Minimal Transportation Disruptions Model and Ontologies for Modelling of Disruptive Events

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Abstract. Carriers and operators seek effective ways to distribute structured information about transportation disruptions to passengers, drivers and other users of the infrastructure. Transit Alerts, a conceptual application from *Some move*, utilizes all available means of distribution to deliver timely updates about disruptive events. Apart from REST resources and JavaScript Web API, an interlinked repository is proposed to support intelligent assistive technologies. Several ontologies were compared to model the events and share the information from the application repository to third parties in a vendor-independent schema.

Keywords: Transportation Disruptions, Linked Data, Advanced Traveller Information System, ATIS, Information System Integration

1 Introduction

Public transportation is a key economic factor that enables workforce mobility and development of smart cities. Buses, trains and other transportation modes, however, face both scheduled and unexpected disruptive events that negatively impact availability, attractiveness and quality of the service. Carries need adequate means to integrate reports from various sources, inform travellers and staff, and accurately deliver updates with minimal delays and inaccuracies. Furthermore, they strive to analyse, predict and avoid such events in the future. Interoperability is the main challenge for integrating existing reporting systems, as well as devices and facilities used to present updates and responsive measures to stakeholders.

The carriers' immediate concern is to address the distribution of such events. Dispatchers receive unstructured voice or textual information reporting a new disruption or an update on an existing one. Upon acknowledgement, a comprehensive description is compiled and distributed over voice or text to on-board personnel and passengers. Quality of the information process depends on multiple factors:

1. Availability of input information,
2. Speed of reaction,
3. Implemented mitigation measures and quality of information provided to recipients (passengers, passenger-facing employees)
4. Distribution to information channels followed by the intended audience

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Information systems addressing this process must integrate data with different textual formats – extract from plain or RDFa-annotated HTML, XML, JSON[1], RESTful services [3], SOAP, GraphQL[2] or proprietary structured formats – and integrate them with voice information, geospatial data detailing specific points or sections within the transportation network, as well as the current position of affected vehicles. The same integration requirements are applied to distribution channels where third-party distribution systems or devices expose different interfaces to present information.

Transit Alerts is an information system designed in a way that addresses seamless integration of reporting channels and distribution systems in a single dispatcher interface. An internal data model is used across the system. Inbound reports are mapped into the internal data model and outbound messages are transformed to a format that third-party distribution systems understand, assuming they cannot consume the internal data model directly.

Addressing interoperability is the challenge that Semantic Web and Linked Data overcome by nature. When a data model is shared not only by internal subsystems but also exposed to third parties, it enables them to query, reason and analyse structured information from the system.

2 Information System Model

While designing the system, existing information sources[3] were reviewed to define sets of information currently shared with stakeholders, to be designated as required or optional. Reporting structures from major Czech and Slovak rail and bus operators were cross-referenced to determine common denominators and identify a minimum set of attributes required to conceivably report a traffic disruption. *Table 1* provides an overview of the carriers' reporting templates.

Tab. 1. Required (R) and optional (O) attributes of disruptions published by studied carriers

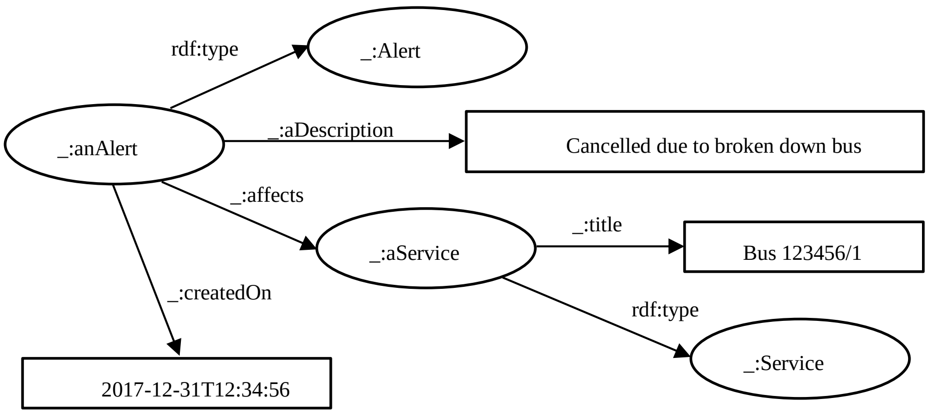
Information	ČD	RJ	LE	ARRIVA	ÖBB	ZSSK
Route	O	O	O	O	O	O
Service	O	O	R	R	O	R
Timestamp From	R	R	R	R	R	O
Timestamp To	R	O	O	O	O	O
Description	R	R	R	R	R	R
Event Type	R	O	R	O	R	R
Measure	O	O	O	O	O	O

[1] ECMA-404 The JSON Data Interchange Format

[2] http://graphql.org

[3] www.cd.cz/mimo, www.le.cz (Actual traffic restrictions), www.regiojet.com/en/news-from-railway-network/, www.arriva-vlaky.cz/jizdni-rad/mimoradnosti-a-zmeny/, www.arrivaexpress.cz/zmeny-v-provozu/ to name a few.

As a result of this analysis, the designed internal data schema consists of at least three required attributes, which are key to providing actionable information: services affected by the event, unstructured textual description and a timestamp of occurrence. Optional information includes estimated time of resolution, root cause, geospatial location of the event within the transportation network and implemented mitigation measures (non-planned rotation of vehicles, substitution services etc.).



Picture. 1. RDF graph for a sample alert (disruptive event)

None of the sources examined provide information in any semantic format, as plain HTML is generally used instead. Respecting the Linked Data best practices[4], we looked for an existing RDF schema or ontology capable of expressing both minimal and structured information about disruptive events in different modes of transportation. Compatibility with ontologies that describe timetables, geospatial information or network information was considered as an advantage.

3 Ontologies Examined

GTFS[5] has been adopted by various systems to process timetable information in a format interoperable with Google Maps and Open Trip Planner [5]. Linked GTFS[6] specifies the feed vocabulary for RDF. GTFS Realtime[7] enables the systems to push trip updates, service alerts or vehicle positions, though this extension is not covered by an RDF schema.

[4] http://www.w3.org/TR/ld-bp
[5] http://gtfs.org
[6] http://vocab.gtfs.org
[7] https://developers.google.com/transit/gtfs-realtime/

The DATEX[8] standard was developed for information exchange between traffic management centres, traffic information centres and service providers in Europe. Its schema[9] specifically covers road transportation.

Service Interface for Real Time Information (SIRI)[10] is a CEN protocol to distribute real time information about public transportation services. This standard was designed for real-time data distribution and utilizes SOAP messaging over web services.

The Transport Disruption Ontology [2] formalizes a framework for modelling of disruptive events regardless of transportation mode. Other ontologies like FOAF, DC or LinkedGeoData are compatible with TD ontology. A general `td:DisruptiveEvent` class represents any event though TD ontology and provides several possible event types.

```
_:aService
  a sj:Service;
  dc:title "Bus 123456/1".

_:aPlaceOfFailure
  a geo:SpatialThing;
  geo:lat "50.076005";
  geo:lon "14.4304176".

_:aPlan
  a td:Plan;
  transit:service _:aService.

_:anAlert
  a td:DisruptiveEvent;
  dt:causeOf td: BrokenDownBus;
  dc:description "Cancelled due to broken down bus";
  event:time [ tl:beginsAtDateTime "2017-12-
31T12:34:56"^^xsd:dateTime ];
  event:place _:aPlaceOfFailure;
  td:impactsOn _:aPlan.
```

Figure 1: Sample of a discruptive event information about a broken bus

Whereas *Picture 1* describes a general RDF graph of a single disruptive event, *Figure 1* demonstrates an example with an applied TD ontology combined with the Social Journeys[11] ontology to express the impacted bus service. This listing defines a public bus service and an alert that the service is impacted by a vehicle failure at known GPS coordinates and a known point in time.

[8] http://www.datex2.eu

[9] http://vocab.datex.org/terms

[10] http://www.siri.org.uk

[11] https://github.com/SocialJourneys/SocialJourneysOntologies

The above information enables profound analysis, such as identifying the most failure-prone services, vehicles or critical points in the transportation network. Having further information about the measures implemented by dispatchers, an analysis of measure effectiveness, as well as automated recommendations is possible.

4 Conclusion

Transport Disruption Ontology[12] has been selected to express internal information in the Linked Data Repository. Apart from the integration of RDF-consuming third-party systems, an expert system may be implemented.

Network managers can identify faulty infrastructure points; carriers and transportation planners may use such data to improve timetables and service reliability, and avoid points of frequent congestion. Smart travel planning systems can query the data source to provide estimates on on-time arrival or plan for alternative routes once real-time data is available.

References

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