Best practices and recommendations for digital inclusion through resilient infrastructure
17th Internet Governance Forum @ Addis Ababa, Ethiopia
28 November 2022

Network in a Box to Provide Health Services in Remote Areas

- Theme: 1. Digital Inclusion – Health
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Presentation Outline

- Research team
- Introduction
- Research methodology
- Research findings and outcomes
- Recommendations
- Conclusions

Research team

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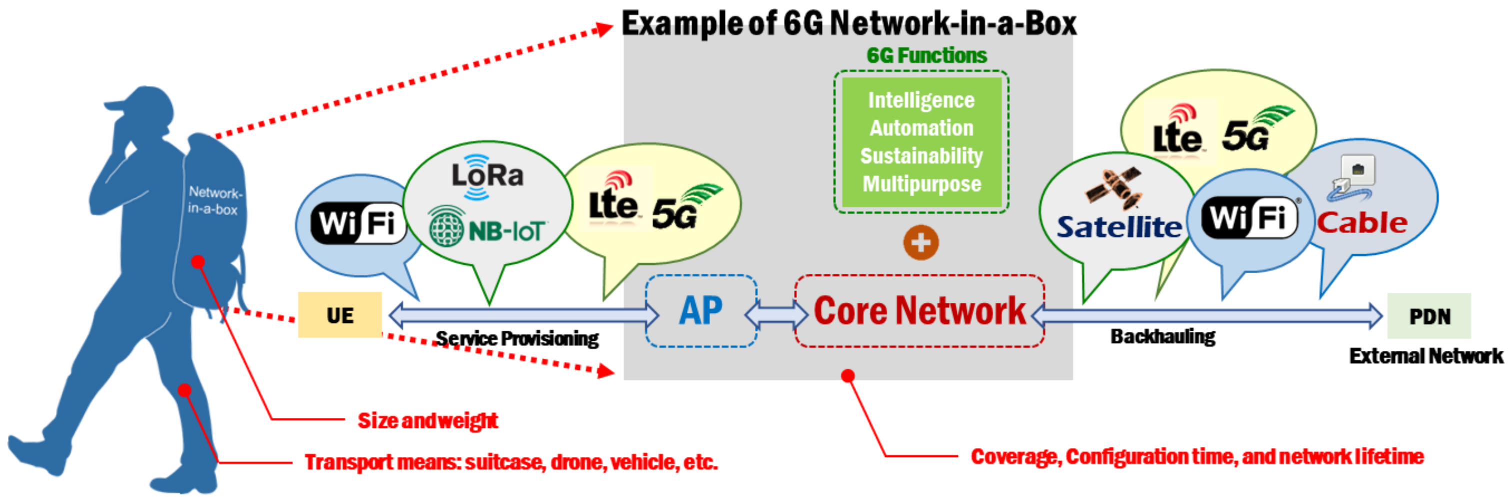
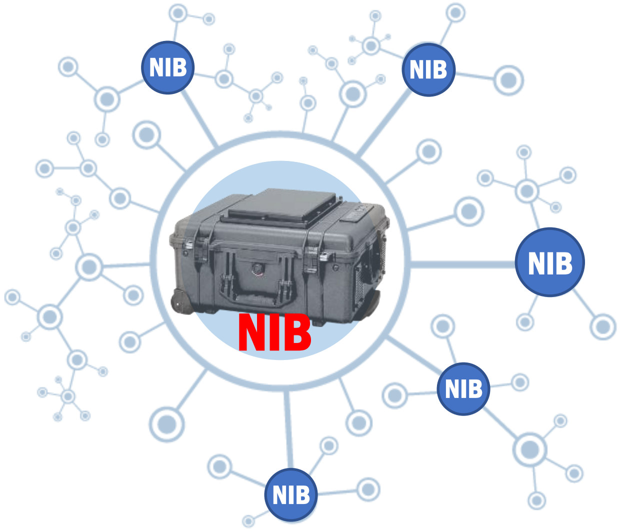
Introduction

- Remote areas suffers insufficient network connectivity.
  - Connectivity for health, education, economics applications, etc.
  - Broadband data service
  - Internet-of-Things (IoT) information
- Remote areas require cost-effective networking solutions.
  - Lightweight and portable network solution
  - Fast and easy deployment.
  - Network flexibility
  - Inter-operability
- The potential network solutions support broadband data and IoT data simultaneously.

Introduction

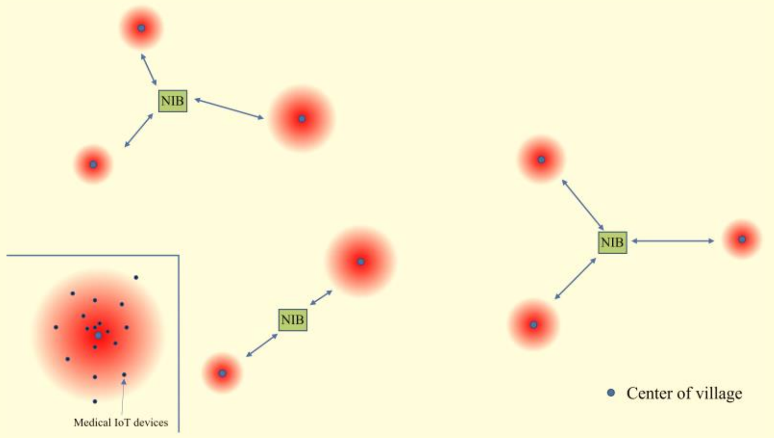
- Network-in-a-box (NIB)
  - Single all-in-one portable device consisting of all software, firmware, and hardware modules supporting service provisioning and backhauling in a network
- Objective : optimal deployment of multi-NIB network for broadband and health IoT service in remote areas



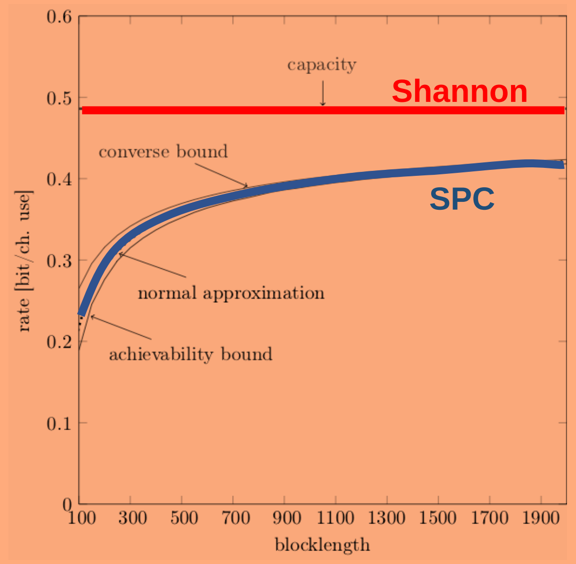


Research methodology

- User Distribution
  - Deterministic
  - Sparsely populated
  - Clustered
  - Gaussian



- User Rate Model
  - Shannon capacity
  - Short packet commun.



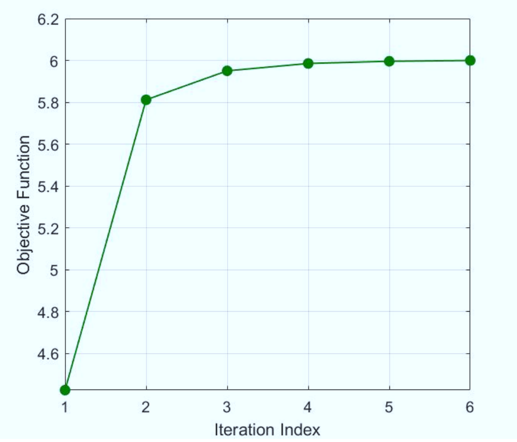
- Optimization
  - Throughput maximization
  - Given parameters
    - Block length
    - Required data rate
    - Tolerable Delay
    - Network bandwidth
  - Variables
    - NIB locations
    - User associations
    - Coding rates for packets

Research findings and outcomes

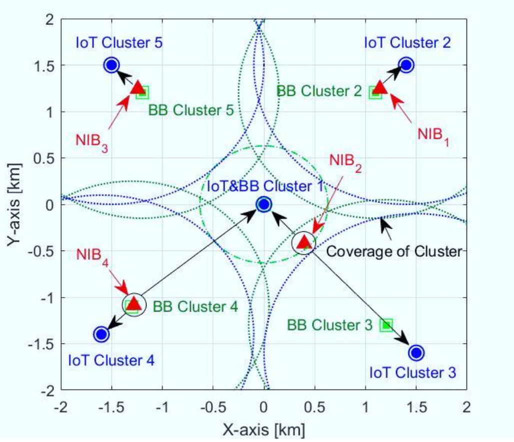
- Iterative Algorithm
  - Local optimality
- Simulation Results in Example

Definition	Parameter value
Number of NIBs (N)	4
Number of IoT user clusters (K)	5
Number of BB user clusters (K)	5
Center location of IoT user cluster (μ_k^{iot})	(0,0), (1.4,1.5), (1.5,-1.6), (-1.6,-1.4), (-1.5, 1.5) [km]
Center location of BB user cluster (μ_k^{bb})	(0,0), (1.1,1.2), (1.3,-1.3), (-1.3,-1.1), (-1.2, 1.2) [km]
Radius of IoT user clusters ($R_{k,\mathrm{iot}}$)	0.7, 1.5, 1.5, 1.5, 1.5 [km]
Radius of BB user clusters ($R_{k,\mathrm{bb}}$)	0.63, 1.35, 1.35, 1.35, 1.35 [km]
Weight of IoT user density (ω_k^{iot})	3/7, 1/7, 1/7, 1/7, 1/7
Weight of BB user density (ω_k^{bb})	1/3, 1/6, 1/6, 1/6, 1/6
Variance of IoT user distribution ($\sigma_{k,\mathrm{iot}}^2$)	0.0532, 0.244, 0.244, 0.244, 0.244 [km^2]
Variance of BB user distribution ($\sigma_{k,\mathrm{bb}}^2$)	0.0431, 0.198, 0.198, 0.198, 0.198 [km^2]
Processing delay (c_d)	1.5
Latency limit (τ_{th})	10 [ms]
Number of bits in a block (B_n)	256 [bits]
Minimum rate threshold for IoT (R_{th})	5 [Mbps]
Total bandwidth (W_{tot})	40 [MHz]
Individual bandwidth for IoT and BB links	5 [MHz]
Path loss exponent (α)	2
Reference SNR (β_0)	80 [dB]

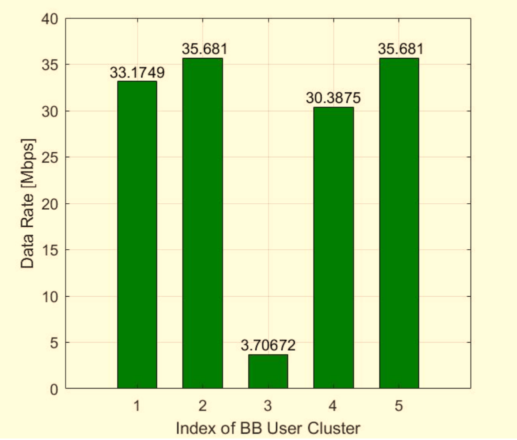
Convergence



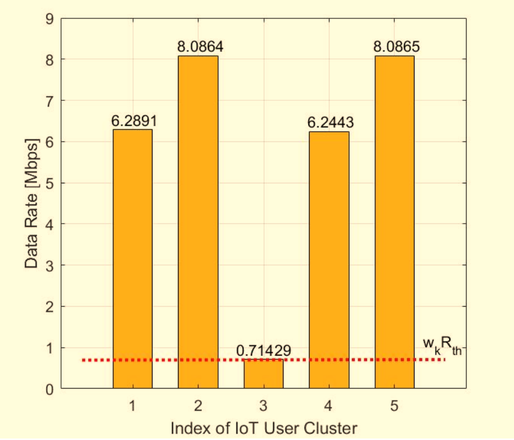
NIB deployment



Broadband data rate



IoT data rate



Recommendations

- To alleviate the NIB-based network load in remote areas
  - Limited backhaul capacity – Satellite backhaul
  - Network traffic and latency – Mobile edge computing and caching
  - Evaluation of age of information

- Further considerations
  - Transport means
  - Coverage mapping
  - Network reconfiguration

Conclusion

- We investigated the feasibility of NIB-based network optimization to support smart health IoT services in rural areas.
  - Mathematical modeling
  - Network deployment problem
  - Proposed iterative algorithm

- Future works
  - Study on coexistence with conventional cellular networks
  - Study on interoperability with sensing, radar, and localization.