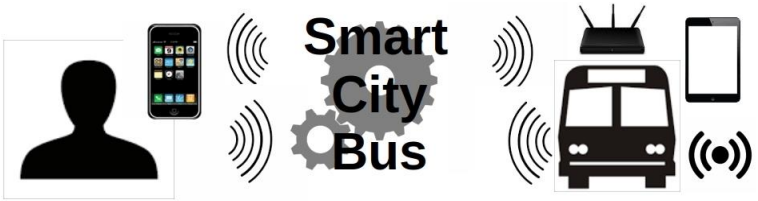


SmartCityBus - A Platform for Smart Transportation Systems

Georgios Bouloukakis, Chrysostomos Zeginis, Nikolaos Papadakis, Kostas Magoutis, George Christodoulou, Chrysanthi Kosyfaki, Konstantinos Lampropoulos, Nikos Mamoulis

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

WSDM'23 - Smart City Day Talks – Singapore, March 3, 2023

SmartCityBus – Key points in today's talk

- Increase **context awareness** in transportation-related spaces
  - More detail on space structure, occupancy, passenger needs
- **More data** will be collected vs. today's smart-transportation systems
  - Context-brokers: are they suitable for large and diverse types of data?
- **Open data**
  - Can transportation-related open data be leveraged *in the wild*?

Smart transportation systems lack full context awareness

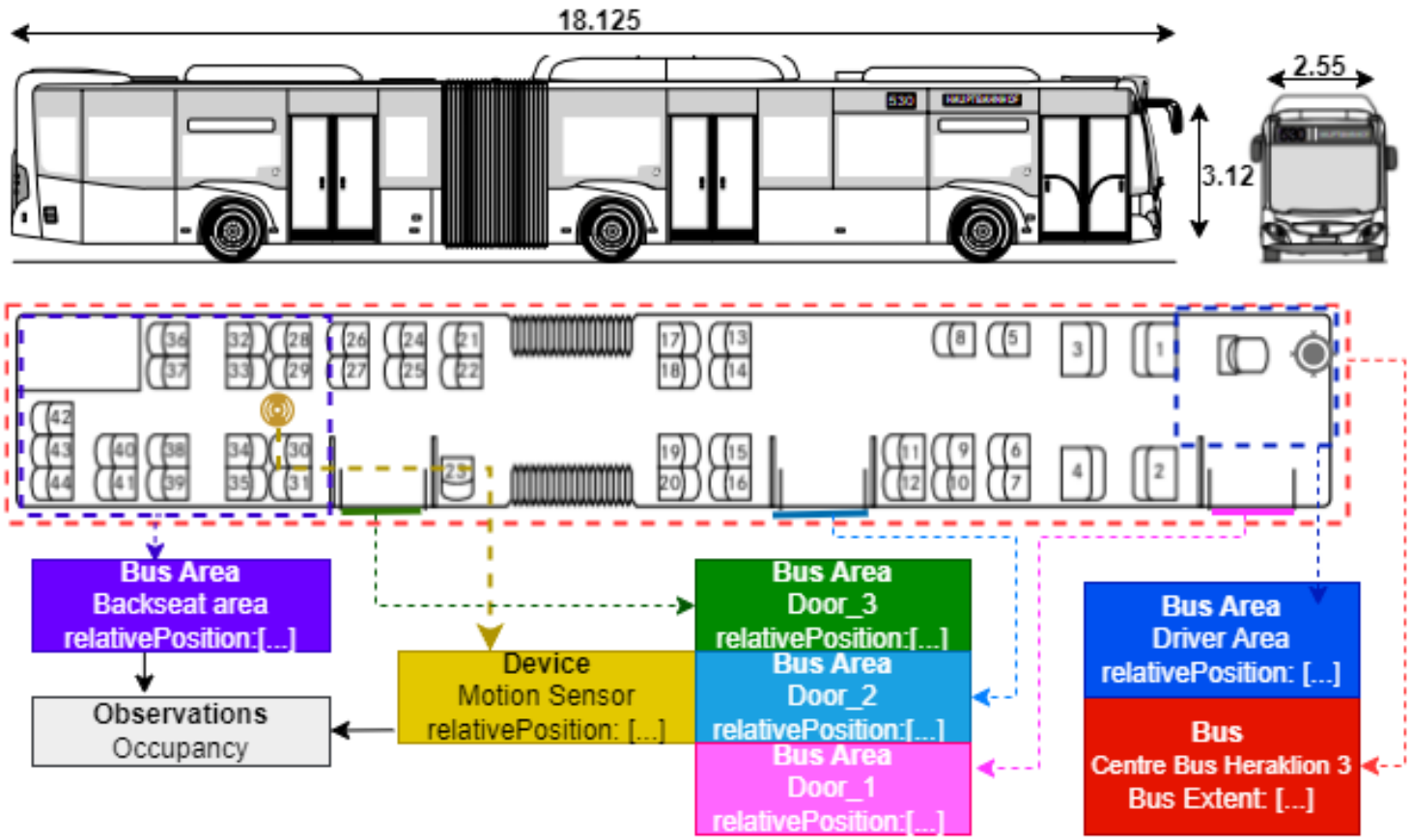
- Current data models capture limited context
  - IoT ecosystem on transportation spaces can be rich
  - Vendor lock-in, focus on using specific devices

- **SmartCityBus solution**
  - **Extend NGSI-LD data model** to represent both static and dynamic context properties of transportation systems

NGSI-LD (Next Generation Service Interface-Linked Data)**:** A data model specification developed by the European Telecommunications Standards Institute (ETSI) to enable the interoperability and exchange of data in smart city and IoT contexts

[BZ+22] G. Bouloukakis, C. Zeginis, N. Papadakis, P. Zervakis, D. Plexousakis, and K. Magoutis. *Enabling IoT-enhanced Transportation Systems using the NGSI Protocol*. In 12th IoT Conference, pp. 33-40, Delft, NL, November 7-10, 2022

Increase context awareness by modeling the interior of buses



Modeling the interior of buses would have various benefits, e.g.

- Are the seats for disabled people fully occupied? (Send another bus in case a need arises)
- Are there specific areas inside the bus with too many (or no) passengers? (Adjust the A/C function)

Simple NGSI-LD transportation models exist

Smart Data Models

A GLOBAL PROGRAM LED BY

FIWARE IUDX OASC OPEN & AGILE SMART CITIES tmforum

Available models cover:

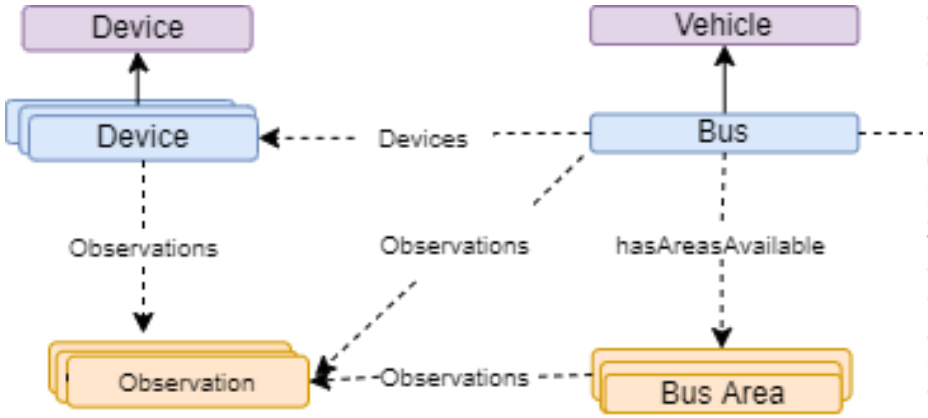
- ❑ Transportation
- ❑ Urban Mobility

https://smartdatamodels.org

Enhancing NGSI transportation models

Extended the following entities:

- **Vehicle Model**: Includes all common properties to vehicle instances of the same type
- **Vehicle**: models a specific vehicle



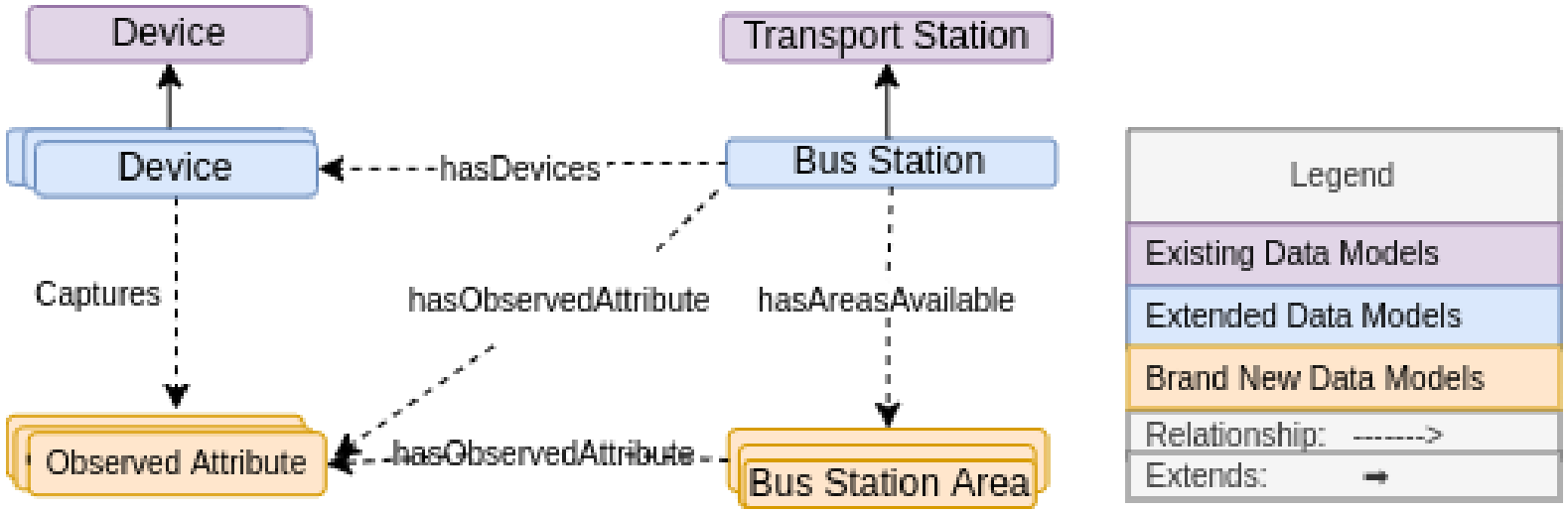

```
...
"type": "Bus Area",
"name": "Driver Area"
"r
"h
..
"t
"n
"r
...
```

```
...
"type": "Device",
"category": "sensor",
"captures":["urn:ngsild:Observation_N03"],
"depth": 3,
"deviceState": "ok",
"direction": "Outlet",
"ipAddress": [
    "99.999.999.99" ],
"value": "15",
...
```

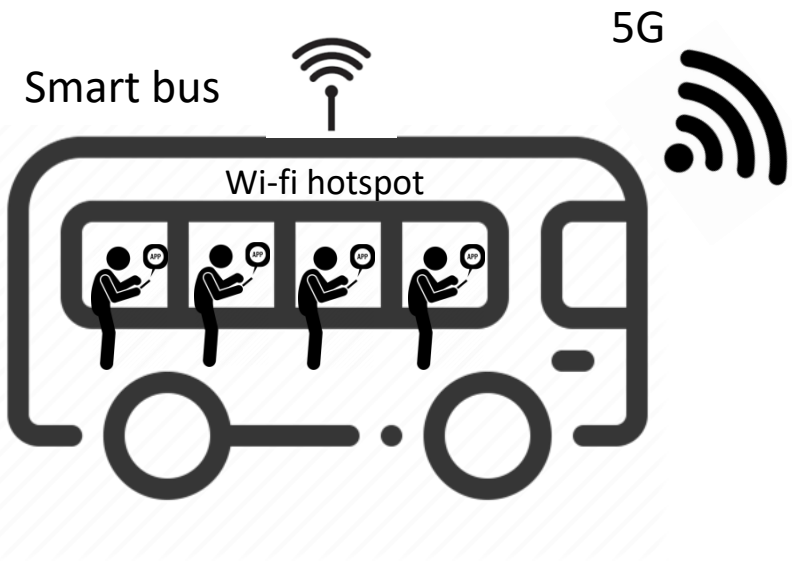
```
...
"id": "urn:ngsild:Observation_N01",
"type": "Observed Attribute",
"name": "Occupancy",
"observationDateTime": "2022-02-21T07:36:17+0000",
"value":15,
...
```

https://github.com/smart-data-

Similarly for stops and stations



Enhanced models bring out new capabilities



NGSI-LD Bus model

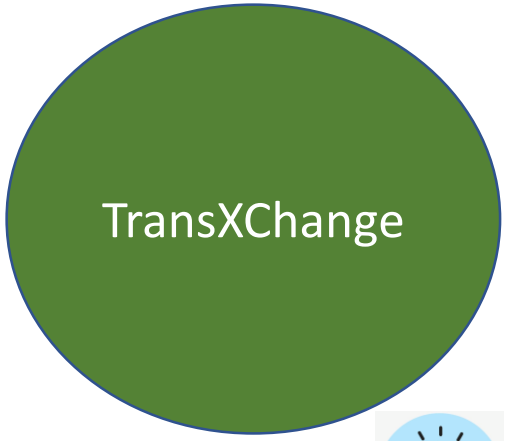
Smart bus stop

NGSI-LD Bus Station model

Spatial Context Properties

Accessibility Application

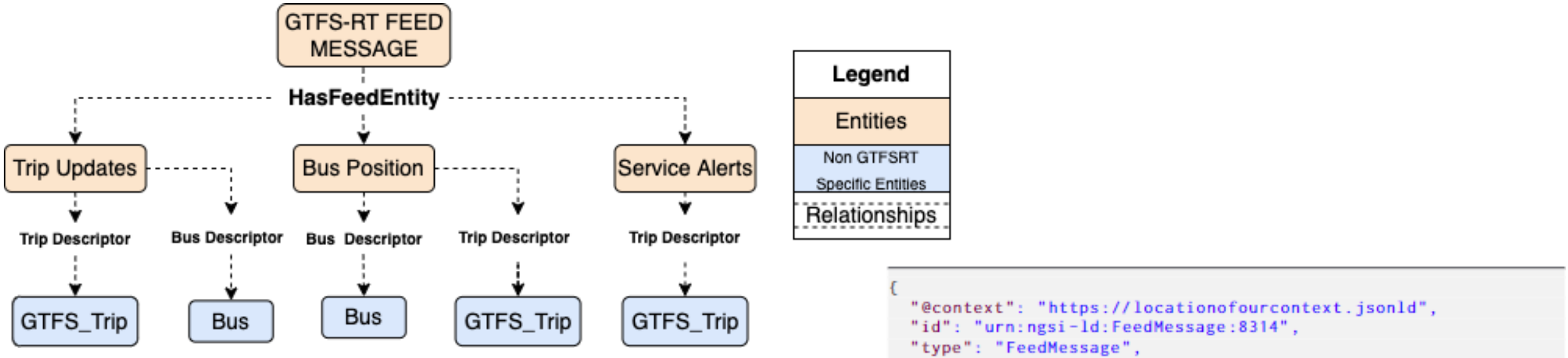
Prevalent smart transportation data models



GTFS-RT (General Transit Feed Specification - Real Time) is an open data format specification for real-time public transportation data, developed by Google in collaboration with several transit agencies. It is an extension of the GTFS format, which is used to describe static transit schedules

TransXChange is a standard XML-based data format for exchanging public transportation data primarily in the UK. Developed by the UK Department for Transport (DfT) in collaboration with the transport industry and local authorities

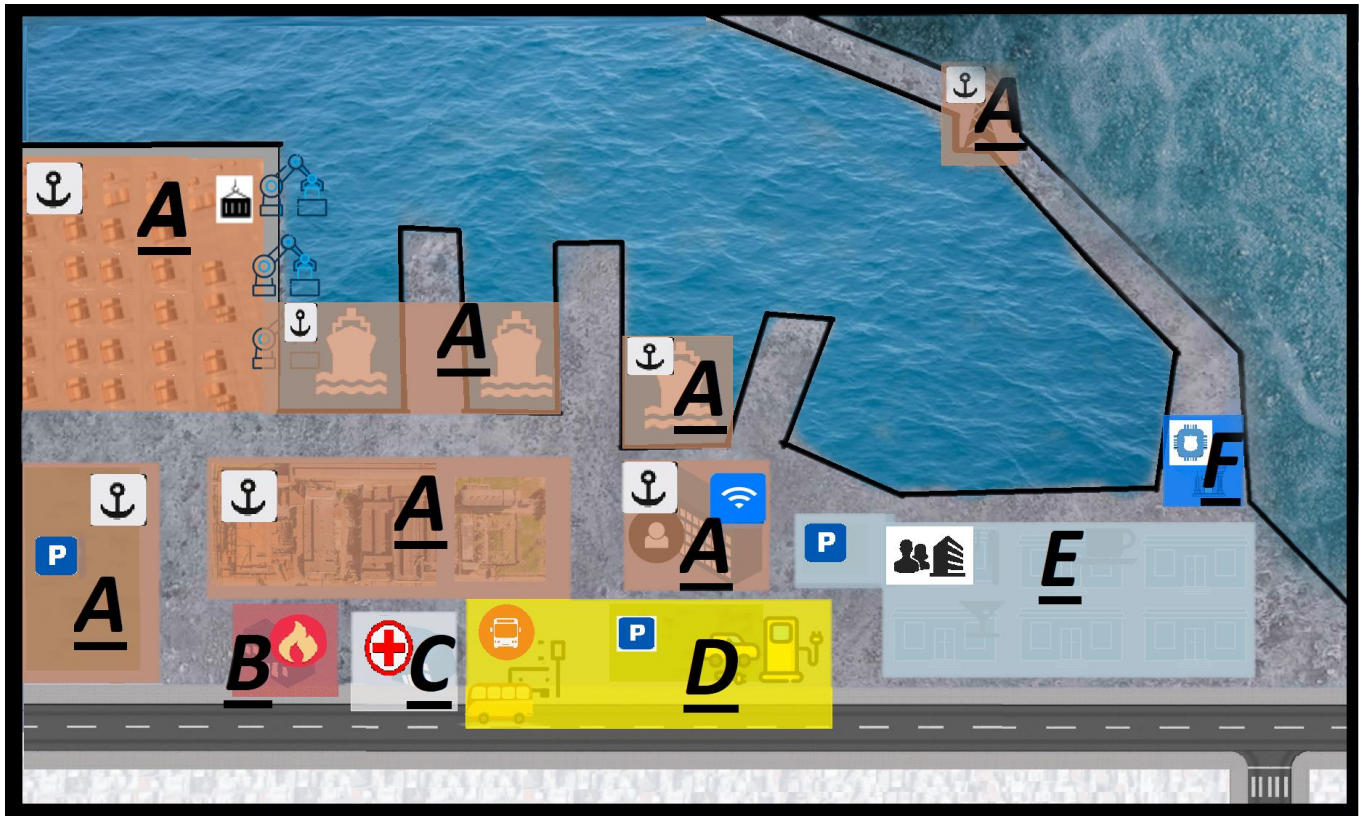
Taking an extra step: GTFS-RT to NGSI-LD mapping




```
1 {                     //FeedMessage
2     1: "1.0"          //gtfs_realtime_version
3     2: 0              //incrementality
4     3: 1644784163     //timestamp
5 }
```

```
{
  "@context": "https://locationofourcontext.jsonld",
  "id": "urn:ngsi-ld:FeedMessage:8314",
  "type": "FeedMessage",
  "FeedHeader":{
    "type": "Property",
    "value":{
        "gtfs_realtime_version": "1.0",
        "incrementality": 0,
        "timestamp": 1644784163,
    }
},
"hasFeedEntity":{
    "type": "Relationship",
    "object":["urn:ngsi-ld:TripUpdates:1"]
},
}
```

Smart public transportation should be integrated into city-wide smart communities



A: Port authority

B: City Fire Dept.

C: First aid

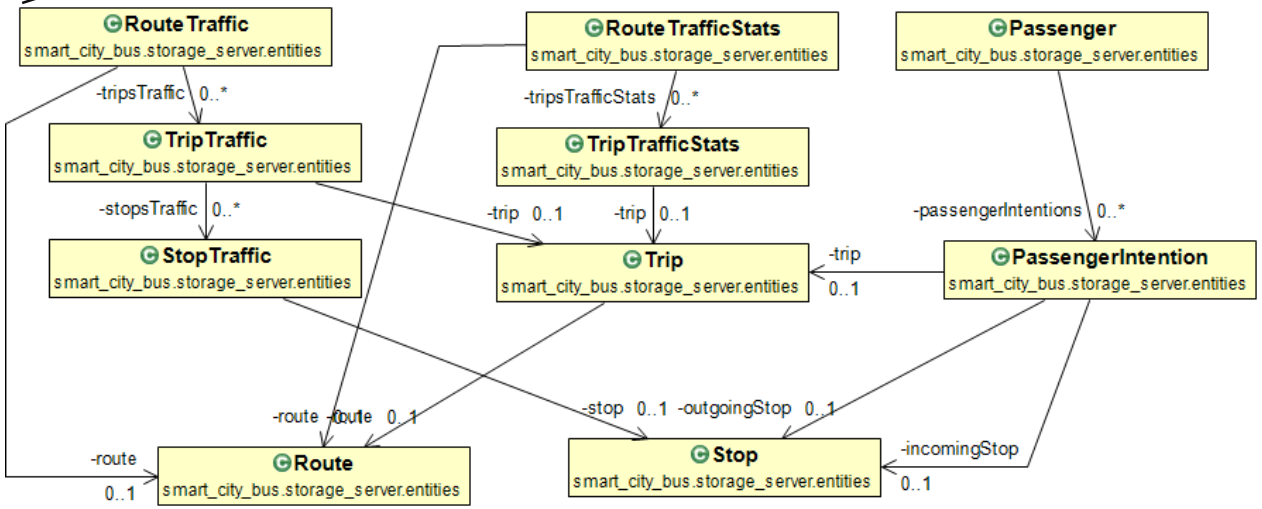
D: City bus terminal

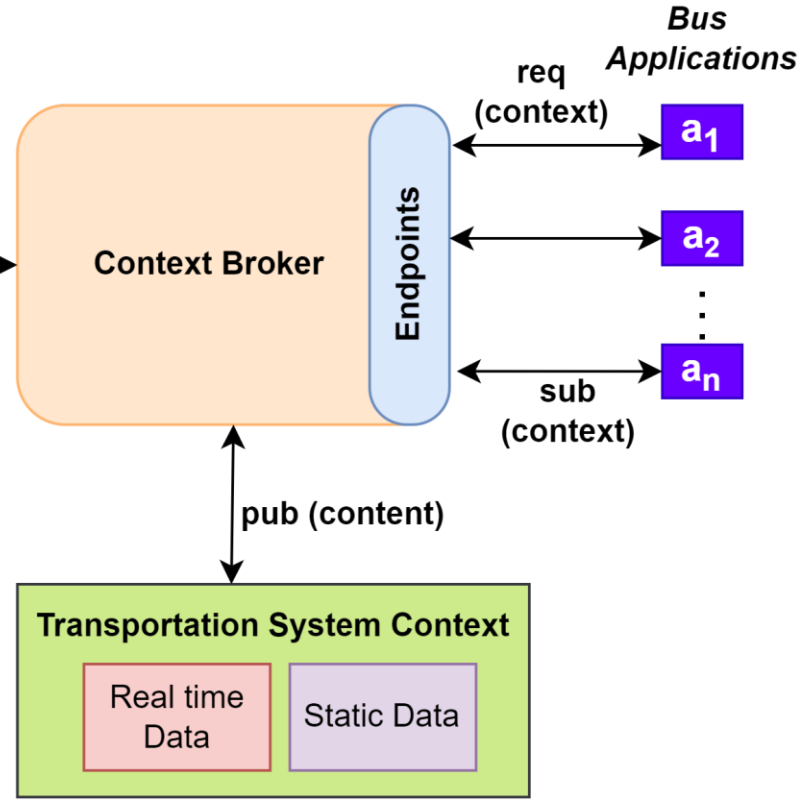
E: Passenger terminal

F: Police

SmartCityBus platform architecture

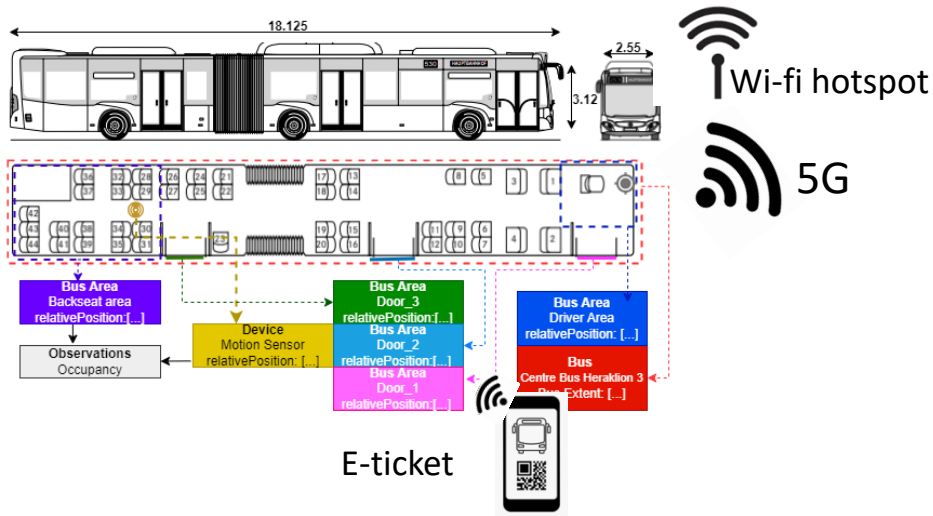
Repository of historical context-broker data
(raw & derived from analytics)





Repository of real-time and static context-broker data

Larger amounts of data to be produced vs. today's apps



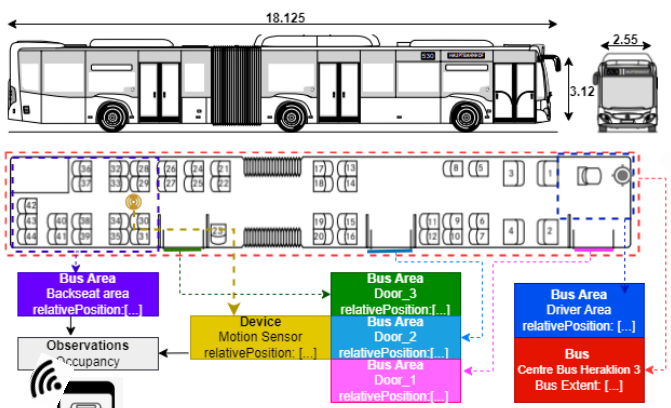
Wi-fi hotspot

5G

E-ticket

People counting
Passenger intents
Detailed occupancy

Smart bus



Wi-fi hotspot

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E-ticket

People counting
Passenger intents
Detailed occupancy

Wi-fi hotspot

SmartCityBus
data repositories

People counting
Passenger intents
Detailed occupancy

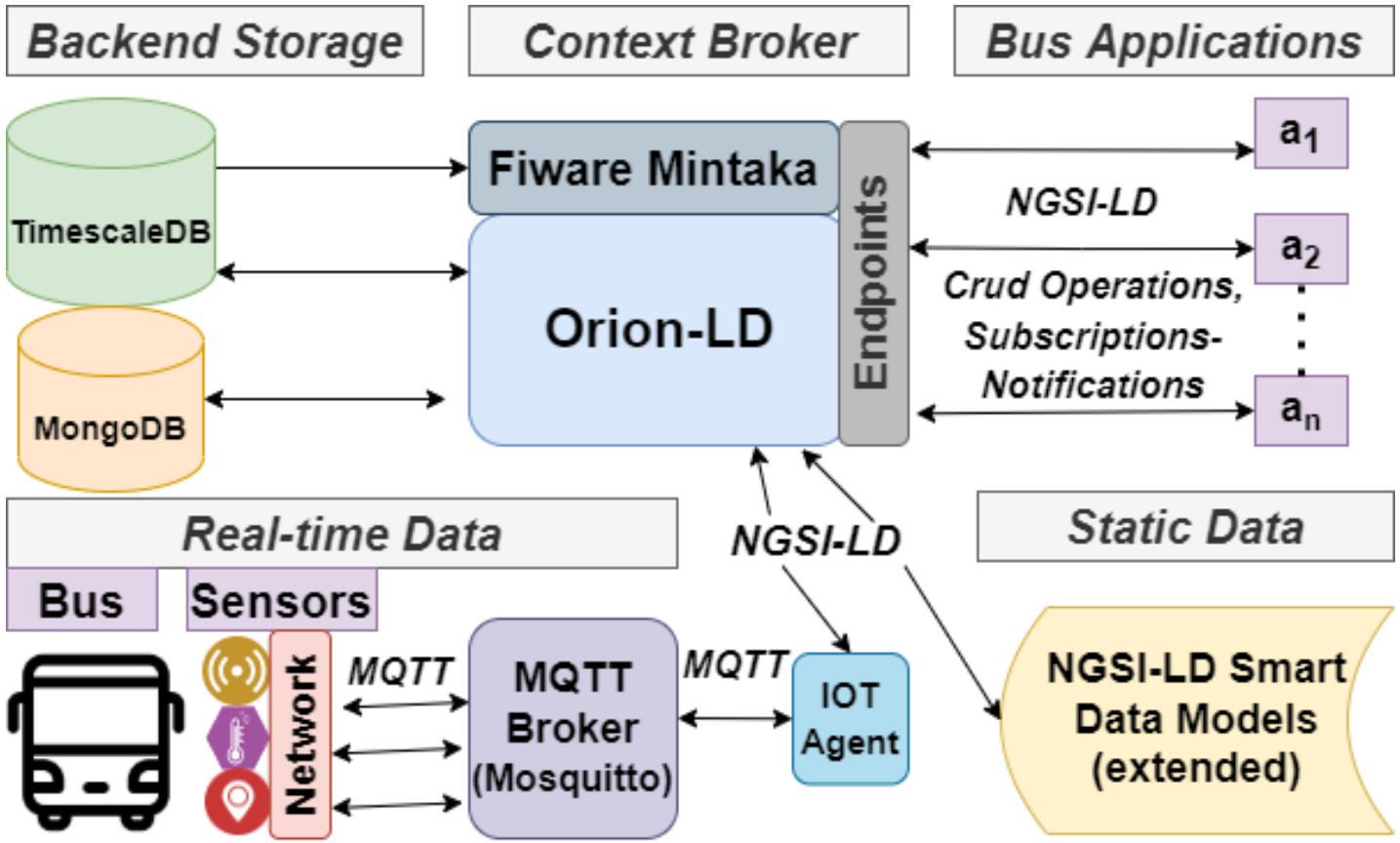
Wi-fi hotspot

5G

Wi-fi hotspot

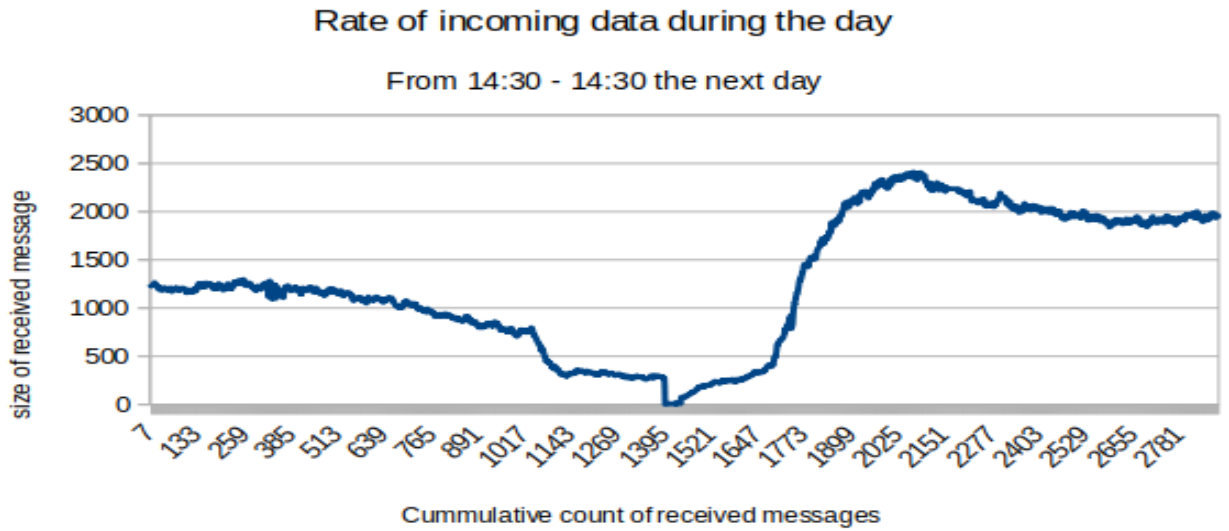
Smart Bus Stop

SmartCityBus prototype



Open data?

- GTFS data published openly
  - Static GTFS (Download: 1/day, average ~300MB)
  - Realtime GTFS (Download: 3/30 sec, average ~1.69MB)



1 day = ~4GB of data
~22300 trips

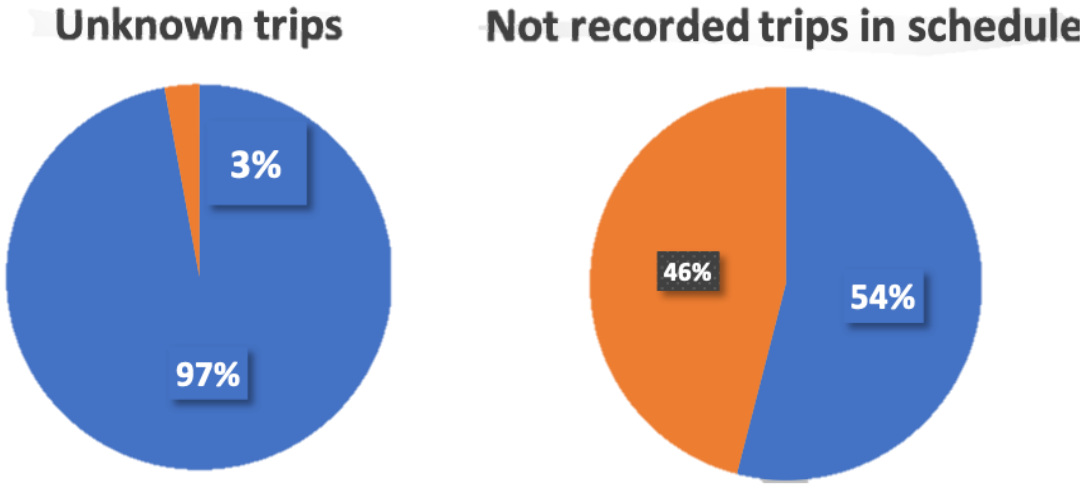
Use of stream-processing reduces the amount of data stored significantly!

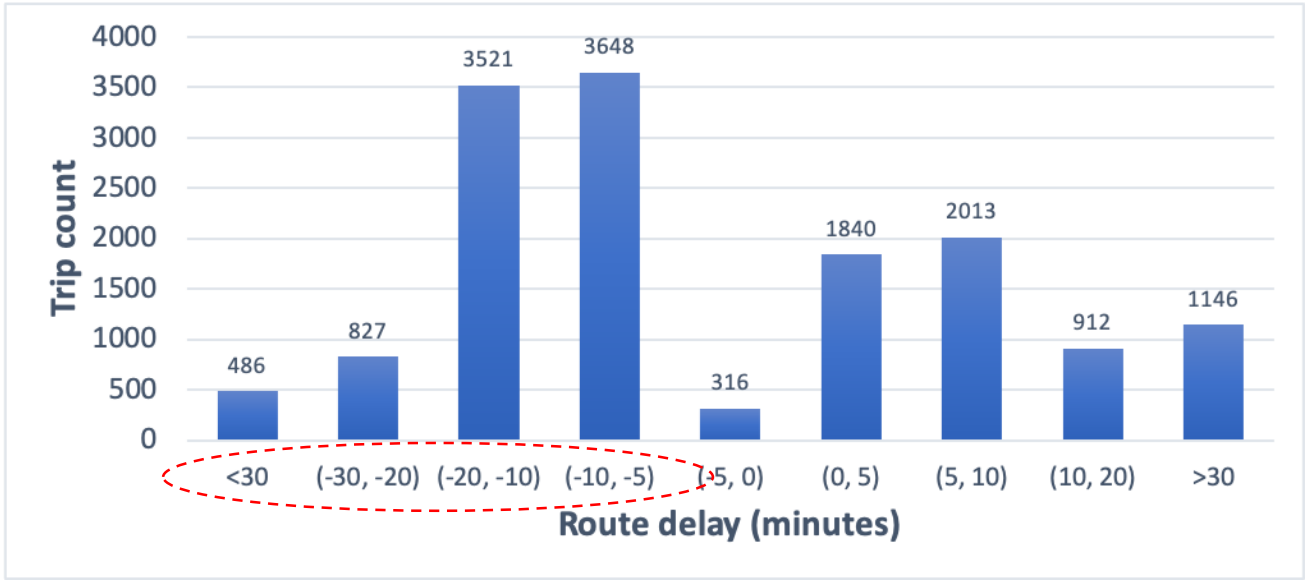
Open datasets *in the wild* are rarely perfect…

- Some trips in the feed could not be mapped to the schedule
- Some scheduled trips are not in the feed
- Schedule inconsistencies are widespread

Need to improve open-data quality & reusability

eosc





Conclusions and future work

SmartCityBus

- Enrich existing models with **context awareness** in buses, bus stops
- Federate with other smart city models, enabling new applications
- Address the many and diverse forms of data
- Address challenges with **open data**, to facilitate exploitation
- Several other directions currently under investigation

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Special thanks to all members of the SmartCityBus Consortium for their contributions in the research presented today

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