ChirpStack vs. The Things Stack

From the downlink communication perspective

Carlos Fernandez Hernandez
Oana Iova
Fabrice Valois

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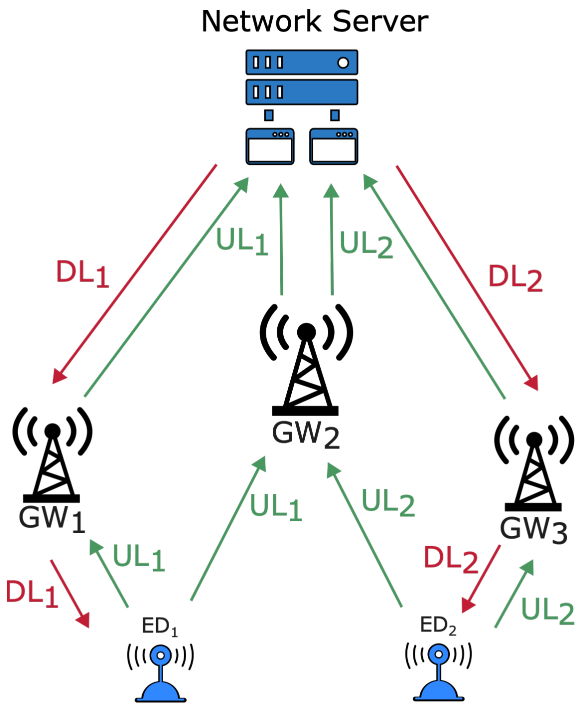
Traffic Flow in LoRaWAN

- Three main entities:
  - End devices
  - Gateway
  - Servers: network, join, application

- Suport bidirectional traffic:
  - Uplink (UL)
  - Downlink (DL)



Transmission and reception of UL and DL traffic

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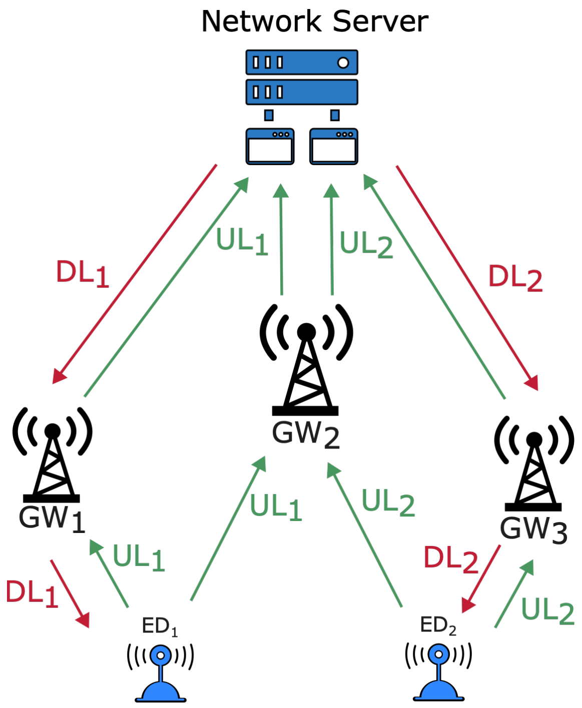
Not recommended, but needed:
- LoRaWAN (OTAA, ADR, sync)
- *Reliability (ACK)*
- Control of actuators
- Firmware Update Over the Air (FUOTA)



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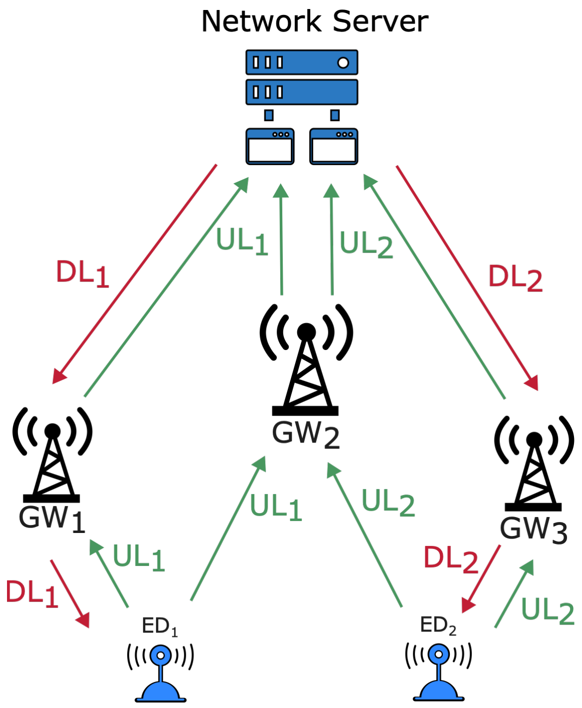
- LoRaW... c)
-
- C
- F... the Air (FUOTA)

WHY?

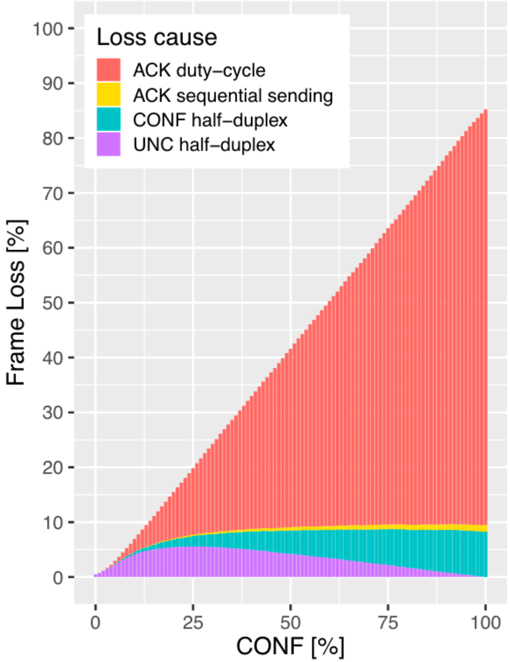


Transmission and reception of UL and DL traffic

Downlink in LoRaWAN

- **Negative impact on network capacity due to:**
  - Duty cycle constraint
  - Half-Duplex gateway
  - Sequentiality in downlink
  - Quasi-orthogonality between UL & DL

- **Uplink and downlink both impacted!** [1, 2]



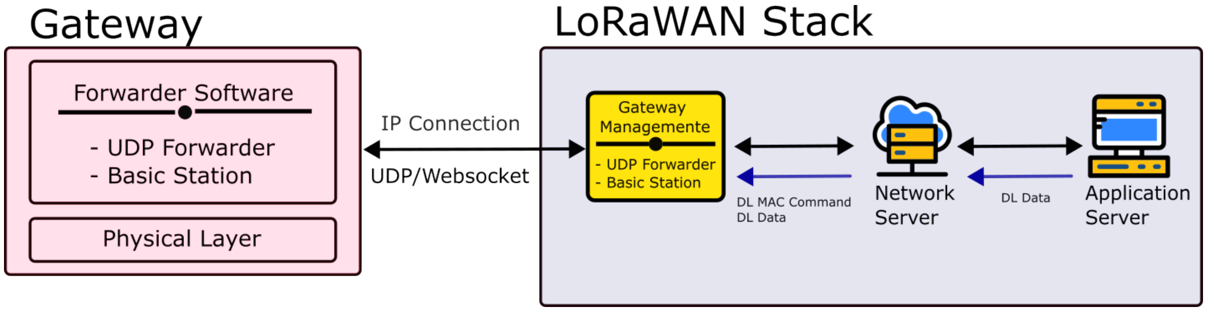
Frame lost due to downlink traffic with single gateway [4]

Performance Evaluation with Downlink

- How to evaluate?
  - Analytically [1, 4]
  - Simulation [2]
  - Emulation - ELoRa [5]

Focus on link between end device and gateway!

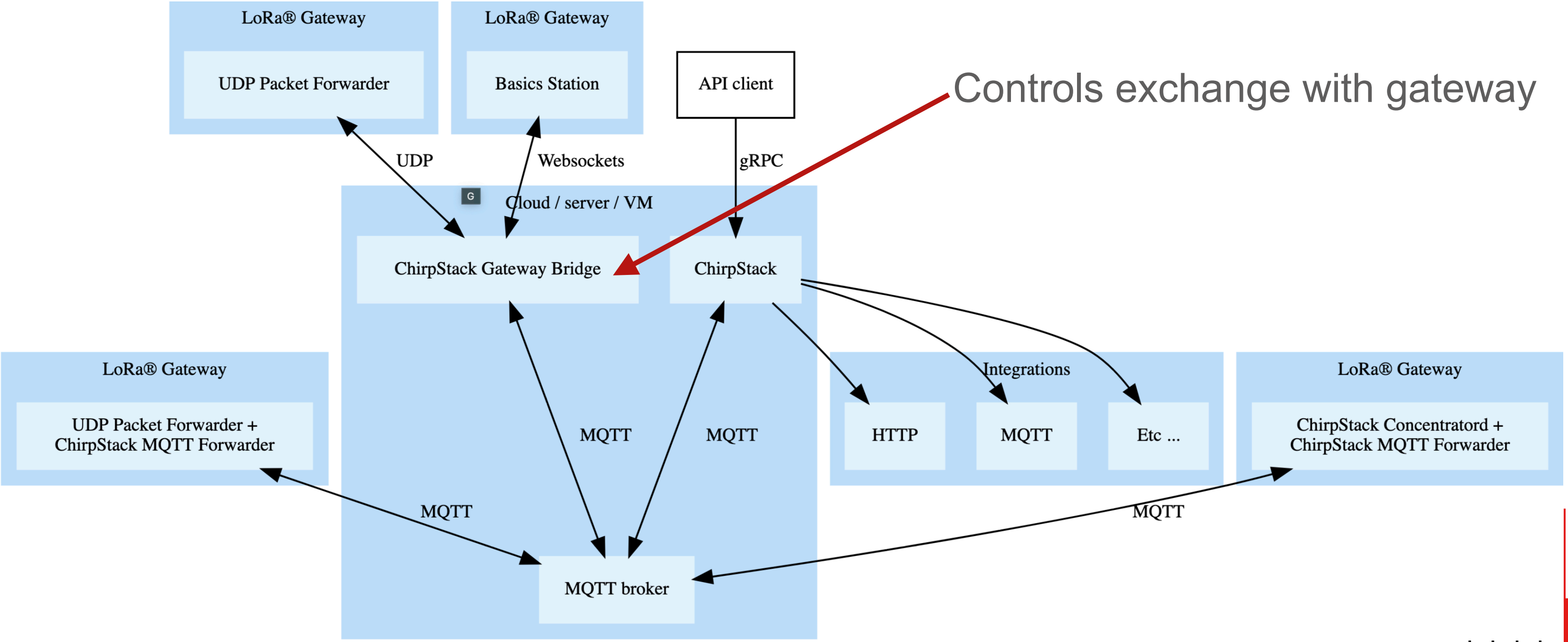
- Network server is responsible for:
  - End device activation and monitoring
  - Controlling LoRaWAN mechanisms
  - **Scheduling downlink packets**



LoRaWAN network architecture

Network Server Implementations: Chirpstack

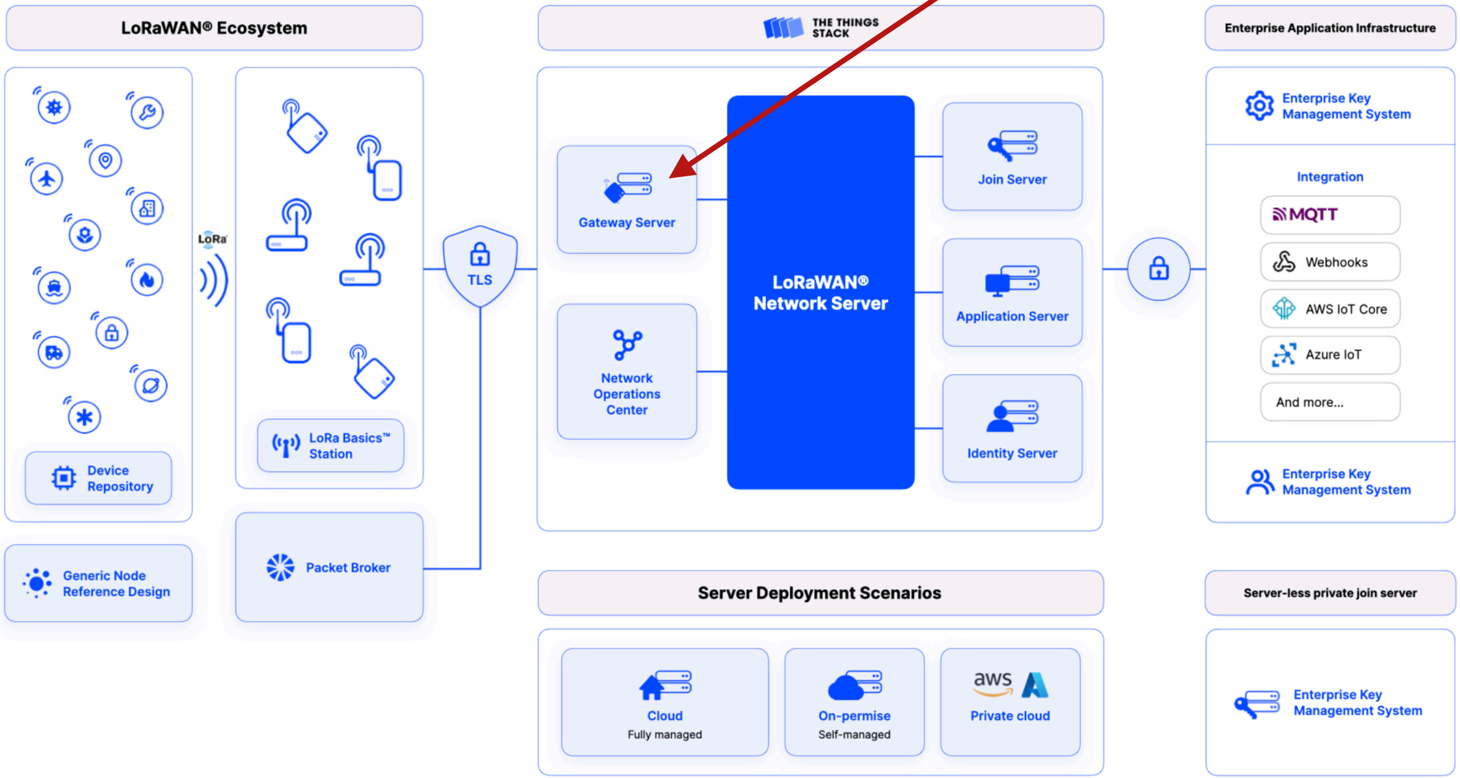
- Simple architecture, open source for private implementation



Network Server Implementations: The Things Stack

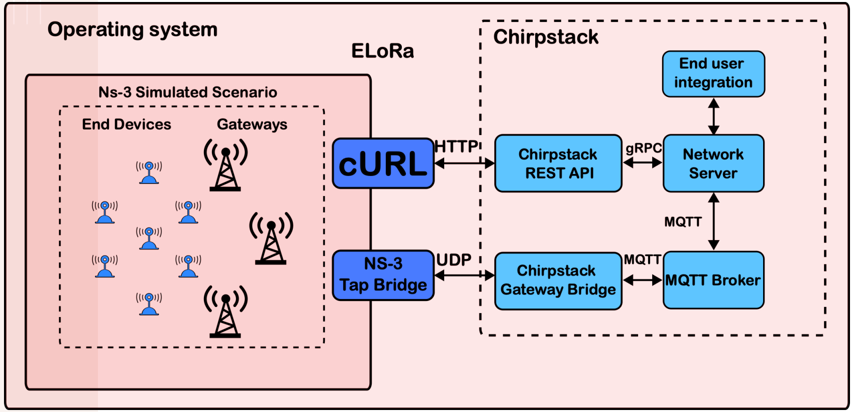
- More complete architecture

Controls exchange with gateway

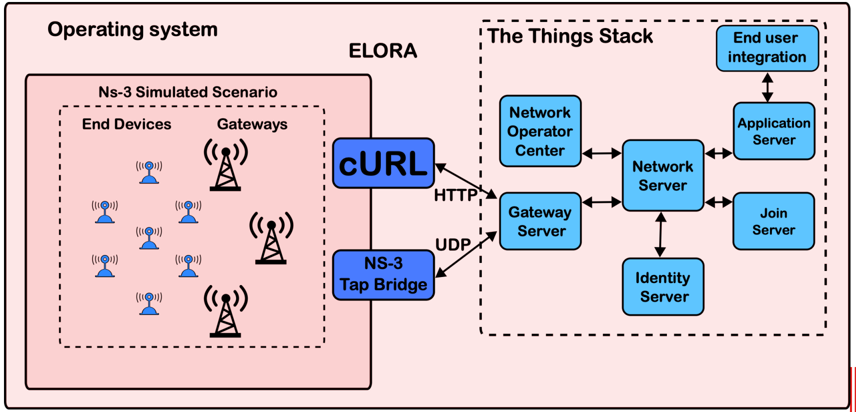


Emulating LoRaWAN with Downlink Traffic: ELoRa

- Focus is in the communication gateway and network server
  - Traffic from end devices to gateway is simulated in NS-3
  - Network server is real

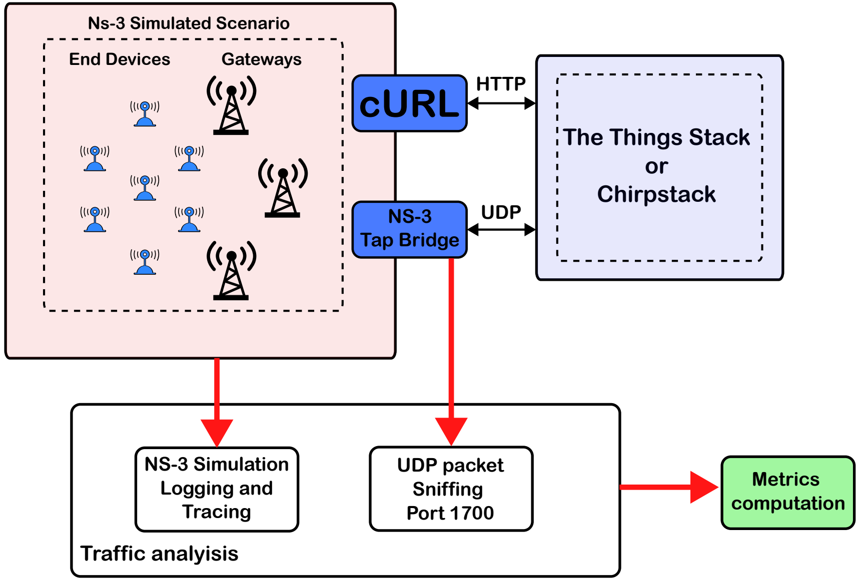


ELoRa with Chirpstack [5]



ELoRa with TTN [new!]

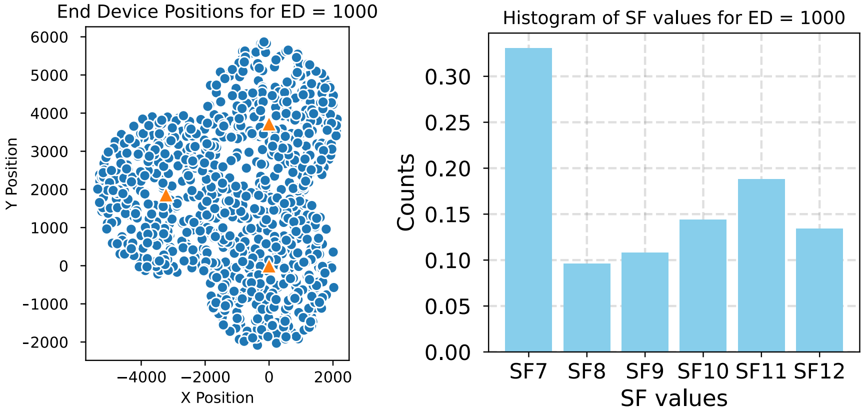
Emulating LoRaWAN with Downlink Traffic: Evaluation



Performance evaluation of network servers

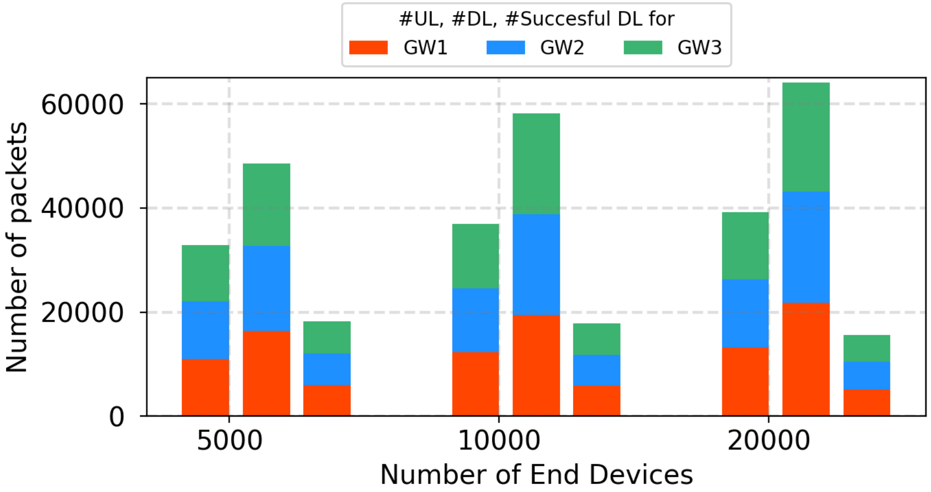
Preliminary Evaluation (work in progress)

- Simulations with 3 gateways
- Traffic: CBR, 1 pkt / 150 s
- Simulation time 90 min
- Random time for transmission start
- No duty cycle (GW)
- SF assign according to distance
- Class A end devices
- Confirm traffic only

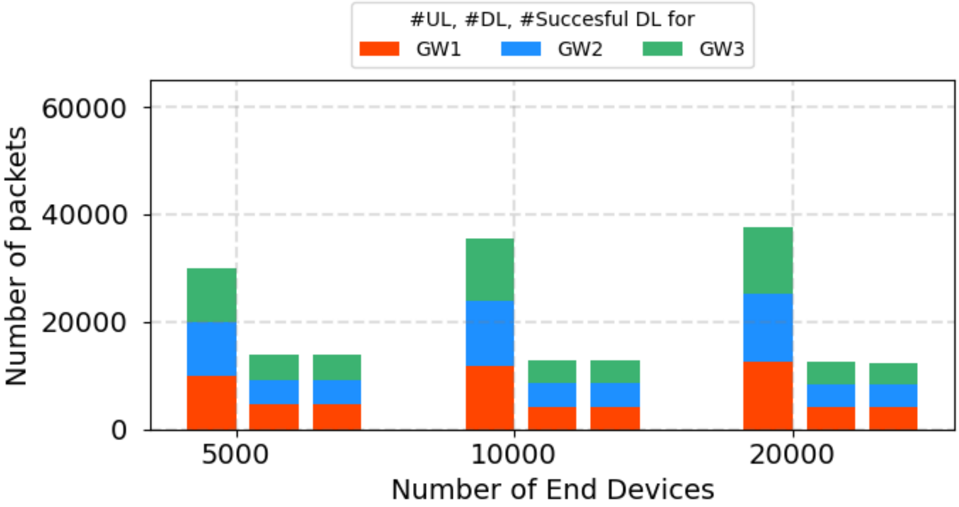


Network topology and SF distribution for 1000 ED

Results: Traffic at the Gateway



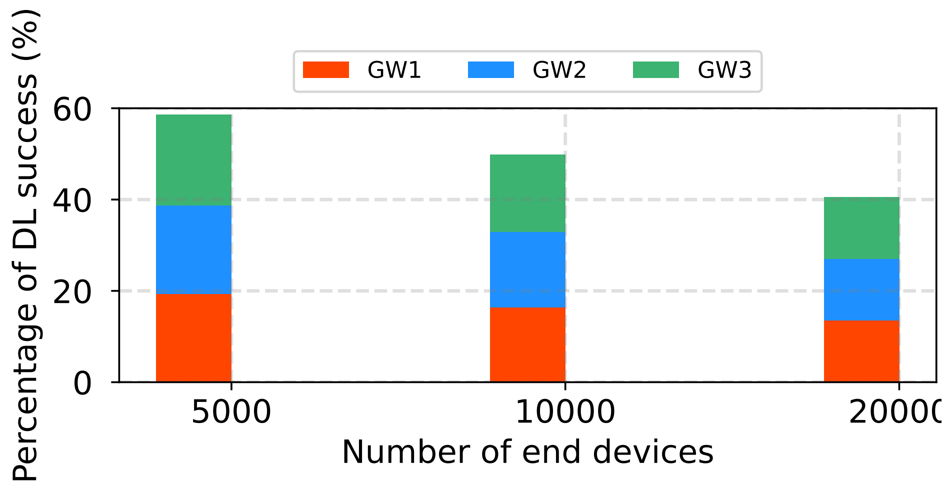
Chirpstack



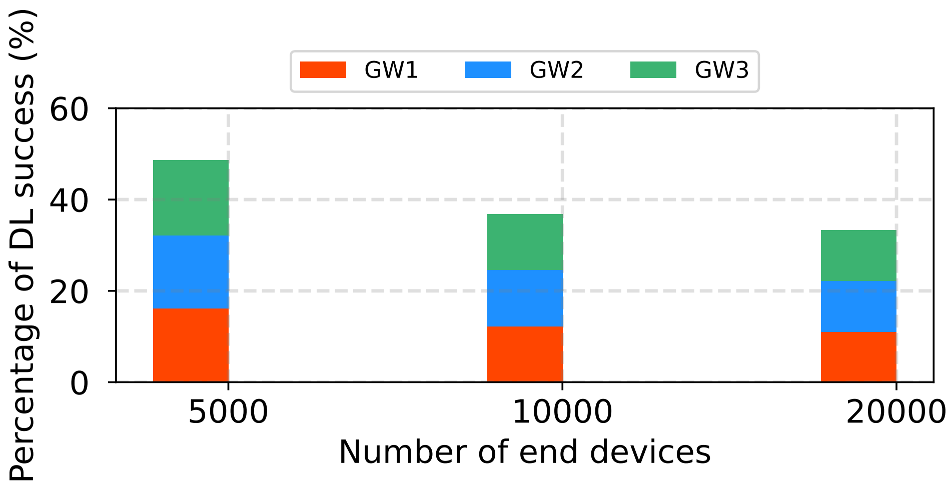
The Things Stack

- Balanced traffic among the gateways
- Chripstack receives more UL
  - TTN gateway busy Tx more than Chirpstack
- Chripstack schedules (much) more DL
  - TTN is more conservative, but more accurate

Results: Successful DL Scheduled at the Gateway



Chirpstack



The Things Stack

- DL success = #successful DL schedules / #total DL that need to be scheduled
- Chripstack schedules more DL than TTN, regardless the number of end devices

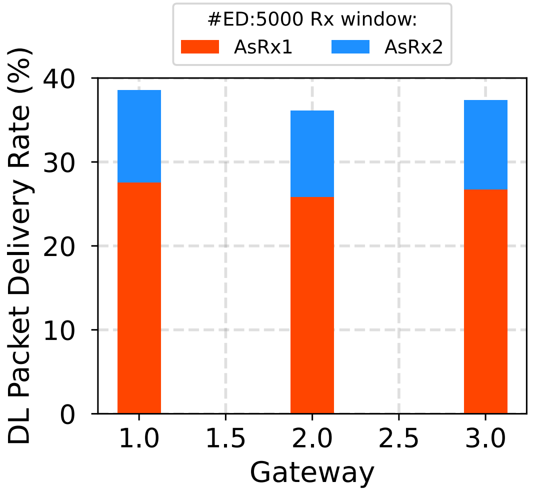
Results: DL Loss Statistics

Expired timestamp

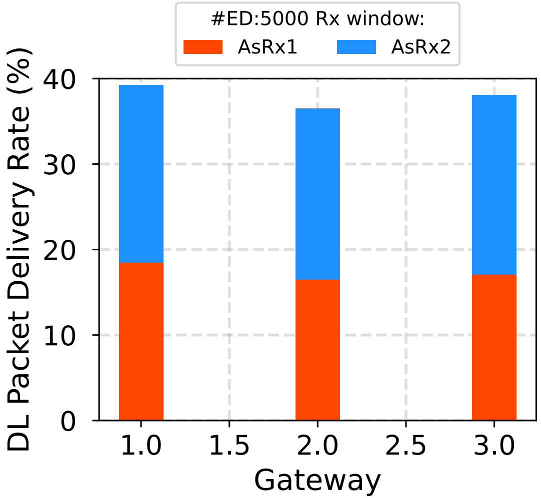
Busy concentrator

Network	End Devices	Pkt Scheduled	Pkt Drop Late (%)	Pkt Loss due Tx (%)	Pkt Tx	Received (%)
CS	5000	18403	1.64	18.40	14715	79.50
CS	10000	18649	5.53	21.37	13631	76.81
CS	20000	18573	16.56	19.20	11932	71.42
TTN	5000	13912	1.28	0.08	13723	78.92
TTN	10000	12766	4.93	0.96	12015	77.99
TTN	20000	12546	14.70	1.12	10561	78.05

Results: DL Packet Delivery Ratio (PDR)



Chirpstack



The Things Stack

- Chirsptack prioritises RX1, TTN prioritises RX2 (higher sensitivity in the receiver, but at the cost of a higher transmission time)
  - TTN server busy transmitting for longer periods (impacting more UL)

Wrap Up

- Conclusion:
  - Chripstack schedules more than the gateways can handle
  - TTN is more conservative
  - None of the servers account for duty cycle

- Future work:
  - Measure fairness
  - Identify deficiencies and strengths in both network servers
  - Improvements of downlink scheduling

References

[1] A.-I. Pop, U. Raza, P. Kulkarni, and M. Sooriyabandara, “Does bidirectional traffic do more harm than good in lorawan based lpwa networks?” in IEEE GLOBECOM 2017, 2017, pp. 1–6. [Online]. Available: https://ieeexplore.ieee.org/document/8254509

[2] F. Van den Abeele, J. Haxhibeqiri, I. Moerman, and J. Hoebeke, “Scalability analysis of large-scale lorawan networks in ns-3,” IEEE Internet of Things Journal, vol. 4, no. 6, pp. 2186–2198, 2017. [Online]. Available: https://ieeexplore.ieee.org/document/8090518

[3] B. A. Kitchenham, D. Budgen, and P. Brereton, Evidence-Based Software Engineering and Systematic Reviews. Chapman & Hall/CRC, 2015.

[4] V. Di Vincenzo, M. Heusse, and B. Tourancheau, “Improving downlink scalability in lorawan,” in ICC 2019 - 2019 IEEE International Conference on Communications (ICC), 2019, pp. 1–7. [Online]. Available: https://ieeexplore.ieee.org/document/8761157

[5]. Aimi & al., "ELoRa: End-to-end Emulation of Massive IoT LoRaWAN Infrastructures", 2023 IEEE/IFIP NOMS, 2023

Thank you for your attention

oana.iova@insa-lyon.fr