Building an Interoperable IoT Ecosystem for Data-Driven Agriculture

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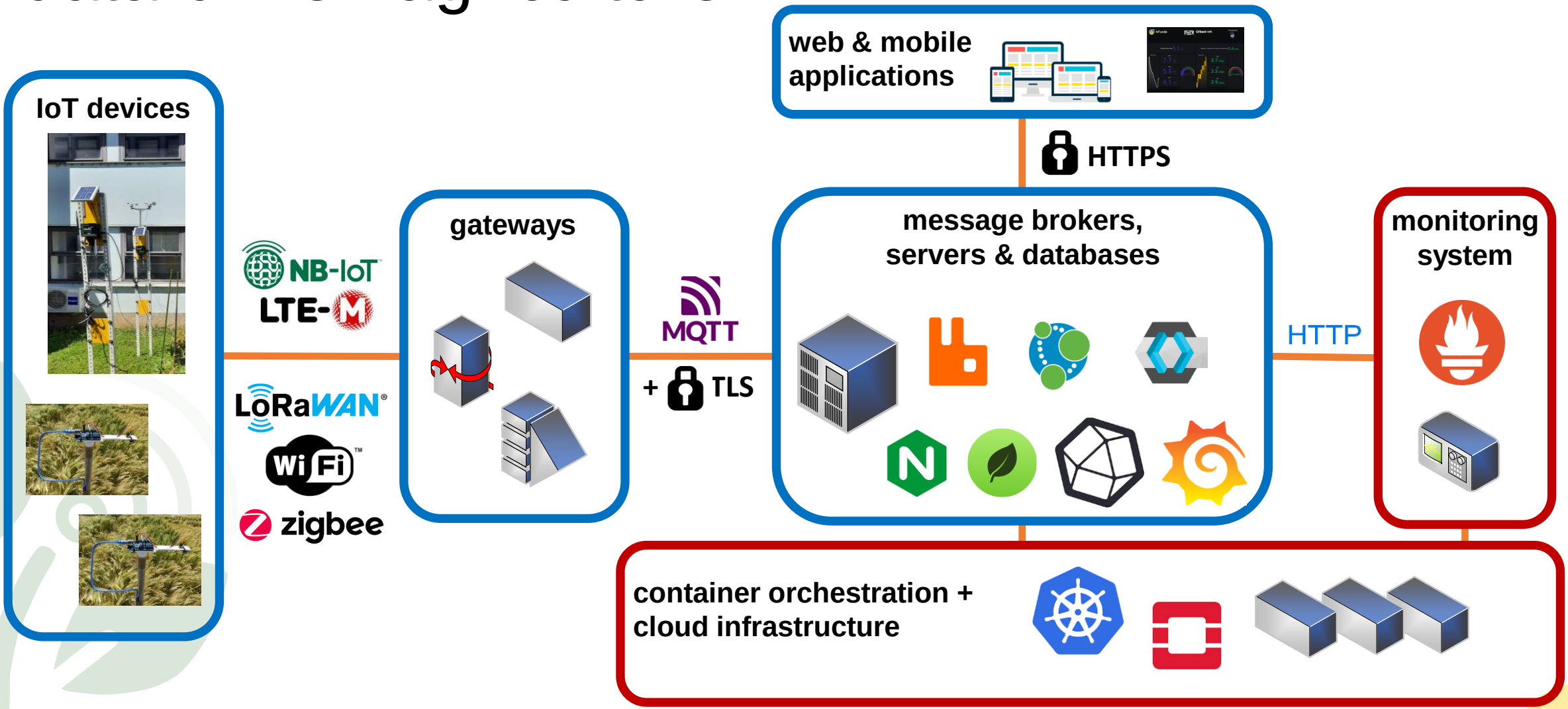
Smart Agriculture

- Usage of Internet of Things (IoT) solutions for continuous monitoring of environmental parameters, soil and crop status (in situ measurements)
  - **goal**: increase of crop yields and profitability
  - **reduce the traditional inputs needed to grow crops** (e.g., fertilizers, herbicides, insecticides)
  - **major challenges**: climate change, transition to organic farming
- Interoperable IoT ecosystem for data-driven agriculture
  - Sensor nodes + communication modules: placed in the fields, continuous measurement and delivery of measured parameters to IoT platform
  - Users end-devices (with mobile/web applications): measurements visualization & analytics using IoT platform services

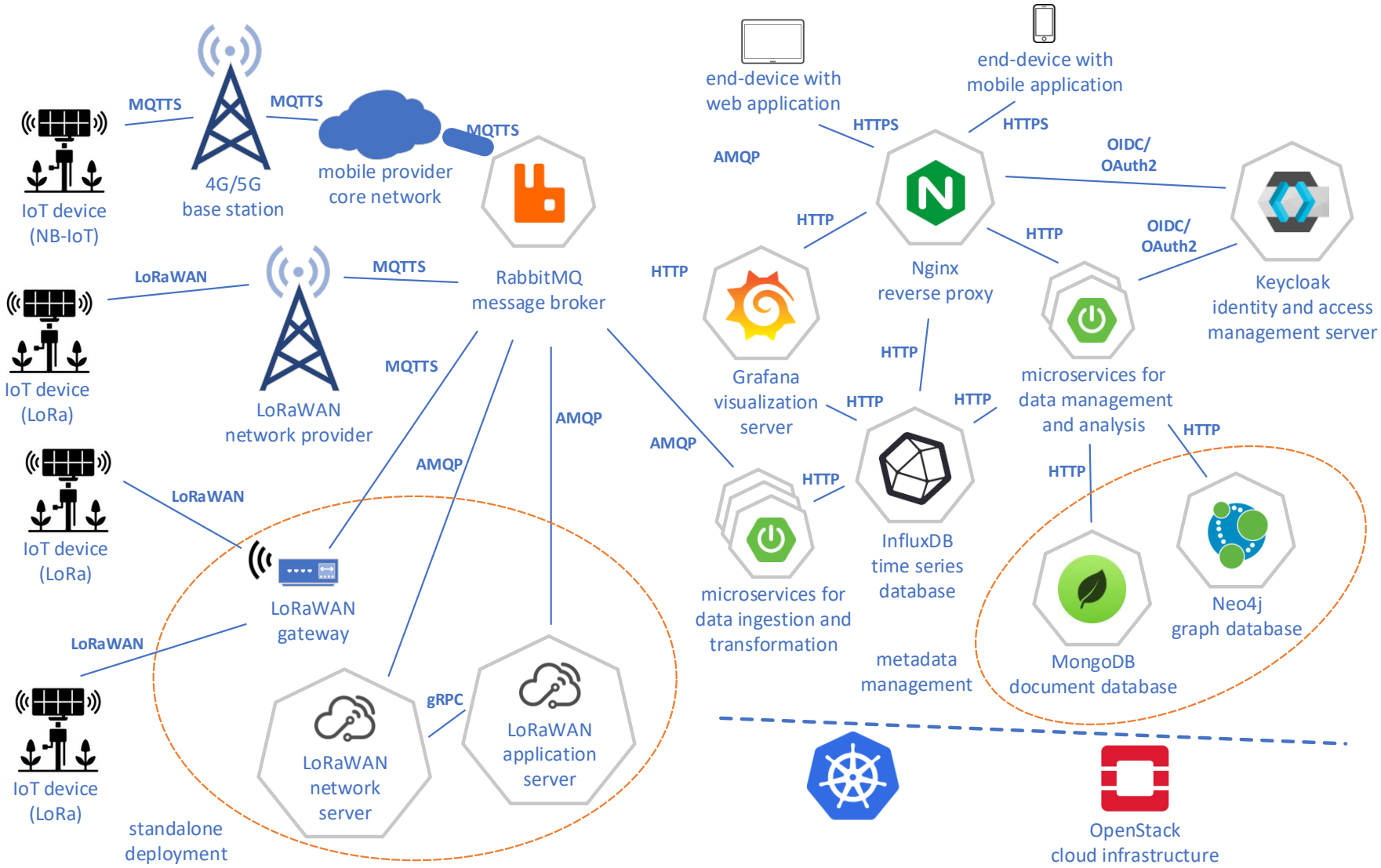
System requirements

- Seamless and reliable exchange of data between
  - diverse IoT devices (with sensors and actuators) and
  - users end-devices (with mobile/web applications)
- Flexible and insightful visualization of collected/stored data
- Scalable and useful analytical services
- Information security & privacy assurance

Interoperable IoT ecosystem for data-driven agriculture



System architecture

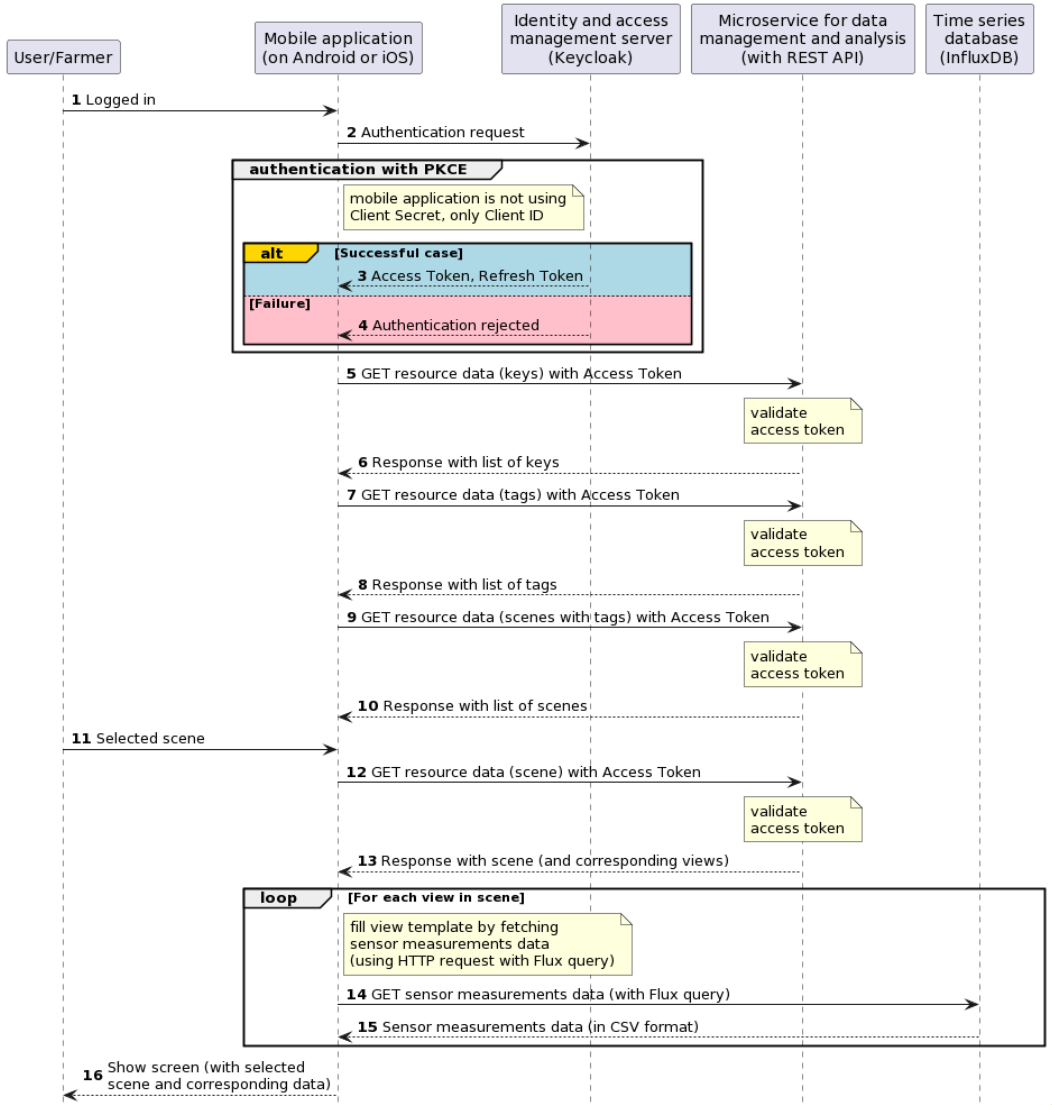


IoT platform

- Contains software components/services running as multiple processes distributed across multiple servers
- Cloud-native microservice architecture (designed following the 15-factor methodology)
  - use of declarative formats for deployment automation
  - maximum portability between execution environments
  - continuous deployment for maximum agility
  - scaling without significant changes to tools, architecture, or development practices
  - Application Programming Interface (API)-first
  - telemetry (which enables monitoring of system performance, health, and key metrics in a highly distributed environment)
  - authentication and authorization

Authentication and authorization

- IoT platform applies OIDC/OAuth 2.0 protocols for authentication and authorization
  - Authorization Code Flow with Proof Key for Code Exchange (PKCE)
- Keycloak as identity and access management server



Data interoperability

- Seamless exchange of data between diverse IoT devices and users end-devices provided by microservices for:
  - **data ingestion and transformation**
    - standardized protocols
    - agreed formats
  - **data management and analysis**
    - graph/semantic networks
- Semantic networks contain concepts and relationships that are relevant to the domain

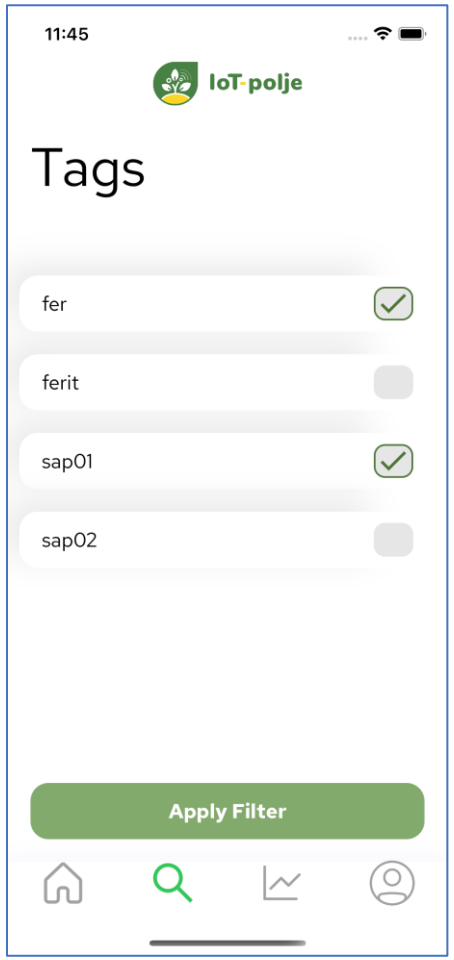
Measurements data

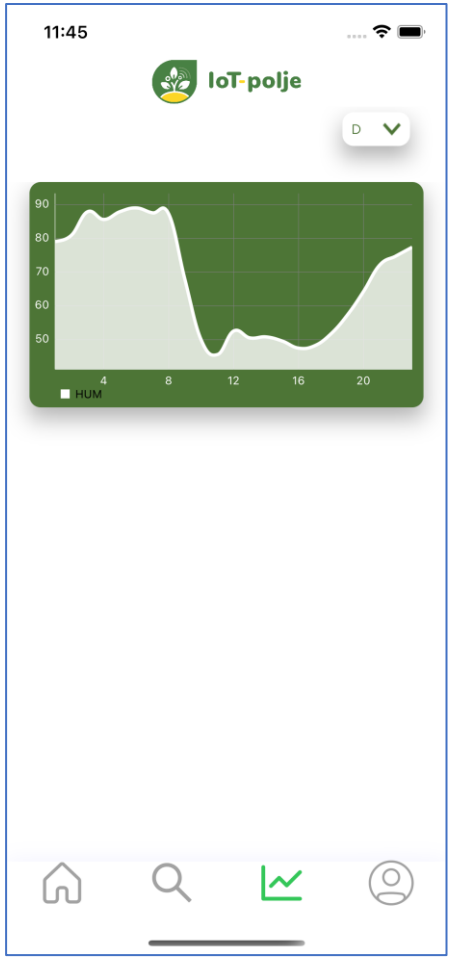
- IoT platform collects agrometeorological and crop conditions
  - heterogeneous IoT devices
  - deployed at locations in Zagreb, Osijek & Tovarnik
- Dedicated sensors measure:
  - air temperature, humidity and pressure
  - soil temperature and moisture
  - leaf temperature and moisture
  - solar/global radiation
  - luminescence and fluorescence
  - precipitation/rainfall
  - wind speed and direction

System validation

→ with FERIT IoT devices and Grafana Web application

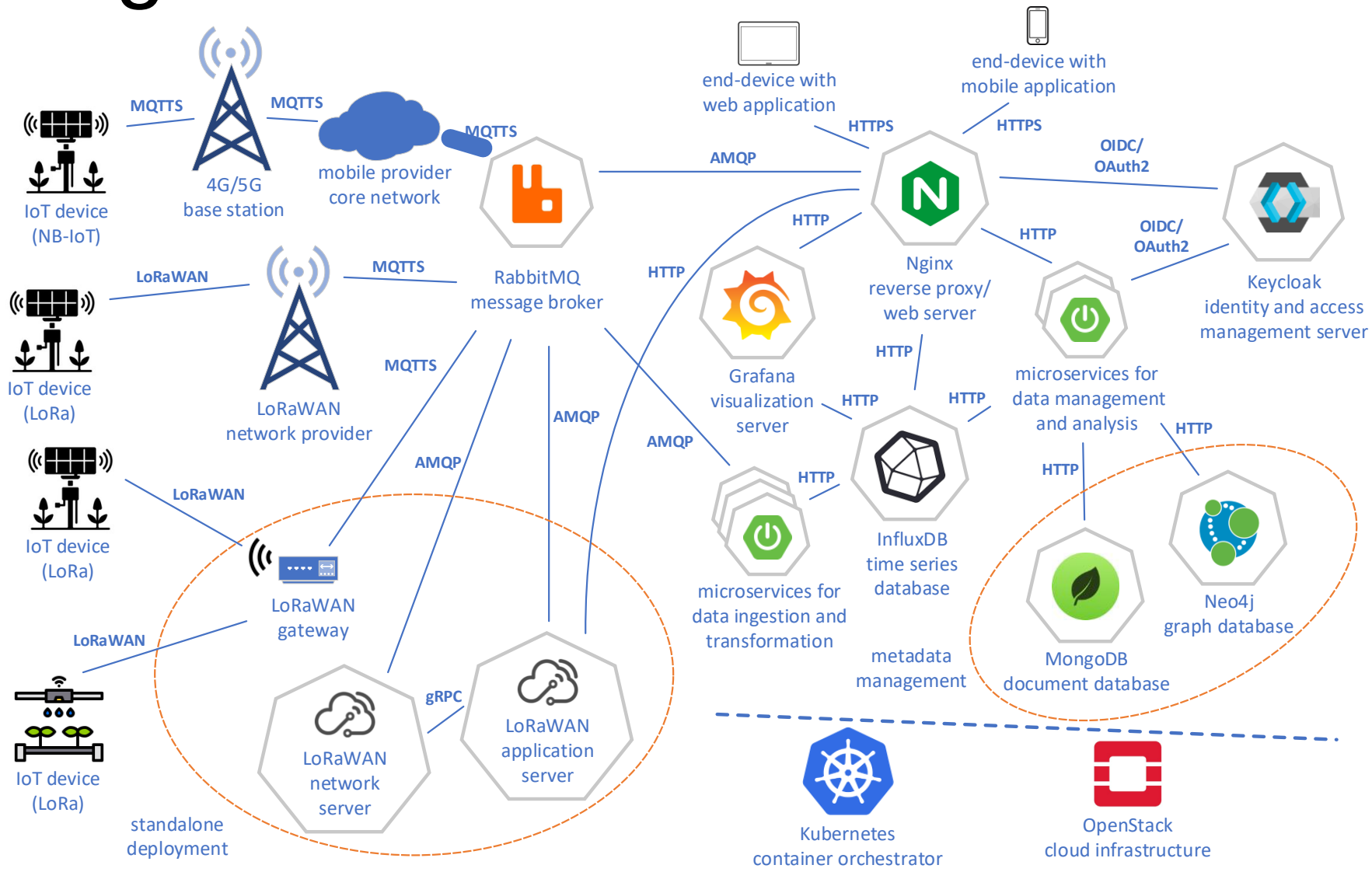
System validation
→ with iOS mobile application





Work in progress

- IoT devices with actuators
- Kubernetes orchestration



Conclusion

- Built interoperable IoT ecosystem for data-driven agriculture
  - reliably collects sensors measurements form heterogeneous IoT devices
  - contains IoT platform with cloud-native microservice architecture
  - provides flexible and insightful visualization of sensor readings from IoT devices
  - enables simple and usable tools for farmers and agronomists
    - assessing current field conditions
    - estimating crop stress levels
    - determining the best time to apply certain cultivation practice
  - ensures enforcement of information security & privacy controls