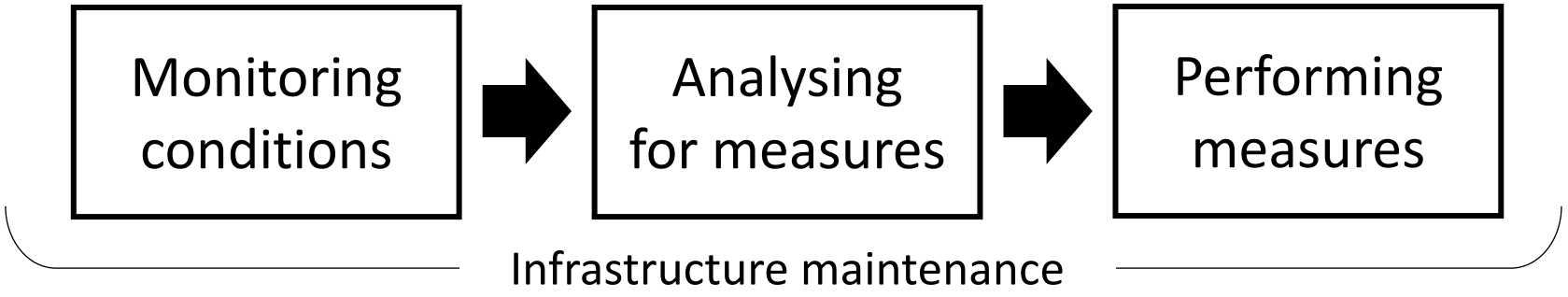
SOLA: Stream OLAP-based Analytical Framework for Roadway Maintenance

Takahiro Komamizu, Toshiyuki Amagasa,
Salman Ahmed Shaikh, Hiroaki Shiokawa,
Hiroyuki Kitagawa

University of Tsukuba

Infrastructure Maintenance

- Infrastructure: roadway, electricity, etc.
- Critical issue for (local) governments
- Traditional way of maintenance
  - **Laboursome**: people periodically check the infrastructure by their eyes.
  - **Non-scalable**: limited number of people are assignable to the periodical checking.



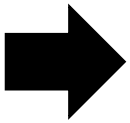
IoT & Crowdsourcing as a Solution for Monitoring

- Sensor devices reduce human-labours for monitoring infrastructure conditions.
  - e.g., Sensors on cars can monitor conditions of roadways.
- Crowdsourcing (including reporting on SNS) is another solution to obtain conditions.
  - e.g., Twitter users claim about bad conditions about roadways.

➡ Lower costs and scalable

Next step: Analysis

- Analysing the data from lower costs and scalable monitoring of infrastructures.
- Heterogeneity issues
  - Multiple sources of data
  - Various models and schemas of data
    - Streaming data, static data
    - Structured (e.g., relational), semi-structured (e.g., XML and JSON), unstructured data (e.g., text)



This paper deals with these issues in a real-world application.

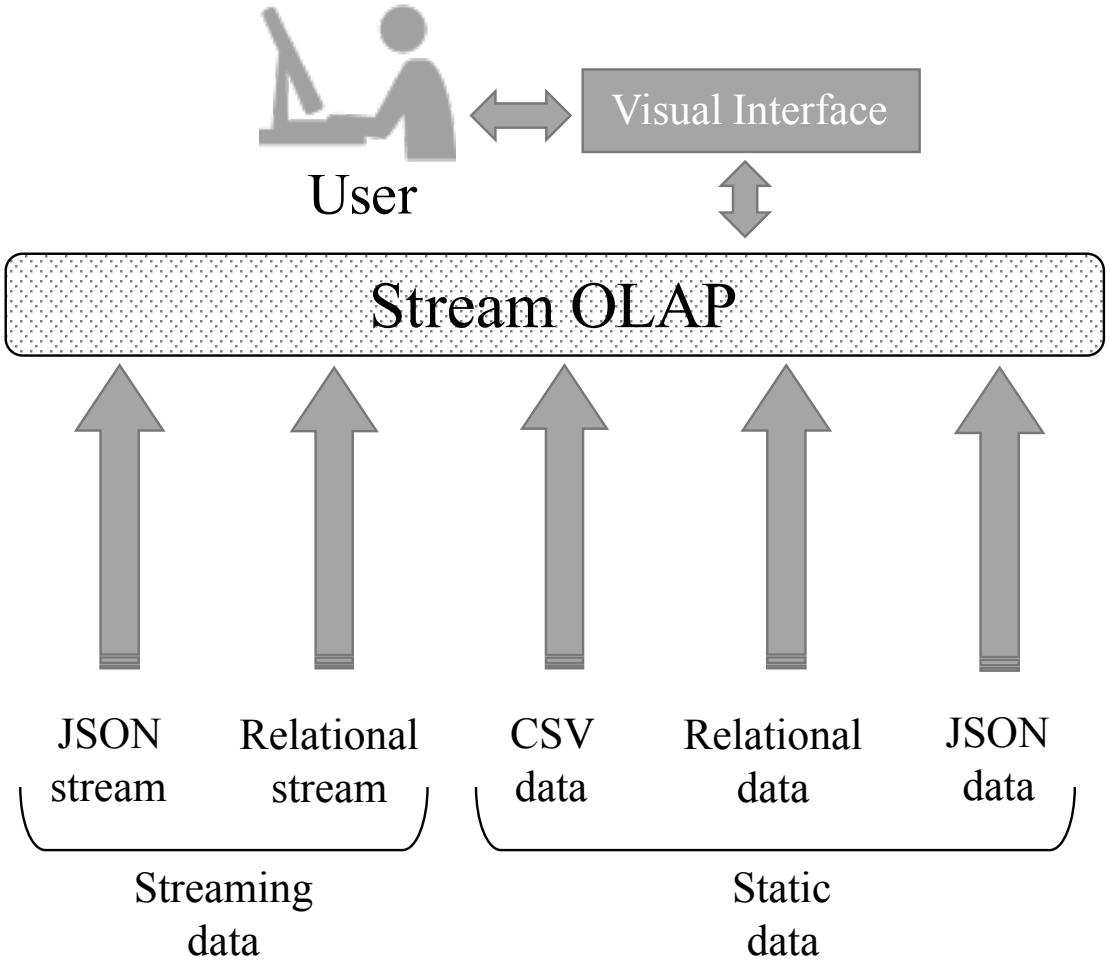
Motivating Scenario: Roadway Maintenance

- Real-world governmental activity in Tsukuba city, Japan
- City officers patrol city roads everyday to monitor road conditions and repair bad conditions (crack and pothole) if possible.
- For now, patrol routings are determined by experienced persons.
  - Still missing bad road conditions
  - Not easy for unexperienced persons

➡ **Systematic support is highly demanded.**

Stream **OL**AP-based **A**nalytical framework

SOLA: Proposed System

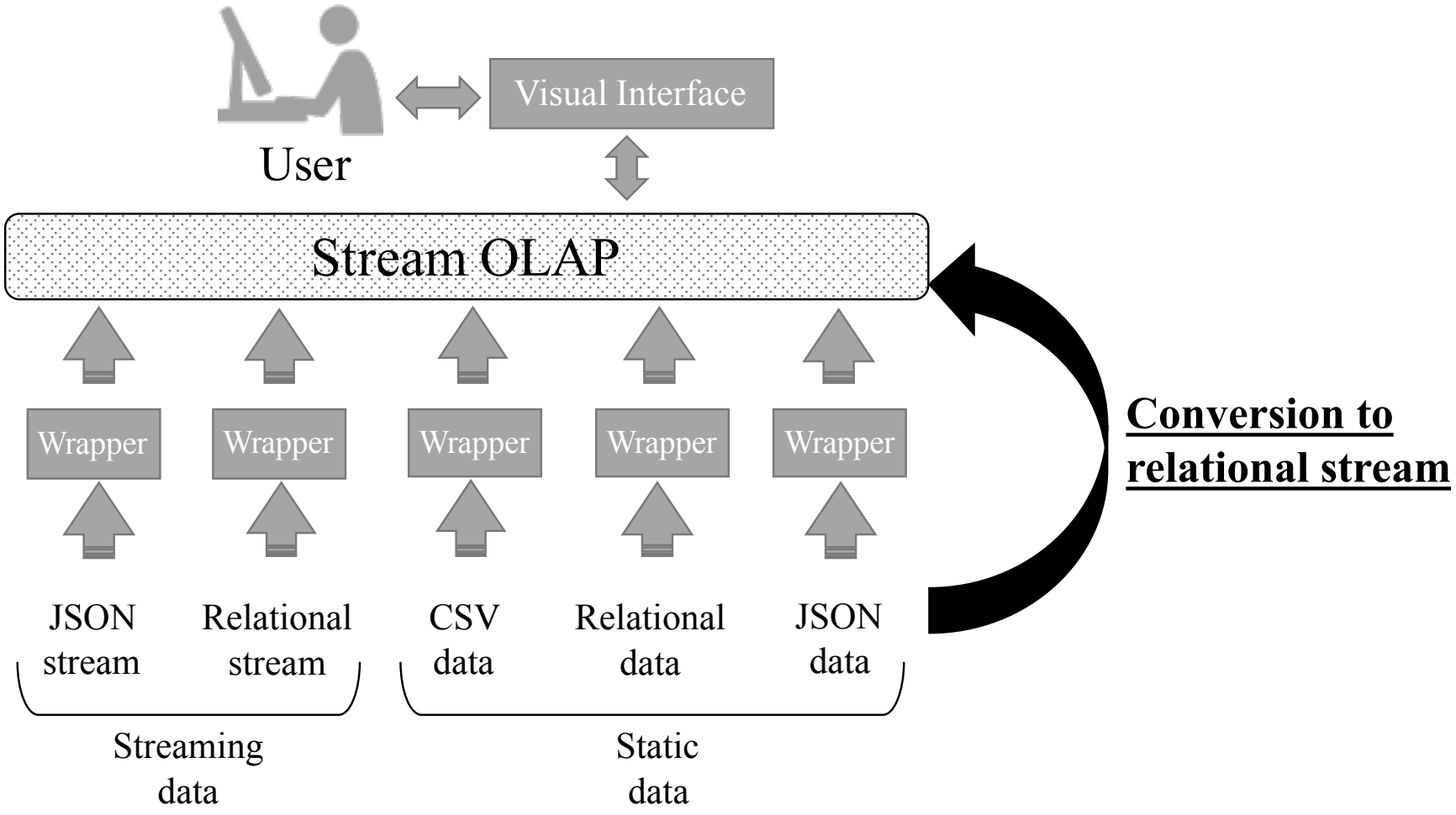


Stream OLAP[1,2]: OLAP for streaming data

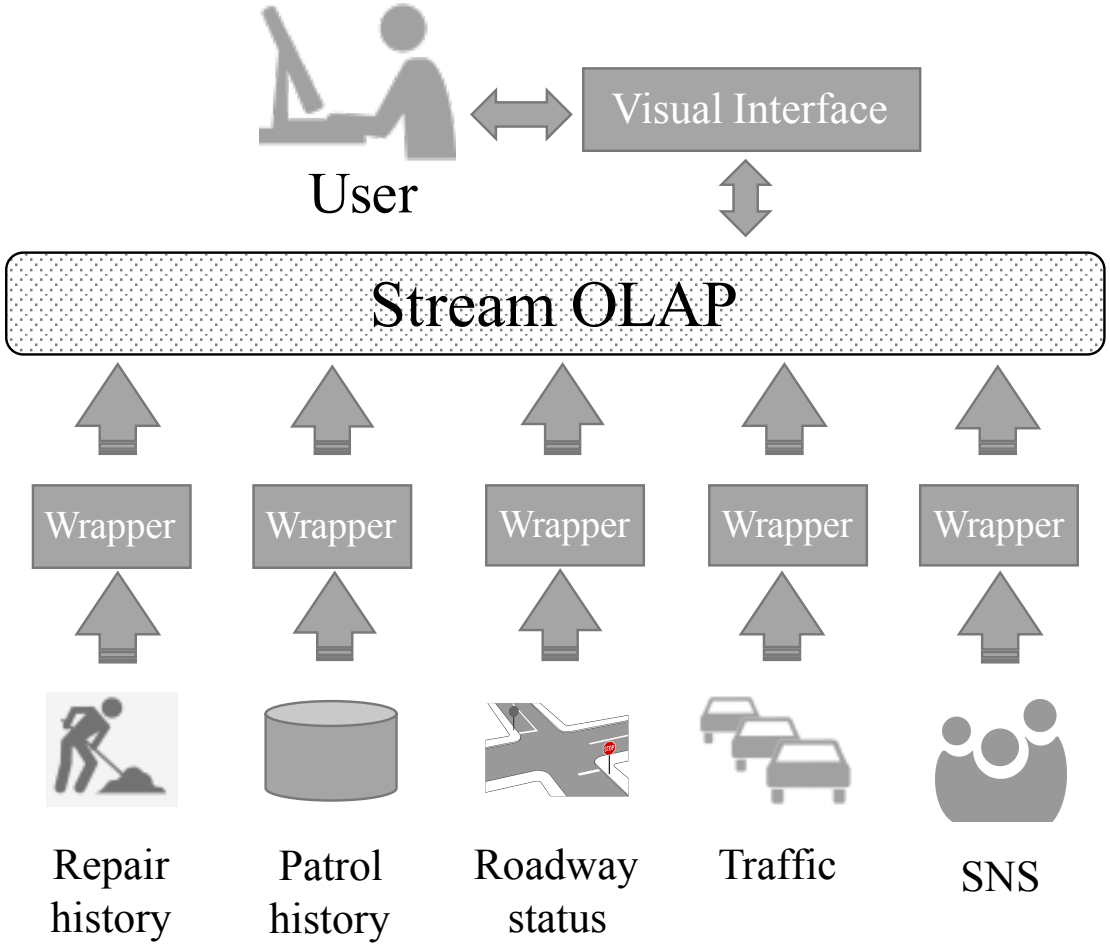
- Based on DSMS (data stream management system)
- Interval of Interest (IoI) as window for aggregation queries.
- Selective query & on-demand query for quick interaction
  - Results on some queries are materialized.
  - Others are calculated on demand.

1. J. Han, et al. Stream Cube: An Architecture for Multi-Dimensional Analysis of Data Streams. Distributed and Parallel Databases, 2005.
2. K.Nakabasami, et al. An Architecture for Stream OLAP Exploiting SPE and OLAP Engine. IEEE Big Data 2015

Stream OLAP for SOLA



SOLAR: Application of SOLA for Roadway Maintenance

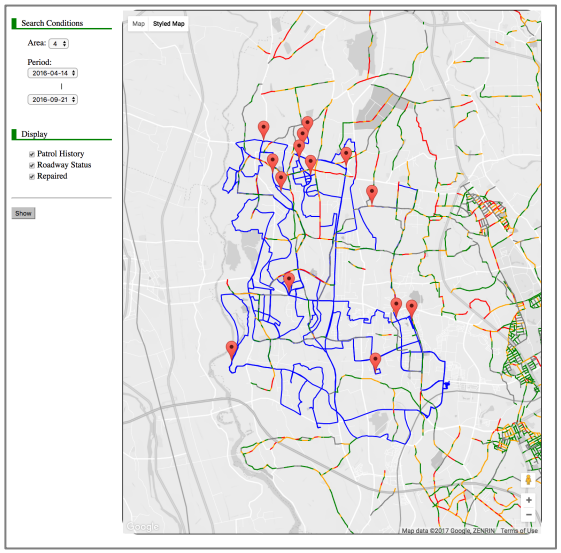


Data for SOLAR

Repair history 	Spatio-temporal points of (temporal) repairs Indicate: repairing facts and frequently repaired roadways
Patrol history 	Spatio-temporal trajectories of patrols Indicate: roadways having been patrolled
Roadway status 	Roughness (e.g., IRI, MCI) of road segments Indicate: damage degrees of road segments
Traffic 	Amount of traffics on road segments Indicate: more cars may damage road segments
SNS 	SNS posts Indicate: irregular conditions of roadways may be reported
…	…

Application-oriented Visual Interface

- Map-based visualization
  - GeoJSON style output for maps
- OLAP interaction
  - Slice, Dice, Roll-up, Drill-down



Real-world Application

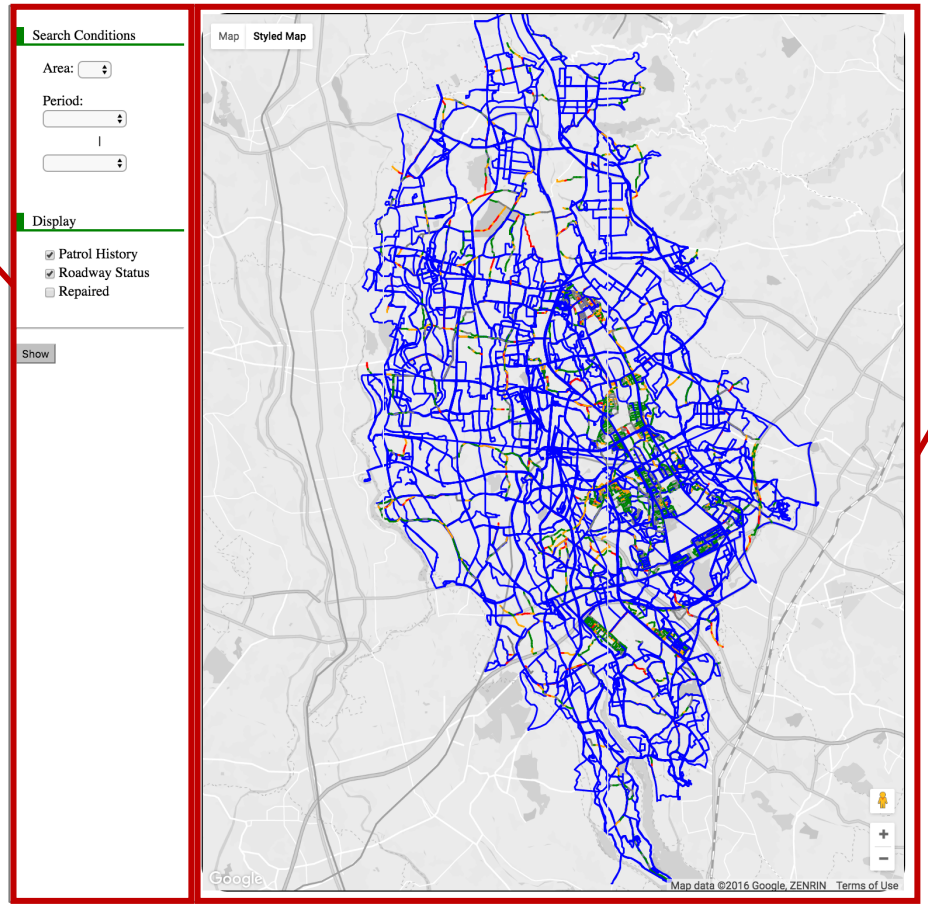
SOLAR in Tsukuba city

- Data
  - Patrol history, repair history, roadway status (MCI: Maintenance Control Index), area information (group) for patrol
- Scenarios
  1. Visualize all patrol histories to ensure coverage of roadways.
  2. For a group, check for recent patrols and repairs in order to decide where to patrol.

Developed Interface

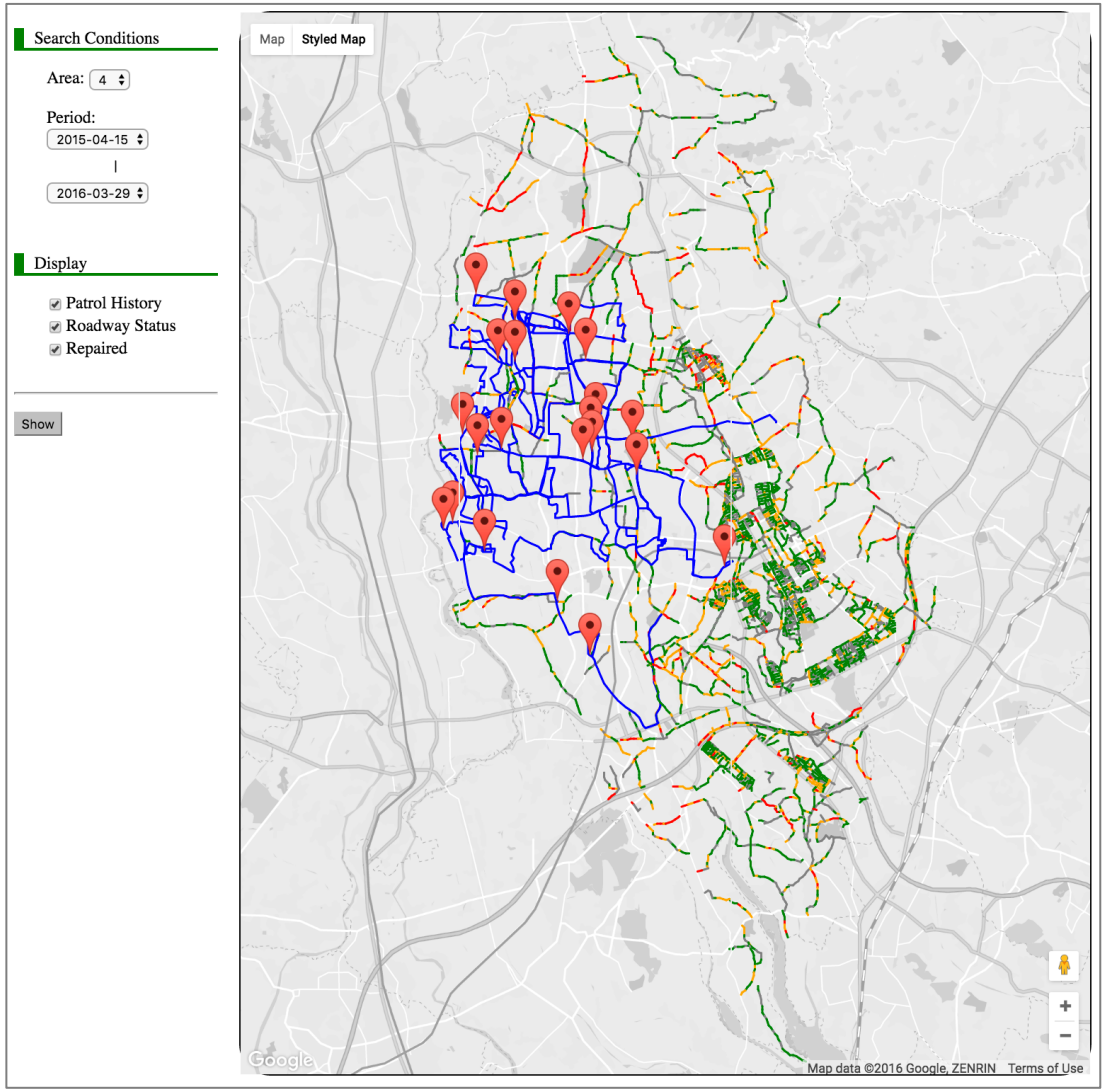
OLAP interaction (limited)

- Slice(Area)
- Dice(Duration)
- Measure selection



Map I/F

Slice(Area=4) & Dice(1 recent year)



Achievement of SOLAR

- Start monitoring patrols including patrol routes and repair history.
- Roadway status survey is fully utilized.
  - To make the survey is mandatory for local government and very costly, however, there was no use other than reporting.
  - It was very hard to utilize the survey for patrol routing due to the large volume of reports.
- “Useful visualization for deciding patrol routing” — city officers’ comment

Conclusion

- Conclusion
  - SOLA: a stream OLAP-based analytical framework
  - SOLAR: Application for roadway maintenance
  - Real-world use case of SOLAR
    - Indicate applicability of SOLA for real-world scenario.
- Future directions
  - Prioritizing roadways
  - Patrol routing recommendation
  - Planning suggestion for full repair