Flexcomm Simulator: Exploring Energy Flexibility in Software Defined Networks with ns-3

Workshop on ns-3 (WNS3) 2023

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Financed through FCT within the project FLEXCOMM (EXPL/CCI-INF/1543/2021)
Introduction

• The Information and Communication Technologies (ICT) sector accounts for 5% to 9% of global electricity consumption and 2% of greenhouse gas emissions

• Data transmission networks alone are responsible for half of these amounts

• These numbers are expected to increase
Software Defined Networks (SDNs)

- Dynamic and manageable approach to network management
- Decouples the control and data planes

[Diagram showing traditional network and software defined network with OpenFlow communication]
Energy Flexibility

• Energy availability in specific regions
• Distributed Energy Resources (DERs)
• Available energy differs across the electrical grid
Flexcomm Simulator

- Built with ns-3
- *Pipeline workflow*
Flexcomm Simulator

- Existent modified modules
- New developed modules
Flexcomm Simulator

- Existent modified modules
- New developed modules

- New configuration language
- ns-3 agnostic
- Non-verbose
Flexcomm Simulator

- Existent modified modules
- New developed modules

- OpenFlow 1.3 support
- Software switch implementation
- Controller interface
- MPI support added
Flexcomm Simulator

- Existent modified modules
- New developed modules

• Adds Energy Flexibility to the simulation
Flexcomm Simulator

- Existent modified modules
- New developed modules

- Simple Network Management Protocol (SNMP)
- Collect information from network devices
Flexcomm Simulator

- Existent modified modules
- New developed modules

- Allows to model energy consumption
- A new workload-based energy model
- Improved logging
Flexcomm Simulator

• Existent modified modules

• New developed modules

• Measure performance metrics of network flows
Flexcomm Simulator

- Existent modified modules
- New developed modules

- **Utilization statistics**
- **Links and Switches**
Flexcomm Simulator

- Internal and External SDN Controllers support
Flexcomm Simulator

- Distributed Simulations
- High Performance Computing infrastructures
Proof of Concept
Energy Flexibility-Aware Routing

• Metropolitan Area Network (MAN)
• Energy Flexibility-Aware novel routing algorithm
Proof of Concept
Energy Flexibility-Aware Routing

• Minimal Quality of Service (QoS) impact

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<th>Metric</th>
<th>OSPF</th>
<th>Novel</th>
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<tr>
<td>Packet Loss (%)</td>
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Proof of Concept
Distributed Simulations

• Decrease simulation duration
Future Work

• Continuing the development of the Flexcomm Simulator

• Development of more advanced energy flexibility-aware routing strategies
  • Proactive decisions
  • Prioritize QoS sensitive communications (e.g., VOIP)
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