- Converged solution
 - networks and services cooperate to deliver high bandwidth and extremely low delay to users.

IDEA: 5G networks can be the solution to the connectivity divide



Key Questions

- What are the main challenges that need to be faced for the adoption of 5G networks in rural and low-income zones?
- Is it possible to define a holistic 5G architecture explicitly designed to serve such zones?



Our Contributions

- We highlight the main challenges that need to be faced for the exploitation of 5G networks in rural and low-income zones.
- We select the main pillars that should be pursued to face the aforementioned challenges.
- We sketch a new 5G architecture explicitly designed to serve rural and low-income zones.

5G Technology Challenges

	Rural Scenario	Low-Income Scenario
Service Type	HD Video, Emergency Service, e-Health, e-Learning	Basic Connectivity, Emergency Service, Delay Tolerant, e-Health, e-Learning
Network Constraints	Coverage, Guaranteed Bandwidth	Coverage
Energy Sources	Power Grid, Renewable Sources	Unreliable Power Grid and/or Renewable Sources
Network Cost from the User Side	Same as standard urban users	Low
Business Model	Subsidized by the government	Subsidized by the government
Required Network Flexibility	High	High
User Mobility	Pedestrian, Vehicular	Pedestrian, Low Speed Vehicular



Socio-Economic Challenges

Challenge	Explanation
Affordability	The cost of broadband connectivity can be a financial barrier
Applications and service relevant to users	Users need applications that are necessary to their primary development needs.
Improvements in human skills	ICT-based skills in the areas such as computer networking, web and basic applications development and elementary network security are essential in all societies.
Impact of the networking on environment	The networking can drive energy efficiency, smart systems and services to enable more productivities. However, networking is to be also a growing source of material consumption and greenhouse gas (GHG) emissions.



A diagram showing five interlocking polygonal shapes arranged in a circle around a central hexagon. The shapes are colored: magenta (top-left), red (top-right), blue (left), green (bottom), and yellow-green (right). Each shape contains text. The central hexagon is light gray and labeled 'Main Pillars'. The background features faint, stylized icons of gears, arrows, and network nodes.

Coverged Solution

Reusability of
Network
Components

Main
Pillars

Unmanned Aerial
Vehicles (UAVs)
and Avanced
Radio Techniques

Exploitation of
Commodity
Hardware

Solar-Powered
Energy-Efficient
Devices

The background of the slide is a complex, abstract composition. It features a light blue base with various white line-art icons representing networks, gears, and data flow. Overlaid on this are several large, semi-transparent geometric shapes in shades of magenta, pink, and light blue. In the lower-left, there's a cluster of overlapping translucent shapes in blue, green, and yellow. The overall aesthetic is modern and technological.

Coverged Solution

The last mile of the network should be orchestrated in conjunction with the metro and core one.

The network provider is also acting as a service provider.



Reusability of Network Components

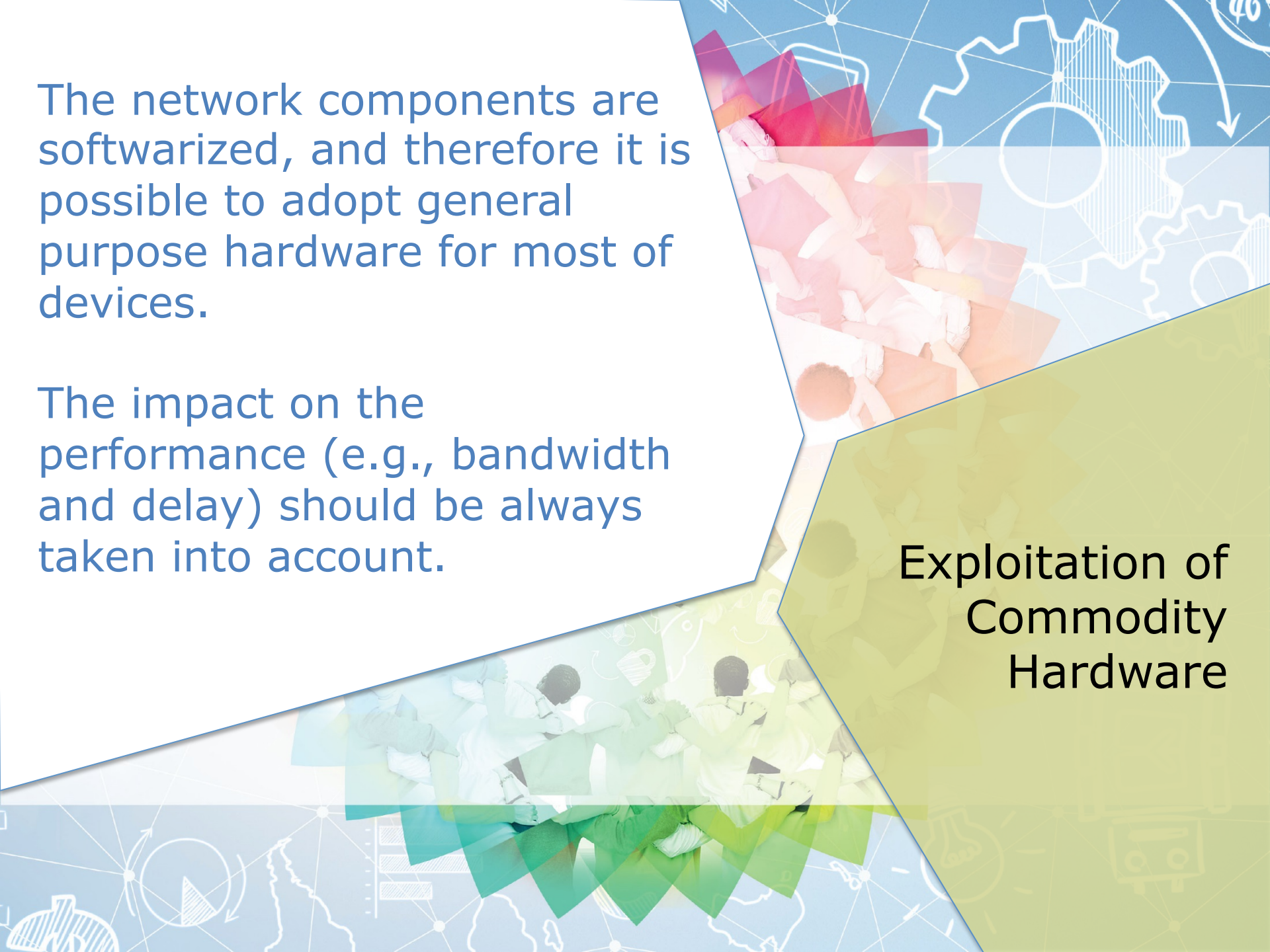
Virtualize most of the network components by means of virtual functions shared among the network elements and managed by a centralized entity

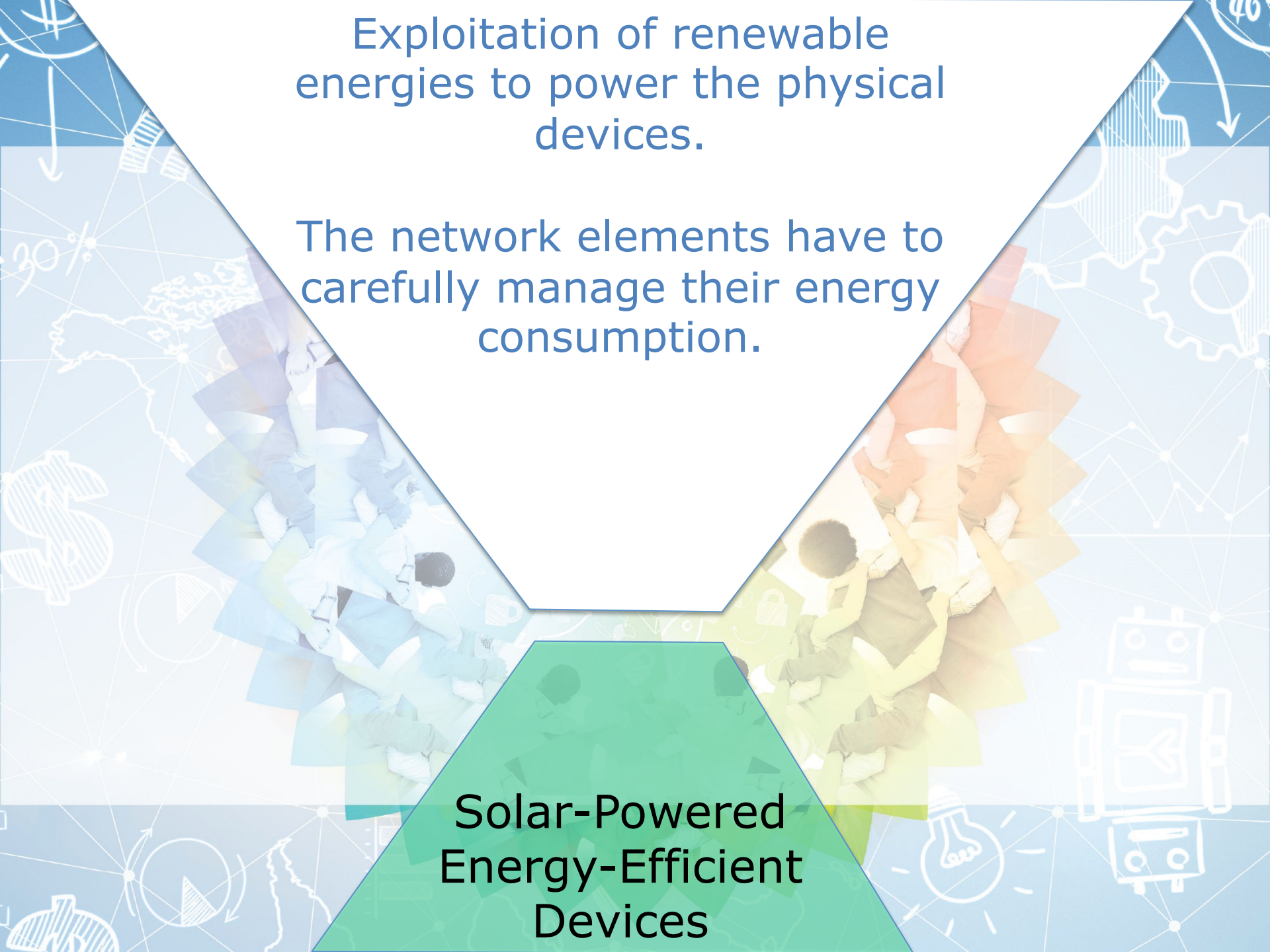
Each network element is composed of a set of virtual elements

The network components are softwarized, and therefore it is possible to adopt general purpose hardware for most of devices.

The impact on the performance (e.g., bandwidth and delay) should be always taken into account.

Exploitation of
Commodity
Hardware





Exploitation of renewable
energies to power the physical
devices.

The network elements have to
carefully manage their energy
consumption.

**Solar-Powered
Energy-Efficient
Devices**

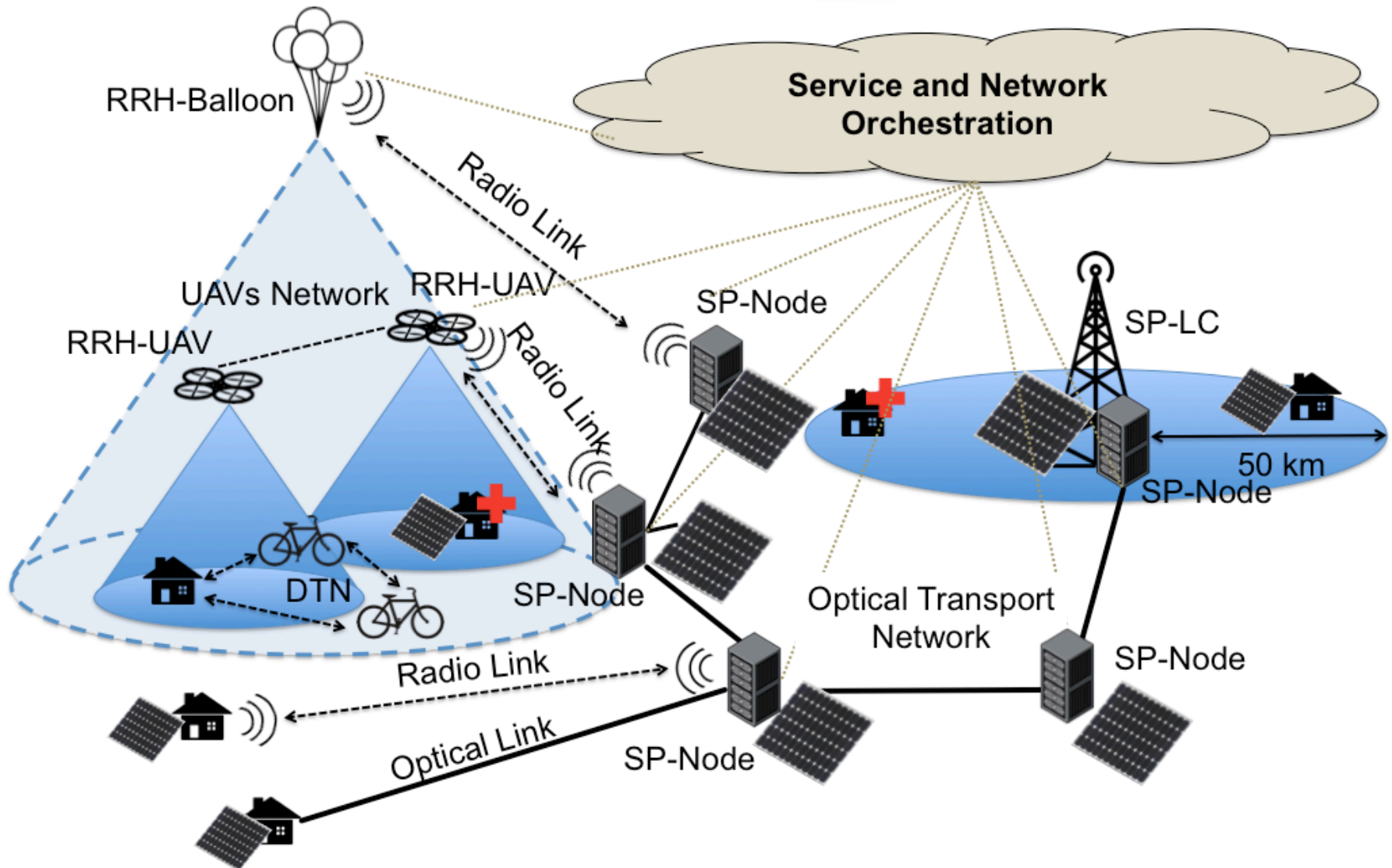


Unmanned Aerial Vehicles (UAVs) and Advanced Radio Techniques

Radio Elements mounted on
top of UAVs.

Massive antenna arrays to
deploy radio elements covering
ultra-large cell sizes.

Proposed Architecture





Conclusions and Future Works

- We have focused on the problem of providing 5G services in rural and low-income areas, by considering the main challenges that need to be faced.
- We have proposed a set of pillars to follow, as well as a reference architecture.
- As next step, we plan to evaluate the costs for adopting the proposed solution (CAPEX and OPEX)
- We plan also to face different technological aspects
 - optimal UAVs trajectory
 - practical radio issues such as the impact on the uplink channel
 - dimensioning of the solar panels.

The image features a central graphic of a group of people in business attire standing in a circle with their hands clasped. This is overlaid with a large, multi-layered circular graphic that resembles a stylized flower or a complex mandala. The layers of this graphic are colored in a gradient from purple at the top, through pink, red, orange, yellow, green, and finally blue at the bottom. The entire composition is set against a light blue background filled with various white line-art icons related to business and technology, such as gears, a dollar sign, a pie chart, a lightbulb, and a computer monitor. The text "Thank you for your attention. Questions?" is centered over the middle of the image in a bold, dark blue font.

**Thank you for your attention.
Questions?**