Actility
Connecting with intelligence

Webinar

Key Infrastructure and LoRaWAN Network Server features for industrial IoT deployments

How to deploy a reliable network from day one?
What are the main caveats and pitfalls ?
What are the differences between Open Source and professionally supported LNS solutions ?

Agenda - Field Experience

- Based on extensive experience with large (and small) enterprise customers:
- Number of gateways, number of devices,…
- Actility was able to « destiller » the Key Features, around
  - LNS
  - Gateway & device
  - AS integration
  - Management/ Operational excellence
  - Infra
  - Non-funtional
    - Quality
    - Support & Maintenance

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Solution Components

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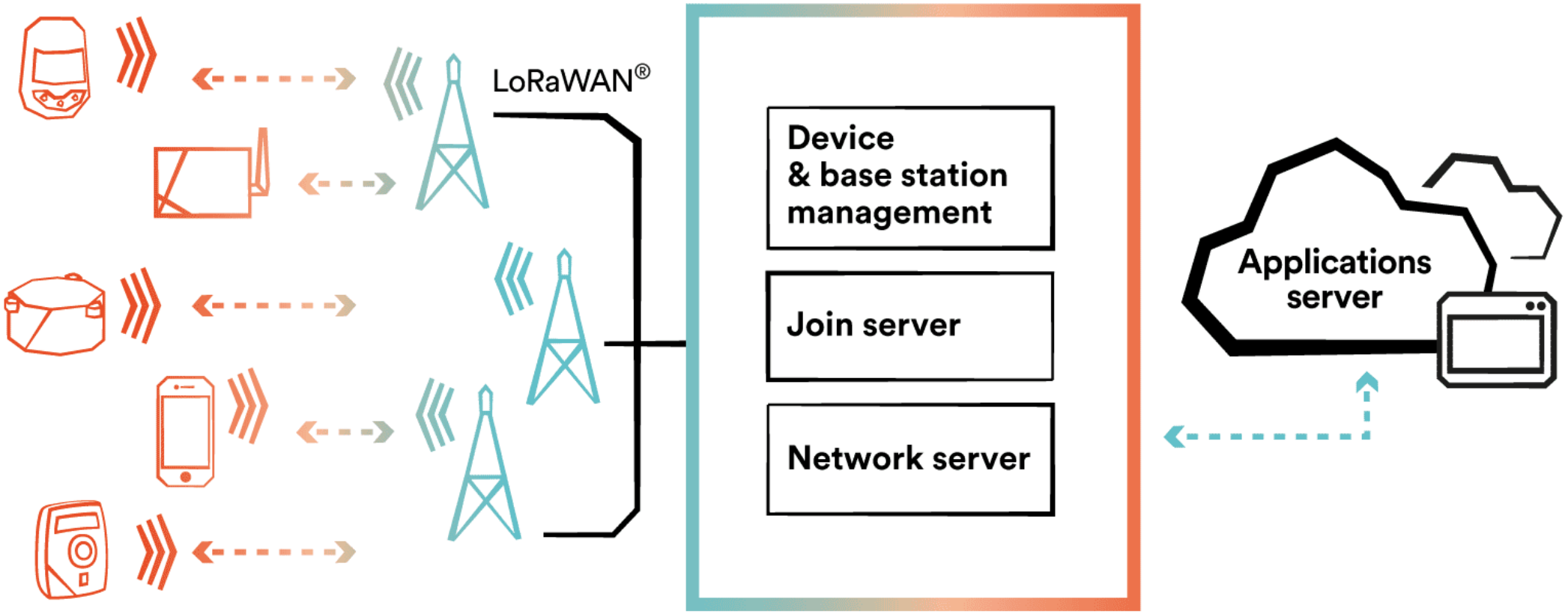
Solution Overview



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Gateways and Gateway Software

Is the LNS **hardware-agnostic**?
If so, which gateway manufacturers have been integrated?

Does the **Gateway Software** provide the right level of:

- **Security:**
  - Secure VPN (IPSec/TLS) between GW and LNS
  - PKI management
- **Reliability:**
  - Packet queuing (e.g. backhaul outage)
  - Backhaul failover (e.g. ethernet <-> 4G)
- **Troubleshooting:**
  - Remote support access
  - RF & WAN statistics in the OSS
  - RF Spectrum Scan
- **Manageability:**
  - Remote software upgrade
  - RF channel management (incl. Multi-RF boards)
  - Packet filtering based on NetID
  - Optimized Backhaul data consumption (e.g. satellite/4G)
- **Feature uniformity:**
  - Management functions independent from GW Vendor/Type/Region/Reference Design/OS/etc.

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LNS role

LoRaWAN™ Network Server (LNS) implements the MAC layer of LoRaWAN™ standard:

- Uplink:
  - Data routing to Application Servers or to home LNS (roaming)
  - Verify message integrity (via MIC)
  - Uplink frame deduplication (RF macro diversity or frame repetition by the device)
  - **Adaptive Data Rate**
- Downlink:
  - Route selection/optimization
  - Downlink scheduling: RX1, RX2, RXC, pingslots
- MAC Layer management
  - MAC commands (per device)
  - MAC-level acknowledgments
  - MAC-level security, e.g. replay attack detection and mitigation

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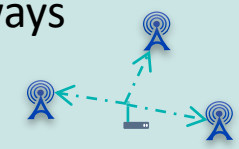
Does LNS support…? (1/3)

	Does LNS support…?	Having this feature allows…
LoRaWAN Standard	the latest LoRaWAN™ specification (v1.0.4 & v1.1)	onboarding all LoRaWAN™-compliant devices, without exclusion.
	all regional profiles (aka ISM Bands)	supporting LoRaWAN™ deployments anywhere, in any region of the world.
	the latest LoRaWAN™ backend interfaces specification (v1.1)	supporting the latest roaming and OTA activation features, whatever the LNS NetID.
	class B	reducing downlink latency of battery-powered sensors, for actuation use-cases (e.g., close water or gas valve).
Reliability	RF macro diversity, i.e., ability to route the device's uplink packets through multiple gateways 	Boosting radio coverage & capacity by deploying additional gateways where needed. RF macro diversity guarantees service continuity in case of gateway outage. **A centralized LNS architecture is key for Self-Organizing Networks (SON)**, i.e., gateway addition and withdrawal does not require additional configuration.
	high availability architecture with automatic database synchronization	deploying **reliable, fault-tolerant** LNS cluster with **zero-touch operation** through automated failover/failback. Geo-redundant architectures are essential for Disaster Recovery Plan (DRP).

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Does LNS support…? (2/3)

	Does LNS support…?	Having this feature allows…
Operability	multi-tenant traffic segregation	isolating LoRaWAN traffic between different tenants: i.e. uplink packets for network-B cannot be routed through network-A's RAN except in case of roaming agreement.
	remote gateway configuration	online update of the gateway's RF configuration (channel plan, antenna gain…) as well as remote maintenance.
Value-Added Services	multicast	optimizing downlink spectral efficiency to support firmware upgrade over the air (FUOTA) and smart lighting use-cases.
	passive roaming	supporting collaborative networks to extend RF coverage.
	embedded Join Server (JS) function	local processing of OTA activation requests, in absence of a standalone JS.

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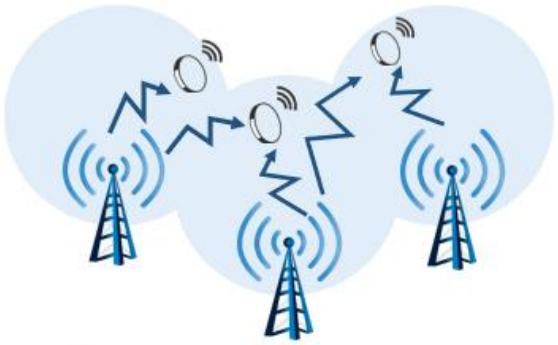
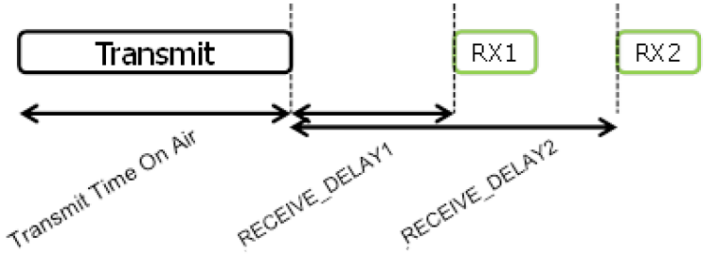
Does LNS support…? (3/3)

	Does LNS support…?	Having this feature allows…
Quality of Service (QoS)	smart selection of the best gateway to route downlink packets to each device	operating a heterogeneous LoRaWAN network with a mix of outdoor macro (up to 72 channels) and indoor pico gateways (typically 8-channels) while offering the best downlink QoS to each device according to its link quality and mobility profile.
	smart selection of the downlink transmission slot for each packet	improving DL spectral efficiency, prioritizing the transmission slot that offers the best link budget, the most optimum data rate while fulfilling the regulatory limits (duty cycle, dwell time…).
	advanced ADR mechanisms	offering the best trade-off between QoS (packet error rate, RF overlapping) and device's power consumption, to maximize its battery lifetime and reduce TCO.





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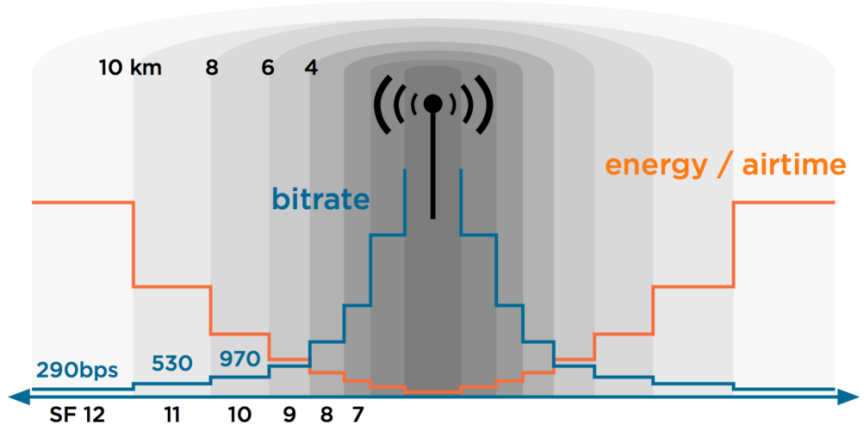
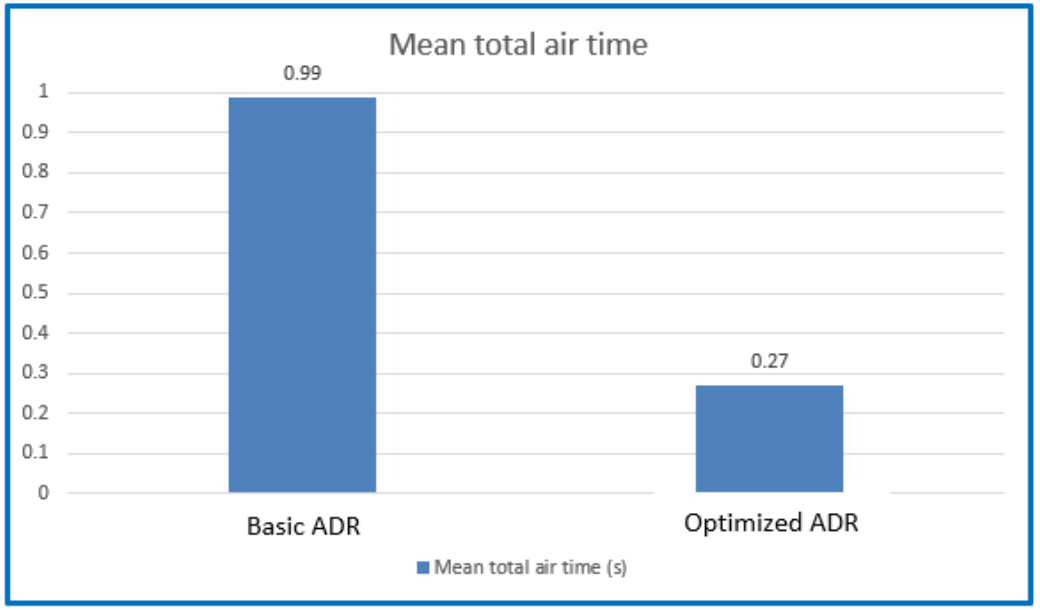
ADR is key for LoRaWAN

An efficient ADR mechanism shall:

- **Dynamically adapt the device's transmission parameters** (TxPower, number of transmissions, data rate) according to the quality of the device-BS radio link
- **Minimize the device's battery consumption** while fulfilling the target quality metrics (especially the uplink packet error rate)
- **Adjust its reactivity** to avoid too volatile decisions (increasing signaling overhead induced by MAC commands) or slow response to abrupt RF changes (e.g. the nearest GW to the device goes down)





Field tests show significant reduction (-72%) of average total air-time per uplink frame counter.

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Performance benchmark by IIoT integrators

Field tests conducted by a Singaporean industrial IoT system integrator

Number of Nodes = 2
Message Length = 51
Confirmed Message
Modem number of attempts = 1
Application retries until no error
Actility SaaS

ThingPark LNS

Message Duration

Attempts	2	3	4	5	6	7	8	9	10	12	Grand Total
1	96.24%	0.92%	0.06%	0.92%	0.09%	0.03%	0.03%	0.00%	0.03%	0.00%	98.32%
2	0.00%	0.00%	0.06%	0.06%	1.20%	0.03%	0.00%	0.00%	0.00%	0.03%	1.39%
3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.16%	0.13%	0.00%	0.28%
Grand Total	96.24%	0.92%	0.13%	0.98%	1.30%	0.06%	0.03%	0.16%	0.16%	0.03%	100.00%

96.24% of the message is successfully sent out within **1 attempt** with message interval of **2 seconds**.

%Message Received by Actility TPE

Hour	Received
13	100.00%
14	100.00%
Grand Total	100.00%

Server receives 100% of the messages.

Number of Nodes = 2
Confirmed Message
Modem Retry = 1

Open Source LNS

Delay vs ACK (Node)

Delay	RXWIN1	RXWIN2	NOACK
2	67.50%	0.90%	31.60%
4	70.40%	0.50%	29.10%
6	70.80%	0.20%	29.00%
8	64.90%	0.30%	34.80%
10	67.20%	0.20%	32.60%
12	65.90%	0.50%	33.60%
14	65.50%	0.20%	34.30%
16	68.20%	0.40%	31.40%
18	65.70%	0.70%	33.60%
20	64.50%	0.30%	35.20%
Grand Tota	67.06%	0.42%	32.52%

Node receives 67.6% acknowledgement.

Delay	5	4
2	96.10%	3.70%
4	98.30%	1.60%
6	96.30%	3.50%
8	96.70%	3.30%
10	97.00%	2.90%
12	96.10%	3.80%
14	96.80%	3.10%
16	97.00%	2.90%
18	96.80%	3.20%
20	97.80%	2.20%
Grand Total	96.89%	3.02%

Message rate =
1 Message per 5.0 seconds

% ACK Received (Node)

Hour	RXWIN1	RXWIN2	NOACK
0	64.53%	0.28%	35.20%
1	71.98%	0.29%	27.73%
2	61.42%	0.59%	37.98%
3	61.23%	0.31%	38.46%
4	70.87%	0.65%	28.48%
5	69.26%	0.00%	30.74%
6	67.59%	0.93%	31.48%
7	60.00%	0.74%	39.26%
8	56.06%	0.00%	43.94%
9	74.63%	0.98%	24.39%
10	68.09%	0.53%	31.37%
11	67.35%	0.96%	31.69%
12	71.74%	0.62%	27.64%
13	70.19%	0.17%	29.64%
14	66.93%	0.32%	32.74%
15	67.21%	0.32%	32.47%
16	64.52%	0.00%	35.48%
17	67.25%	0.39%	32.36%
18	65.19%	0.21%	34.60%
19	68.22%	0.22%	31.56%
20	67.63%	0.24%	32.13%
21	65.93%	0.49%	33.58%
22	63.59%	0.53%	35.88%
23	65.68%	0.54%	33.78%
Grand Tot	67.06%	0.42%	32.52%

% Message Received (Server)

Hour	Receivd	Not Receivd
0	93.85%	6.15%
1	90.27%	9.73%
2	90.21%	9.79%
3	87.08%	12.92%
4	89.97%	10.03%
5	88.67%	11.33%
6	87.50%	12.50%
7	87.41%	12.59%
8	87.88%	12.12%
9	91.71%	8.29%
10	91.27%	8.73%
11	90.67%	9.33%
12	89.29%	10.71%
13	89.27%	10.73%
14	91.49%	8.51%
15	88.96%	11.04%
16	87.63%	12.37%
17	92.44%	7.56%
18	89.87%	10.13%
19	91.33%	8.67%
20	93.05%	6.95%
21	89.46%	10.54%
22	92.35%	7.65%
23	92.76%	7.24%
Grand Tot	90.34%	9.66%

Server receives 90.34% of the messages.

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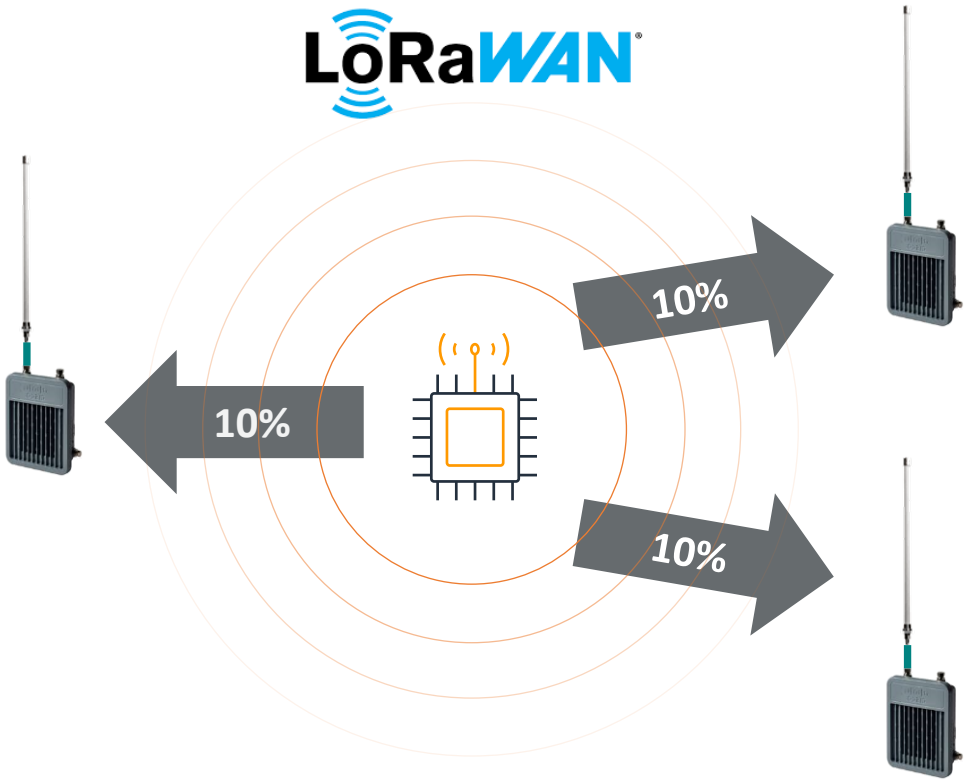
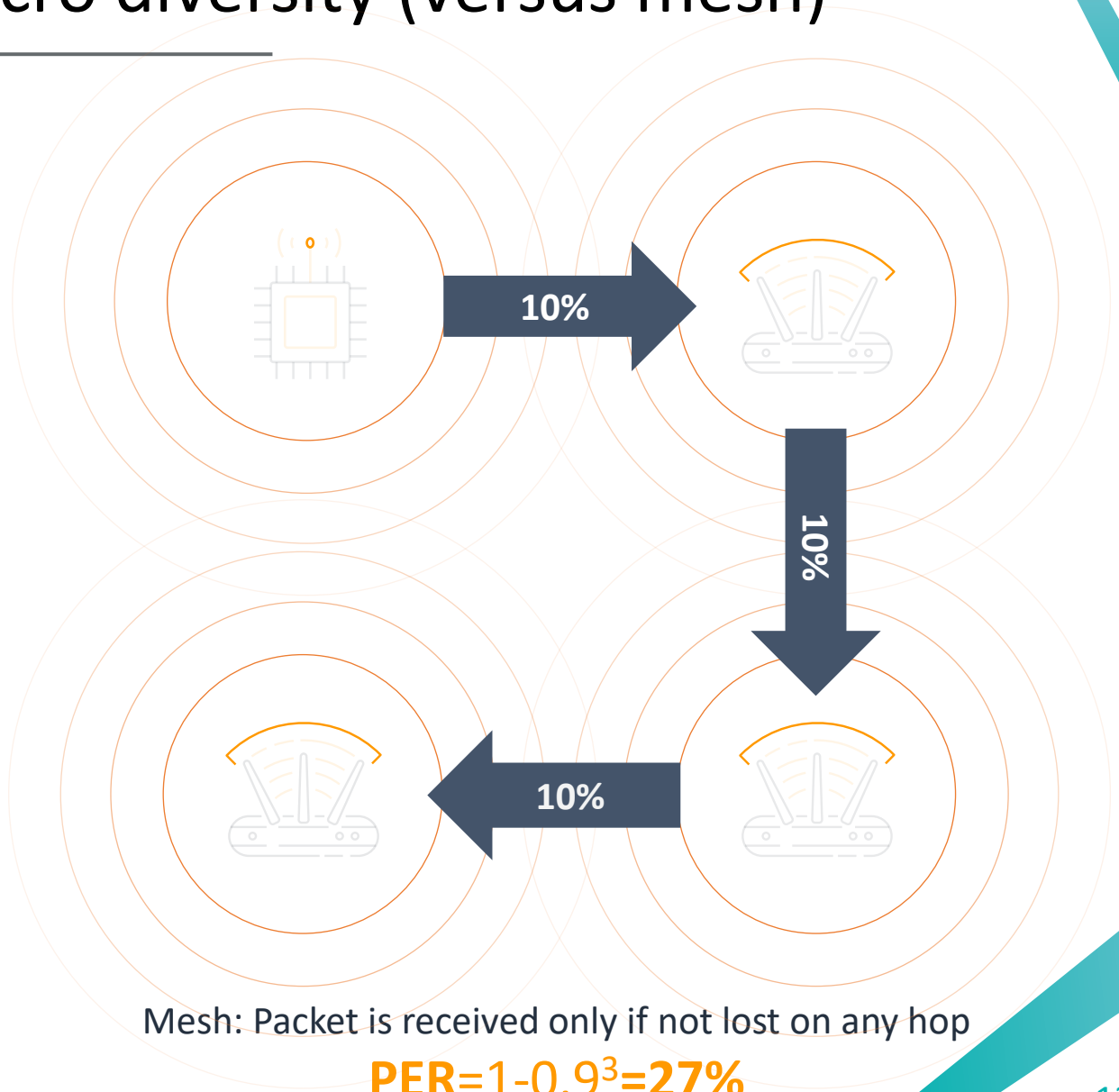
Benefits of LoRaWAN macro diversity (versus mesh)



LoRaWAN macro diversity: Packet is lost only if lost on all 3 antennas:

PER=0.1^3=0.001=**0.1%**



Mesh: Packet is received only if not lost on any hop

PER=$1-0.9^3$=**27%**

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Application Server Integration

Does the LNS provide professionally supported **payload drivers** for LoRaWAN devices?

Can **custom drivers** be added?

Does the LNS provide **Cloud Connectors?**

Generic Connectors:

- HTTP
- MQTT
- AMQP

IoT Platform Connectors:

- AWS IoT
- Azure IoT Hub/Central
- ThingWorx
- IBM Watson
- Here Technologies
- Cumulocity
- Yandex
- SAP
- Etc.

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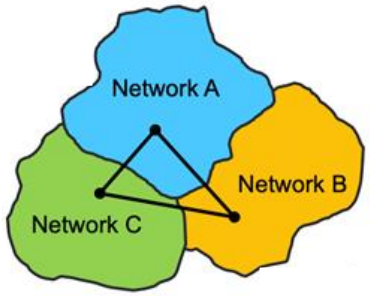
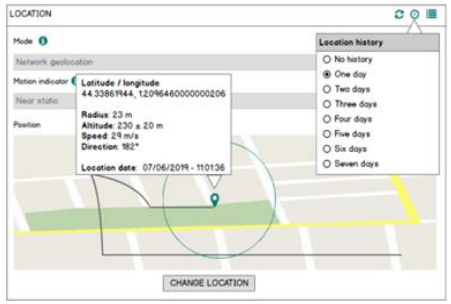
Value Added Services

Does the solution provide **LoRaWAN Roaming**?



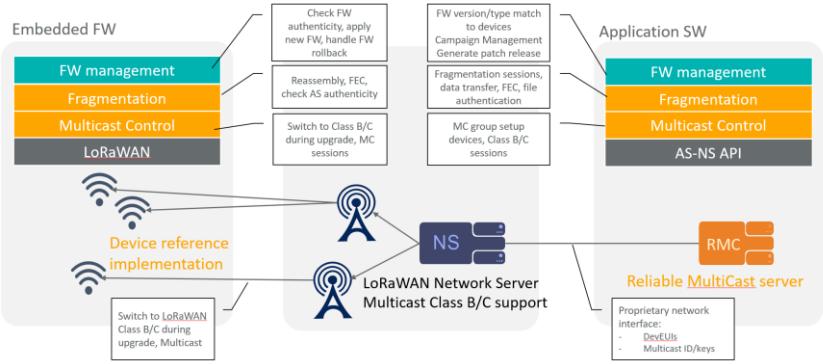
Is the solution LoRaWAN BackEnd Interface based?

Does the solution provide **TDOA/RSSI Geolocation**?



Is the geolocation solution fully integrated?

Does the solution provide **FUOTA?**



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Operational Excellence

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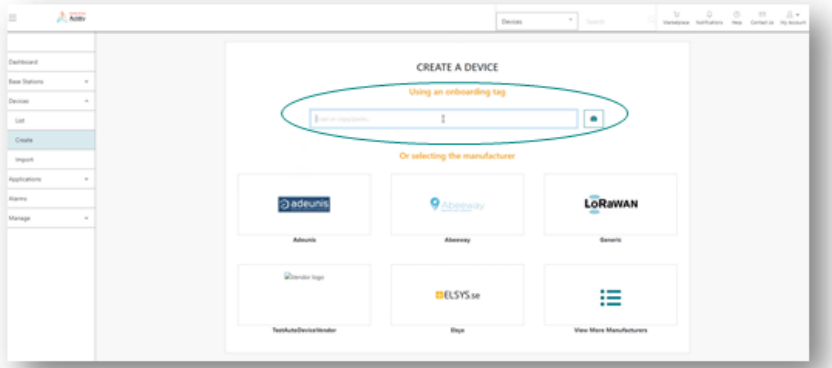
Ease of Deployment

What are the ways for Device provisioning? (batch, API)
Is **device provisioning** through use of standard-based QR code supported?

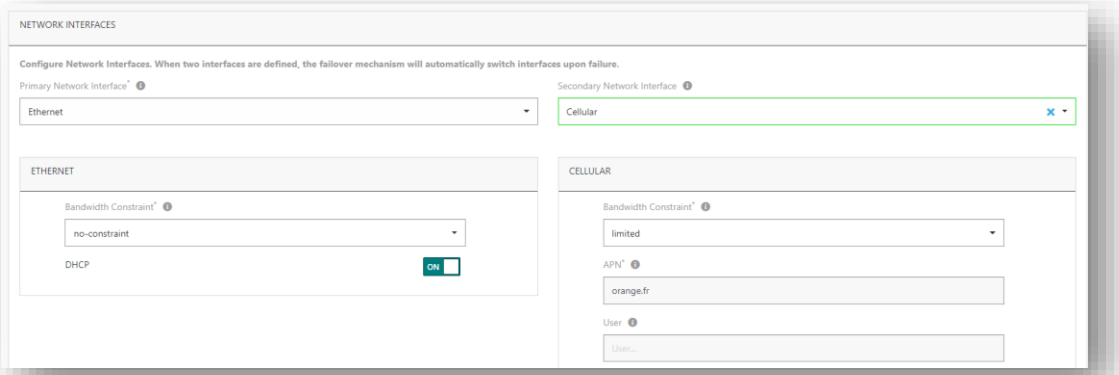
TR005 LoRaWAN® Device Identification QR Codes

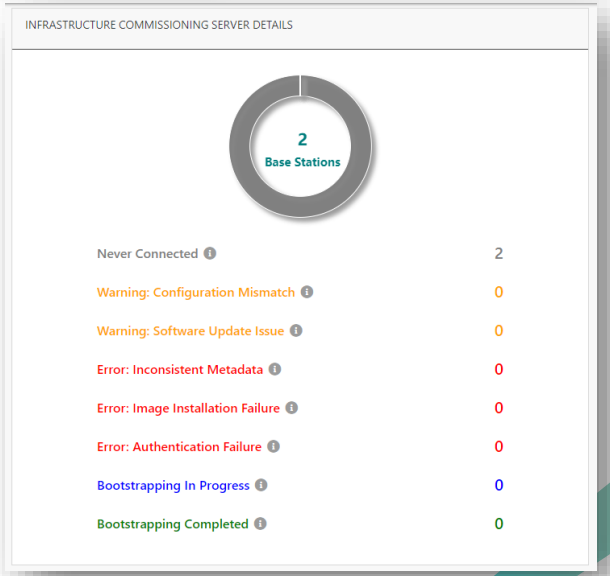
Standard tagging scheme for LoRaWAN® devices to simplify the device onboarding onto a LoRaWAN® network.

SchemaID:	D0
JoinEUI:	11-22-33-44-55-66-77-88
DevEUI:	AA-BB-CC-DD-EE-FF-00-11
ProfileID:	AABB-1122
OwnerToken:	AABBCCDDEEFF
SerNum:	YYWWNNNNNN
Proprietary:	FOOBAR
CheckSum:	AF2C



Can **Gateway deployment** be done via Zero-Touch Configuration Server?





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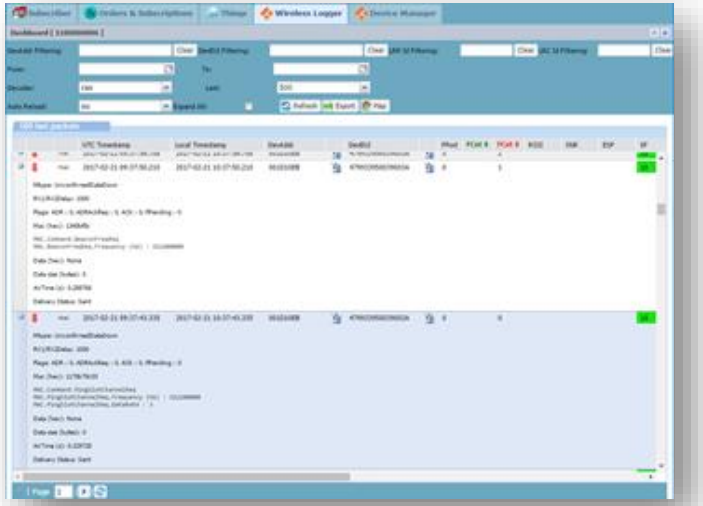
Does the supplier provide tools for Network Analysis?

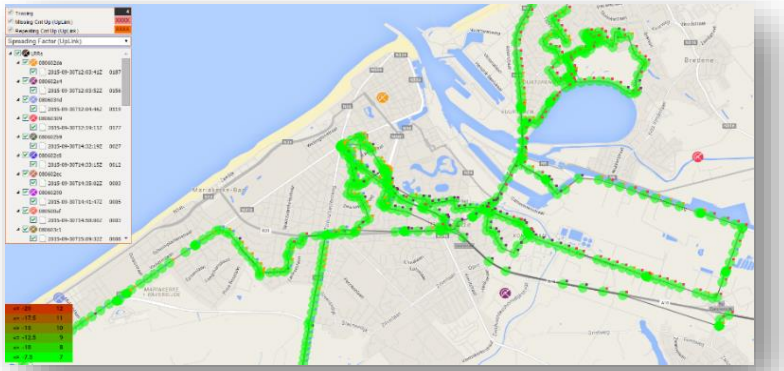
Packet Logger

Log of all UL & DL messages incl. MAC messages & payload decoding ("wireshark" for LoRaWAN)



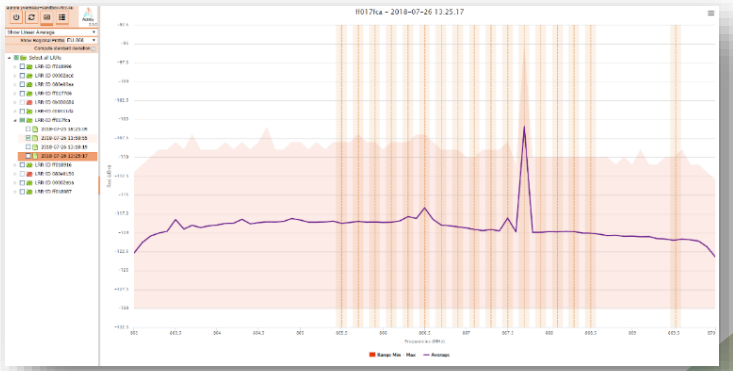
Network Survey

LoRaWAN coverage test analysis tool



Spectrum Analysis

Base Station Radio Frequency scan analysis



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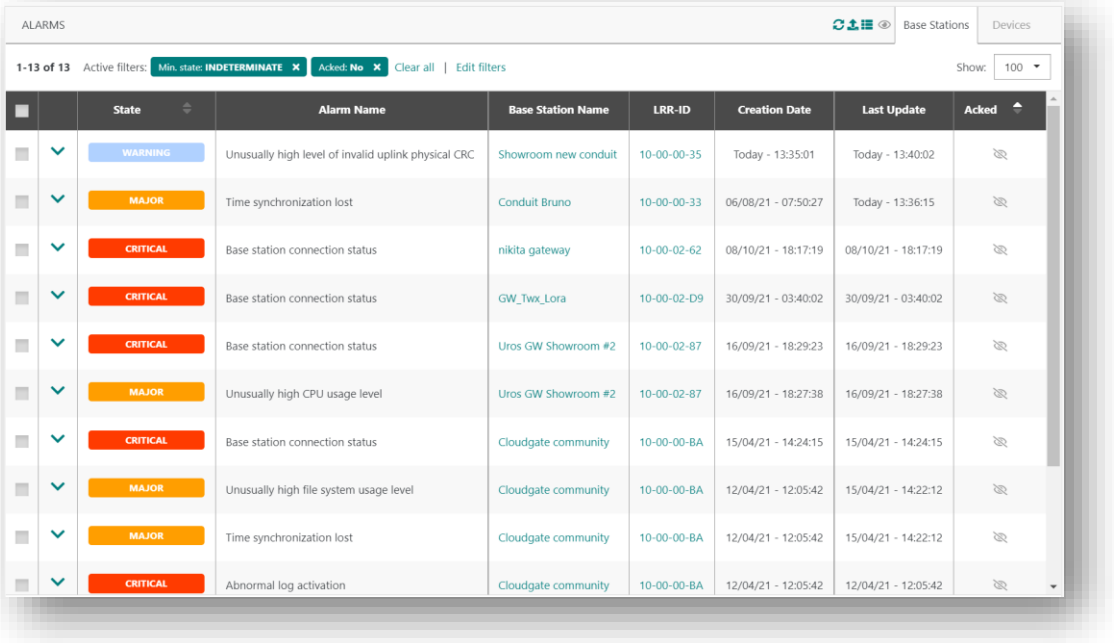
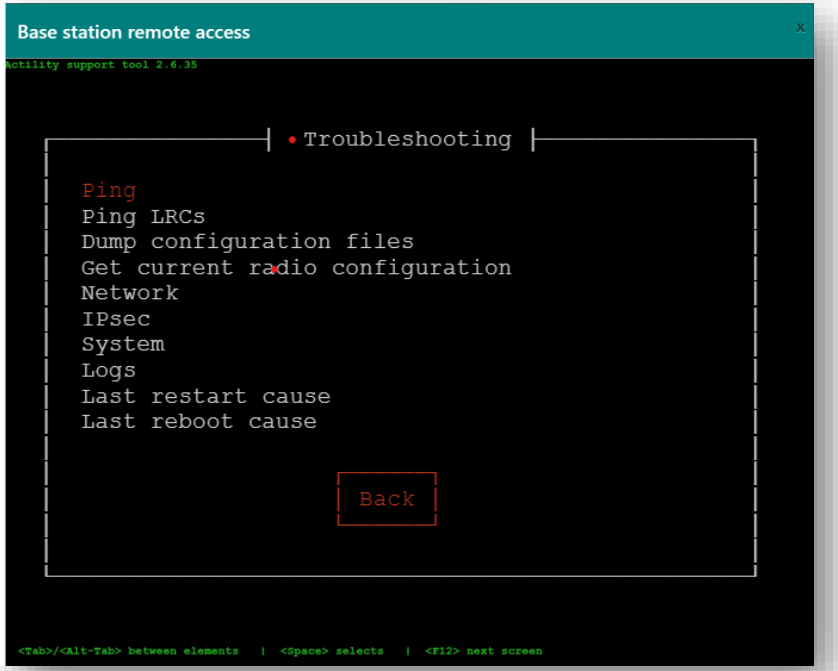
Base Station Troubleshooting

Does the solution provide **Advanced alarm management**?



Does the solution provide **HW agnostic remote access** to the gateway for advanced Troubleshooting?



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Deployment Architecture

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Deployment flexibility

Standalone mode (mono-server)?

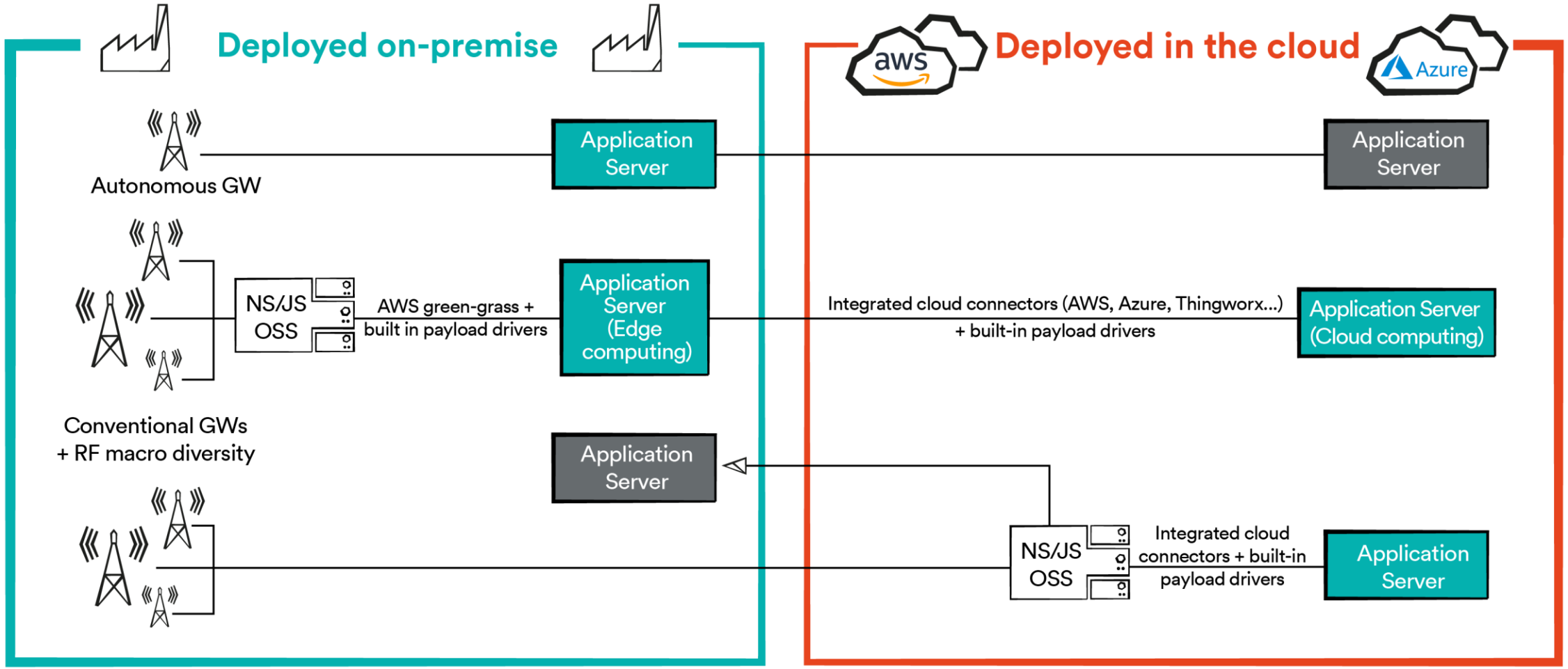
High Availability (geo-redundancy)?

NS/JS OSS

NS/JS OSS

Kubernetes-compatible?

VMWare environment?



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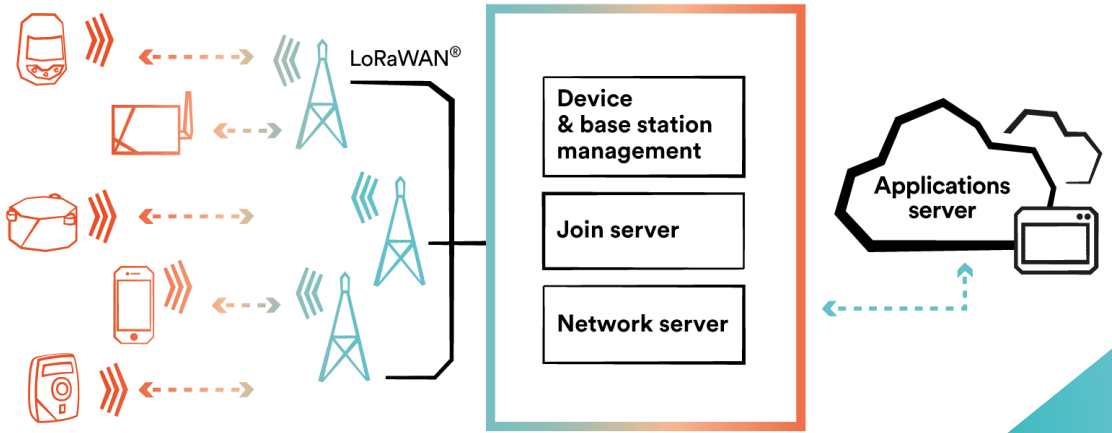
Is it secure enough for production? (1/2)

- **Protocol security** LoRaWAN
  - Does LNS implement LoRaWAN security best practices (e.g. to mitigate replay attacks)?
  - Does LNS support E2E payload encryption between device and AS?
  - Does the solution support a standalone Join Server? Does JS use HSM to store device keys?
- **Interface security**
  - How is GW-LNS interface secured? Does it support both IPSec and TLS options?
  - How does the GW securely retrieve its certificate (PKI Management)?
  - How is LNS-AS interface secured?



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Is it secure enough for production? (2/2)

- **Infrastructure security**
  - How are Operating System and database security patches delivered?

- **Application security**
  - Secure end-user access: multi-factor authentication or delegated authentication
  - Brute force mitigation techniques
  - Role and permission management: read-only vs. read/write
  - How is remote access to gateways or LNS/OSS secured?
  - Periodic security audits? Bounty program?

Is the solution ready to pass the security audits of enterprise's IT department?

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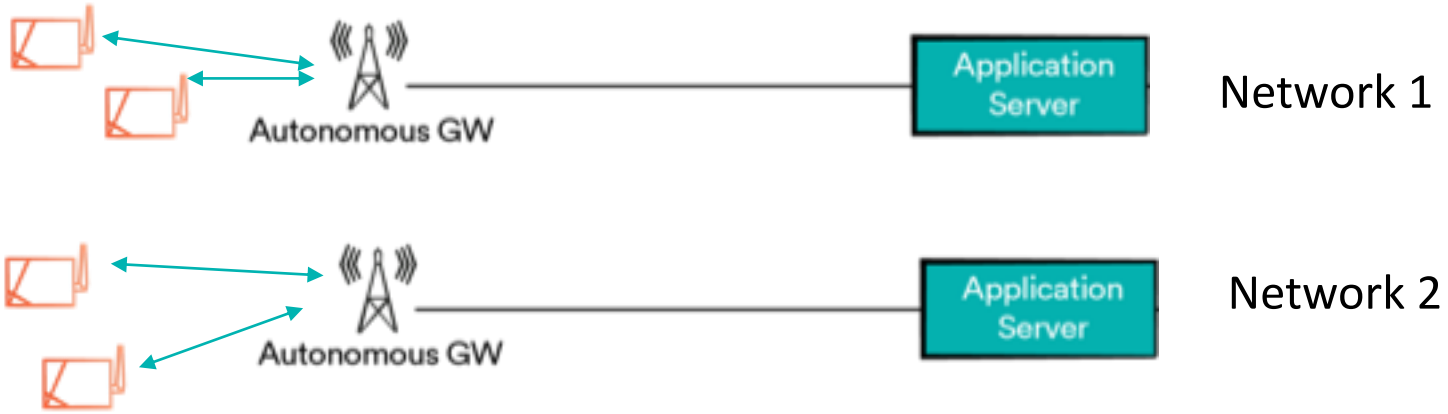
Can it really scale?

- How many devices and gateways can the solution support?
- How dense can the network scale (collision management)?
- What is the peak traffic rate (packets/sec) supported by the solution?
- Can it scale-up (vertically)?
  Is there a clear hardware/sizing profile per deployment segment?
- Can the solution components scale-out (horizontally), e.g. database sharding…?
- Are E2E load & stress test reports available?

Limitations of Embedded NS solution

- Loss of macro diversity when multiple gateways are deployed



- Complexify architecture and operational cost:
  - devices & gateways should be paired during installation
  - devices keys are stored on multiple platform
  - Firmware upgrade is complex and not scalable

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Non-functional requirements

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How to select your supplier ?

- Company Profile:
  - Investment with LoRaWAN
    - Is your supplier an active member of the LoRa Alliance / membership level ?
    - Is LoRaWAN network server the core business of your supplier ?
  - Size
    - Size of R&D dedicated to LoRaWAN products ?
    - Size of support and operation team ?
  - Reference
    - What is the total number of gateways & devices and messages / year managed by the Supplier?
    - Can the Supplier provide Enterprise references in all Regions (ISM band & certification)?
  - Trust
    - Is you supplier ISO9001 certified?
    - Can the supplier provide code-escrow agreements?

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How to select your supplier ?

- Product development
  - What is the size of R&D ?
  - Does your supplier provide a product roadmap?
  - Is your supplier innovative and driving the standard ?
  - Does the Supplier own all required IPR?

- Quality:
  - Is the Supplier ISO 9001 certified?
  - Does your supplier provide bug bixes, at which rate ?
  - How is **testing** of the solution done?
    - Load testing? Regression testing? Record-replay testing?
    - Include bench reports, metrics, etc.

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How to select your supplier ?

- Support
  - How can your supplier help you for the deployment with professional services?
    - Network sizing, coverage, and capacity analysis
    - Manage services
  - Can the Supplier provide 24/7 support with corresponding SLA?
  - Is the Supplier entirely managing system upgrades?
  - Is the upgrade release process documented?

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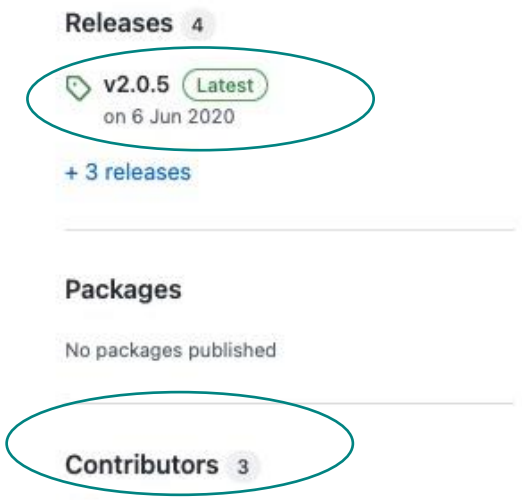
Questions on Open source

- How big is the support community ?
  - Is the community providing frequent patch or fix update ?
  - What is the commitment to have the software available in 2/3 years.
- Free software doesn't mean zero cost & free support...
  - Do you intend to build your own infrastructure ?
  - Do you intend to create a support team ?
  - Are you ready to invest in R&D effort ?
- Is connectivity your main business ?
- Have you calculated all the hidden cost ?
  - Non-regression testing, upgrade management



Open Source Packet Forwarder contributors & status

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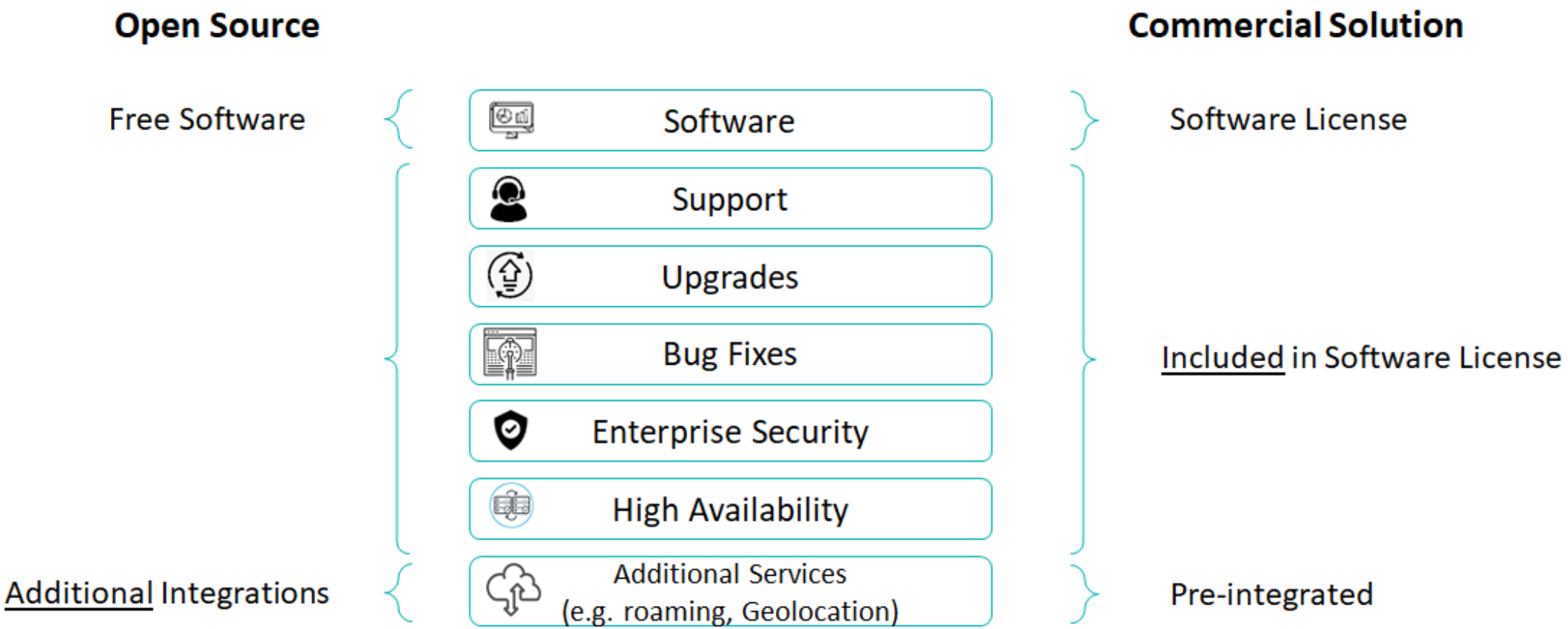
Make the right TCO Comparison!



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Wrap up and Q&A

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Wrap up - Key feature Checklist

The questionnaire to help you select your LoRaWAN Network Solution:

Questionnaire for LoRaWAN Network Solution Selection
Solution Components
Gateways
Is the LNS hardware-agnostic?
If so, which gateway manufacturers have been integrated?
Does the Gateway Software provide the right level of: - Security - Reliability - Manageability & Troubleshooting?
LNS
Does the LNS support the latest LoRaWAN™ specification (v1.0.4 & v1.1)
Does the LNS support all regional profiles (aka ISM Bands)
Does the LNS support the latest LoRaWAN™ backend interfaces specification (v1.1)
Does the LNS support class B
Does the LNS support RF macro diversity, i.e., ability to route the device's uplink packets through multiple gateways
Does the LNS support high availability architecture with automatic database synchronization
Does the LNS support multi-tenant traffic segregation
Does the LNS support remote gateway configuration
Does the LNS support multicast
Does the LNS support passive roaming
Does the LNS support embedded Join Server (JS) function
Does the LNS support smart selection of the best gateway to route downlink packets to each device
Does the LNS support smart selection of the downlink transmission slot for each packet
Does the LNS support advanced ADR mechanisms
Application Server Integration
Does the LNS provide professionally supported payload drivers for LoRaWAN devices?
Can custom payload drivers be added?
Does the LNS provide Cloud Connectors? If so, which? Are they managed and supported by the supplier?
Value Added Services
Does the solution provide LoRaWAN Roaming? Is the solution LoRaWAN BackEnd Interface based?
Does the solution provide TDOA/RSSI Geolocation? Is the geolocation solution fully integrated?
Does the solution provide FUOTA?

Operational Excellence
Ease of deployment
What are the ways for Device provisioning? (batch, API)
Is device provisioning through use of standard-based QR code supported?
Can Gateway deployment be done via Zero-Touch Configuration Server?
Network Analysis
Does the solution provide a tool for detailed packet logging (incl. MAC commands)?
Does the solution provide a tool to support network surveys (e.g. walk or drive tests)?
Does the solution provide a tool to analyse the results of spectrum scans on the gateways?
Network Troubleshooting
Does the solution provide HW agnostic remote access to the gateway for advanced Troubleshooting?
Does the solution provide Advanced alarm management?
Deployment Architecture
Deployment Options
Which deployment options does the solution provide?
Does the solution provide high availability architecture for on premise deployments?
Is the solution Kubernetes compatible?
Security
Does LNS implement LoRaWAN security best practices (e.g. to mitigate replay attacks)?
Does LNS support E2E payload encryption between device and AS?
Does the solution support a standalone Join Server? Does JS use HSM to store device keys?
How is GW-LNS interface secured? Does it support both IPSec and TLS options?
How does the GW securely retrieve its certificate (PKI Management)?
How is LNS-AS interface secured?
How are Operating System and database security patches delivered?
Does the Application provide: - Secure end-user access: multi-factor authentication or delegated authentication - Brute force mitigation techniques - Role and permission management: read-only vs. read/write - How is remote access to gateways or LNS/OSS secured? - Periodic security audits? Bounty program?
Scalability
How many devices and gateways can the solution support?
How dense can the network scale (collision management)?
What is the peak traffic rate (packets/sec) supported by the solution?
Can it scale-up (vertically)?

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Q&A

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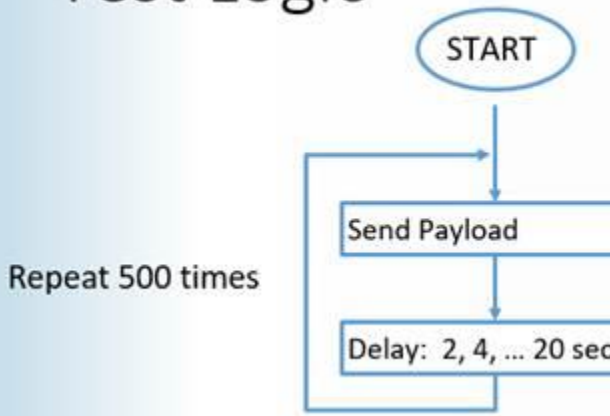
Performance benchmark by Singaporean IIoT integrator (1/3)

Test Logic



Message length = 34 bytes

			Payload					
Message version	Command code	Payload Length	Reader ID	Antenna ID	Tag ID	Tag Timestamp	Message Timestamp	CRC
1	1	1	6	1	12	4	4	4

E.g. :

1. Delay = 2 seconds
2. Send payload. Wait for Delay.
3. Repeat step-2 500 times.
4. Delay = 4 seconds.
5. Send payload, Wait for Delay.
6. Repeat step-5 500 times...
7. Delay = 6 seconds, and so on...

The test code does not perform retry if not acknowledged.

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Performance benchmark by Singaporean IIoT integrator (2/3)

Actility - Test 1

Test time = 11 May 1:30 PM to 11 May 2:40 PM

Number of Nodes = 2
Message Length = 51
Confirmed Message
Modem number of attempts = 1
Application retries until no error
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Message Duration

Attempts	2	3	4	5	6	7	8	9	10	12	Grand Total
1	96.24%	0.92%	0.06%	0.92%	0.09%	0.03%	0.03%	0.00%	0.03%	0.00%	98.32%
2	0.00%	0.00%	0.06%	0.06%	1.20%	0.03%	0.00%	0.00%	0.00%	0.03%	1.39%
3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.16%	0.13%	0.00%	0.28%
Grand Total	**96.24%**	**0.92%**	**0.13%**	**0.98%**	**1.30%**	**0.06%**	**0.03%**	**0.16%**	**0.16%**	**0.03%**	**100.00%**

96.24% of the message is successfully sent out within **1 attempt** with message interval of **2 seconds**.

%Message Received by Actility TPE

Hour	Received
13	100.00%
14	100.00%
Grand Total	**100.00%**

Server receives 100% of the messages.

Actility - Test 4

Test time = 4 May 7:08 PM to 05 May 08:40 AM

Number of Nodes = 1
Confirmed Message
Modem number of attempts = 1
Actility SaaS
[redacted] office

Message Duration	Count of Index
3	98.42%
4	1.08%
2	0.43%
5	0.07%
Grand Total	100.00%

Average message rate = 1 message per 3 seconds.

%ACK Received by Node

Hour	RXWIN1	RXWIN2	NOACK
0	97.87%	0.00%	2.13%
1	98.06%	0.00%	1.94%
2	98.27%	0.19%	1.54%
3	96.52%	0.47%	3.01%
4	98.27%	0.00%	1.73%
5	98.53%	0.29%	1.18%
6	98.91%	0.00%	1.09%
7	98.31%	0.00%	1.69%
8	99.00%	0.00%	1.00%
19	99.47%	0.11%	0.42%
20	98.92%	0.00%	1.08%
21	99.15%	0.00%	0.85%
22	98.80%	0.00%	1.20%
23	97.10%	0.12%	2.78%
Grand Tota	98.36%	0.08%	1.56%

%Message Received by Actility TPE

Hour	Received	Not Received
0	98.82%	1.18%
1	98.87%	1.13%
2	99.04%	0.96%
3	98.42%	1.58%
4	99.08%	0.92%
5	99.12%	0.88%
6	99.64%	0.36%
7	98.94%	1.06%
8	99.00%	1.00%
19	99.79%	0.21%
20	99.46%	0.54%
21	99.15%	0.85%
22	99.00%	1.00%
23	98.38%	1.62%
Grand Total	99.06%	0.94%

Effective Acknowledgment = 98.36/99.06 = 99.3%

Server receives 99.06% of the messages.

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Performance benchmark by Singaporean IIoT integrator (3/3)

Chirpstack - Test 2

Test time = 15 Apr 9:49 AM to 17 Apr 6:26 AM

Number of Nodes = 2
Confirmed Message
Modem Retry = 1

Delay vs ACK (Node)

Delay	RXWIN1	RXWIN2	NOACK
2	67.50%	0.90%	31.60%
4	70.40%	0.50%	29.10%
6	70.80%	0.20%	29.00%
8	64.90%	0.30%	34.80%
10	67.20%	0.20%	32.60%
12	65.90%	0.50%	33.60%
14	65.50%	0.20%	34.30%
16	68.20%	0.40%	31.40%
18	65.70%	0.70%	33.60%
20	64.50%	0.30%	35.20%
Grand Tota	67.06%	0.42%	32.52%

Node receives 67.6% acknowledgement.

Delay	5	4
2	96.10%	3.70%
4	98.30%	1.60%
6	96.30%	3.50%
8	96.70%	3.30%
10	97.00%	2.90%
12	96.10%	3.80%
14	96.80%	3.10%
16	97.00%	2.90%
18	96.80%	3.20%
20	97.80%	2.20%
Grand Total	96.89%	3.02%

Message rate =
1 Message per 5.0 seconds

% ACK Received (Node)

Hour	RXWIN1	RXWIN2	NOACK
0	64.53%	0.28%	35.20%
1	71.98%	0.29%	27.73%
2	61.42%	0.59%	37.98%
3	61.23%	0.31%	38.46%
4	70.87%	0.65%	28.48%
5	69.26%	0.00%	30.74%
6	67.59%	0.93%	31.48%
7	60.00%	0.74%	39.26%
8	56.06%	0.00%	43.94%
9	74.63%	0.98%	24.39%
10	68.09%	0.53%	31.37%
11	67.35%	0.96%	31.69%
12	71.74%	0.62%	27.64%
13	70.19%	0.17%	29.64%
14	66.93%	0.32%	32.74%
15	67.21%	0.32%	32.47%
16	64.52%	0.00%	35.48%
17	67.25%	0.39%	32.36%
18	65.19%	0.21%	34.60%
19	68.22%	0.22%	31.56%
20	67.63%	0.24%	32.13%
21	65.93%	0.49%	33.58%
22	63.59%	0.53%	35.88%
23	65.68%	0.54%	33.78%
Grand Tot	67.06%	0.42%	32.52%

% Message Received (Server)

Hour	Receivd	Not Receivd
0	93.85%	6.15%
1	90.27%	9.73%
2	90.21%	9.79%
3	87.08%	12.92%
4	89.97%	10.03%
5	88.67%	11.33%
6	87.50%	12.50%
7	87.41%	12.59%
8	87.88%	12.12%
9	91.71%	8.29%
10	91.27%	8.73%
11	90.67%	9.33%
12	89.29%	10.71%
13	89.27%	10.73%
14	91.49%	8.51%
15	88.96%	11.04%
16	87.63%	12.37%
17	92.44%	7.56%
18	89.87%	10.13%
19	91.33%	8.67%
20	93.05%	6.95%
21	89.46%	10.54%
22	92.35%	7.65%
23	92.76%	7.24%
Grand Tot	90.34%	9.66%

Server receives 90.34% of the messages.

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