Cooperative Positioning in Urban Environments: Opportunities and Challenges

Never Stand Still | Faculty of Engineering | Australian Centre for Space Engineering Research (ACSER)

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DSRC Proposed for C-ITS

- Each vehicle **broadcasts its own position**.
- Similar to ADS-B or AIS
- Assumes that **sufficiently accurate position** of each vehicle is available from sources such as GPS

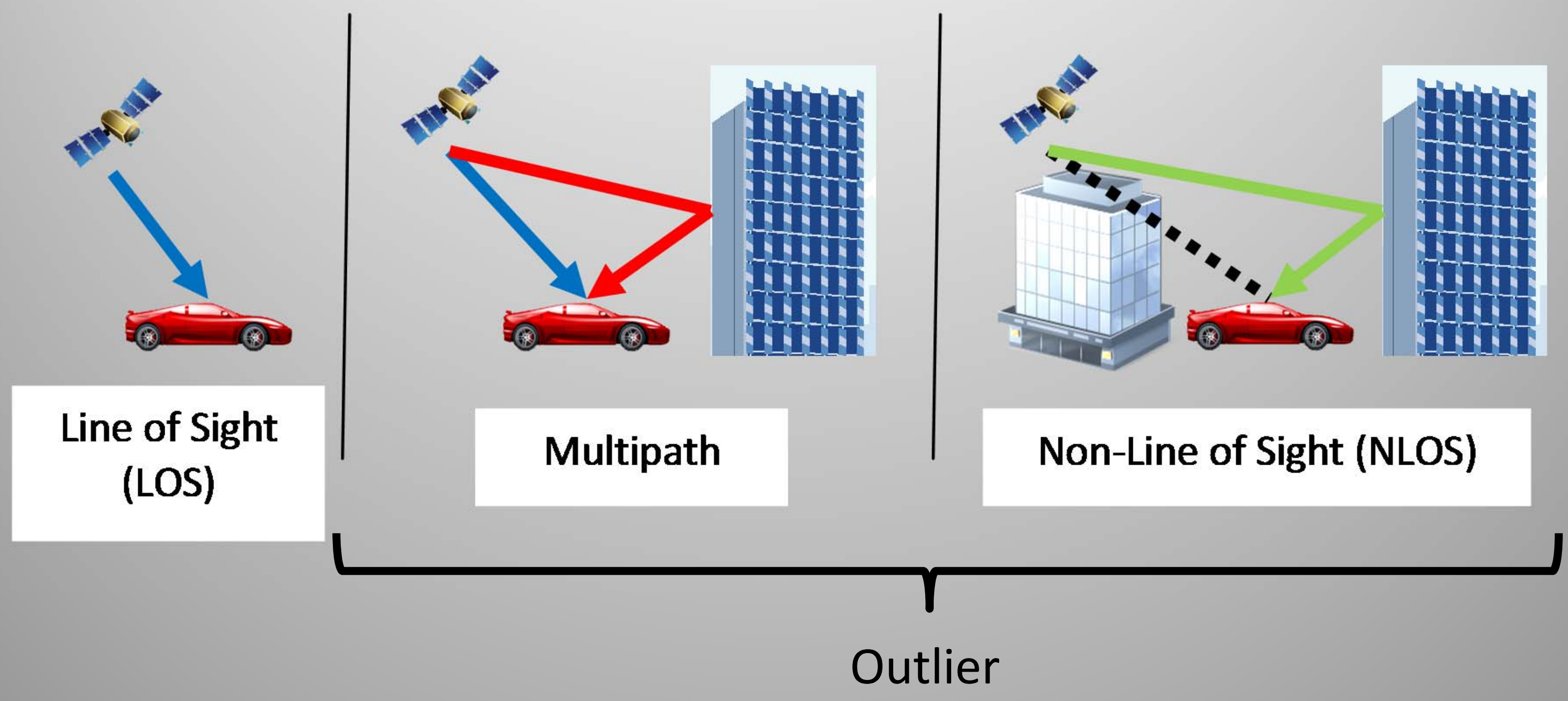
Advantages/Disadvantages of Sensor Systems

GPS/GNSS	LOS-dependant Sensors
Low Cost	**Expensive** (e.g. Radar/Laser)
All-weather	Affected by **rain** (e.g. Optical Systems)
No False Alarms	**False Alarm** (Object Identification Failure)
Able to provide **early warning**	Able to provide warning only when other vehicles are **within field of vision**
Require **all vehicles to be equipped** with GPS/GNSS equipment	**Does not require** other vehicles to be equipped with GPS/GNSS equipment
Cannot prevent collision with pedestrians	**Can** prevent collision with pedestrians

GNSS-Challenged Environments

- Coincidentally, **compact** and **tall** buildings in built-up urban cities:
  (a) Limits the **view of other vehicles** especially at intersections: LOS-based sensors unable to identify threats and
  (b) Obstructs the line-of-sight between UE and the GPS satellites: **potential multipath/NLOS** or GPS unavailable
- **High traffic density** in urban cities
  (a) Cooperative-based systems improves the overall accuracy with larger number of vehicles

Types of Outliers



Integrity for C-ITS

- Aviation industry has a well defined integrity limits – how about C-ITS?
- Position and Velocity integrity
- Receiver Autonomous Integrity Monitoring (RAIM) is a single receiver outlier detection method which serves to indicate the integrity of the position and velocity solution.
- Proposal: perform outlier detection (RAIM) on the network of nodes at measurement level or position level. Hereby dubbed C-RAIM
- results in a very different architecture from single receiver integrity

Node Architecture

Applications	Collision Avoidance	Lane Navigation		
Solution	Position	Velocity	Integrity	Proximity
Sensor/ MEasurement	GPS	V2V Ranging	Inertial	Radar

Approaches to Cooperative RAIM

- GPS position + V2V position
- GPS Pseudorange + V2V range
- GPS Pseudorange + V2V range + INS

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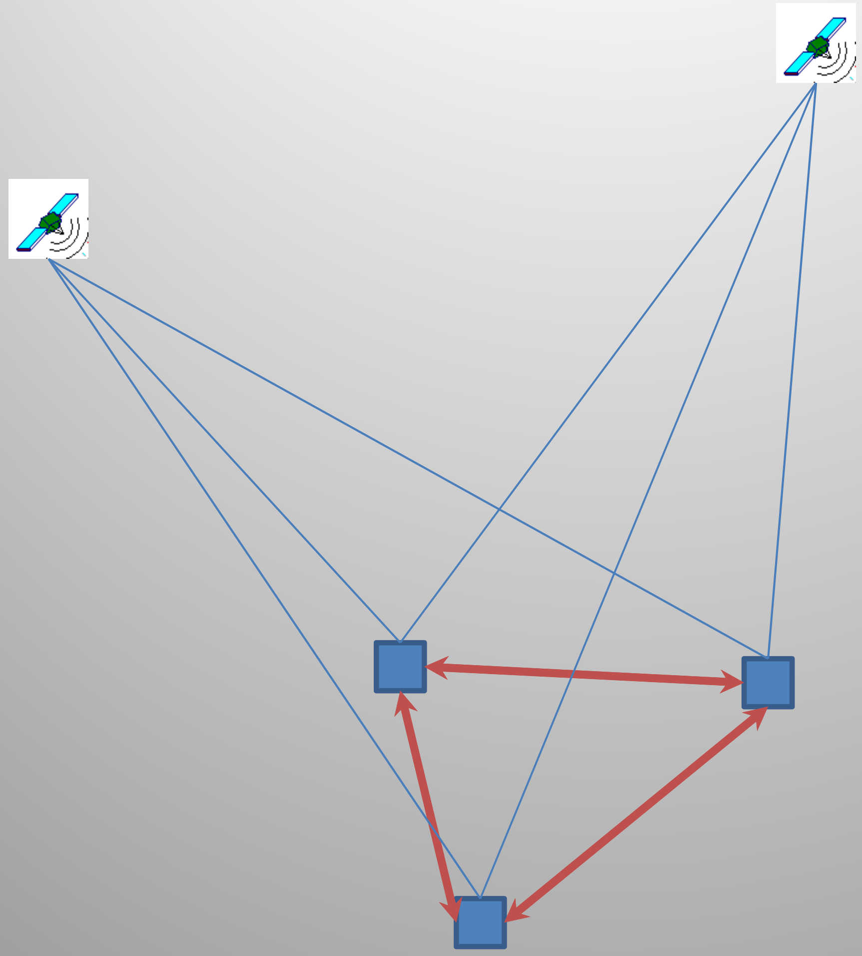
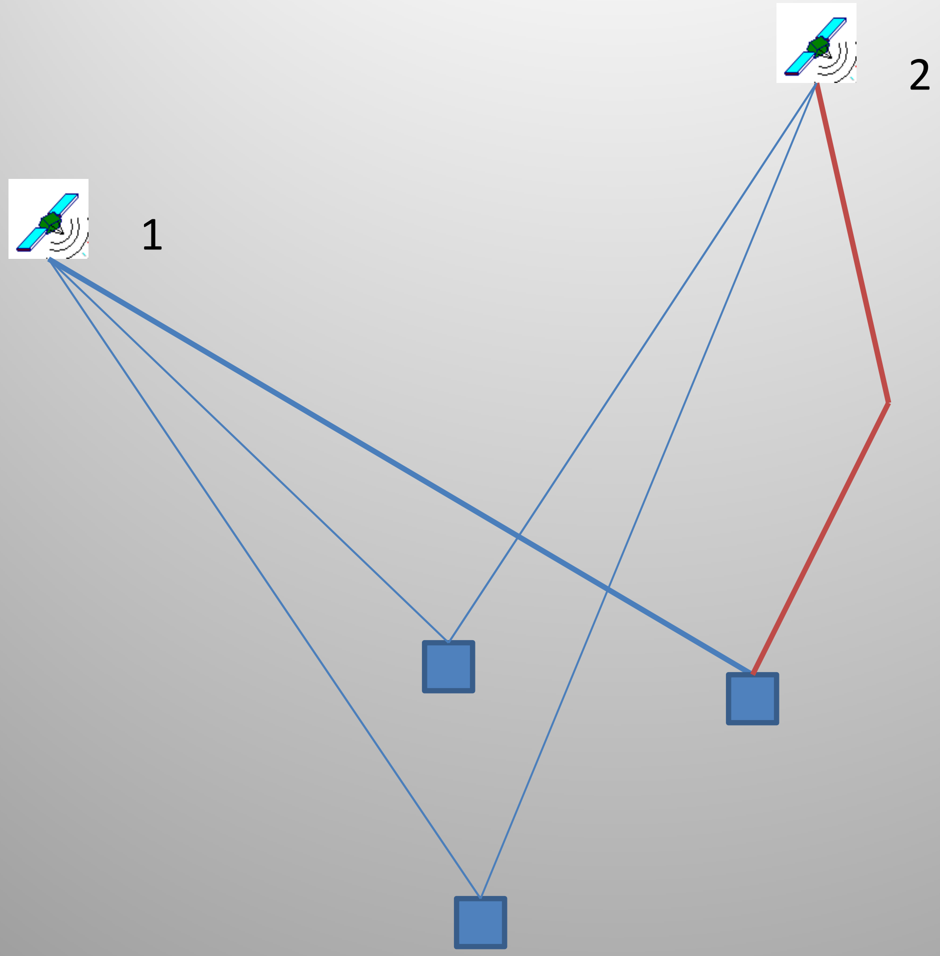
SNAP Lab

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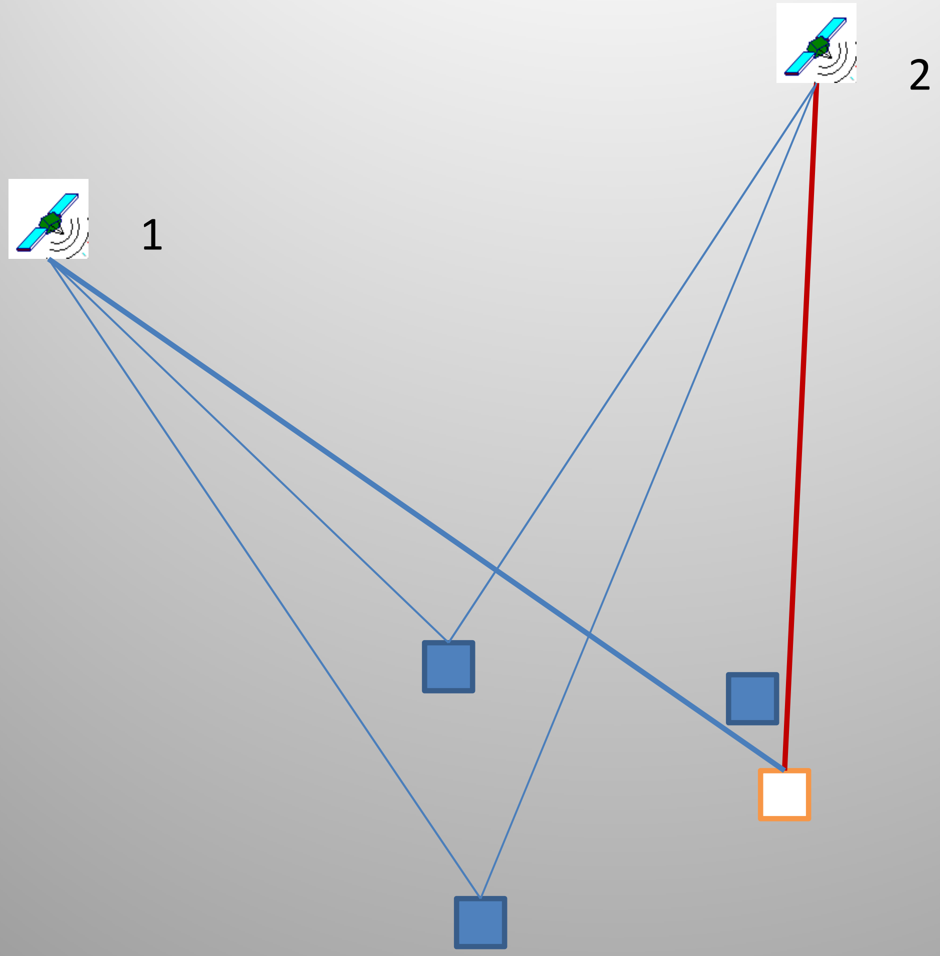
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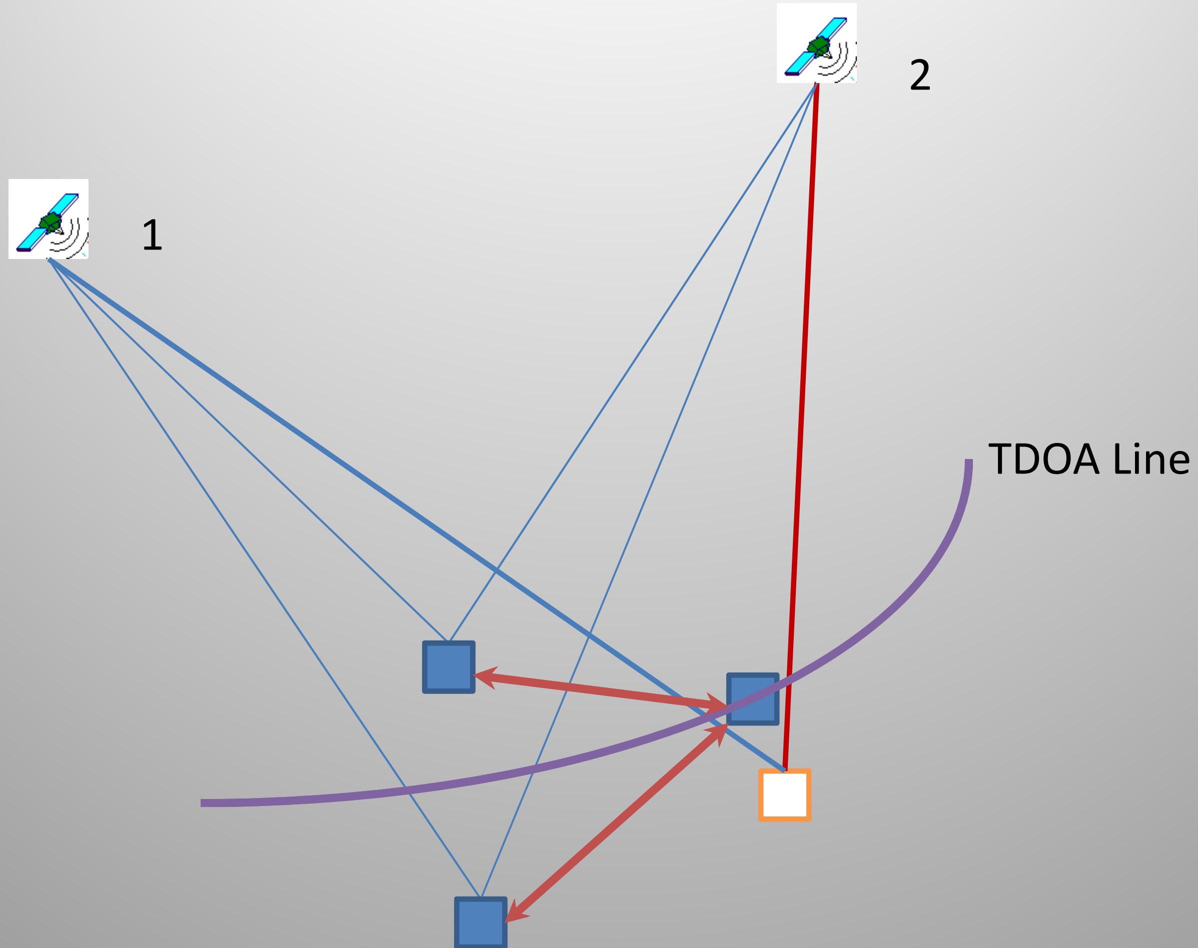
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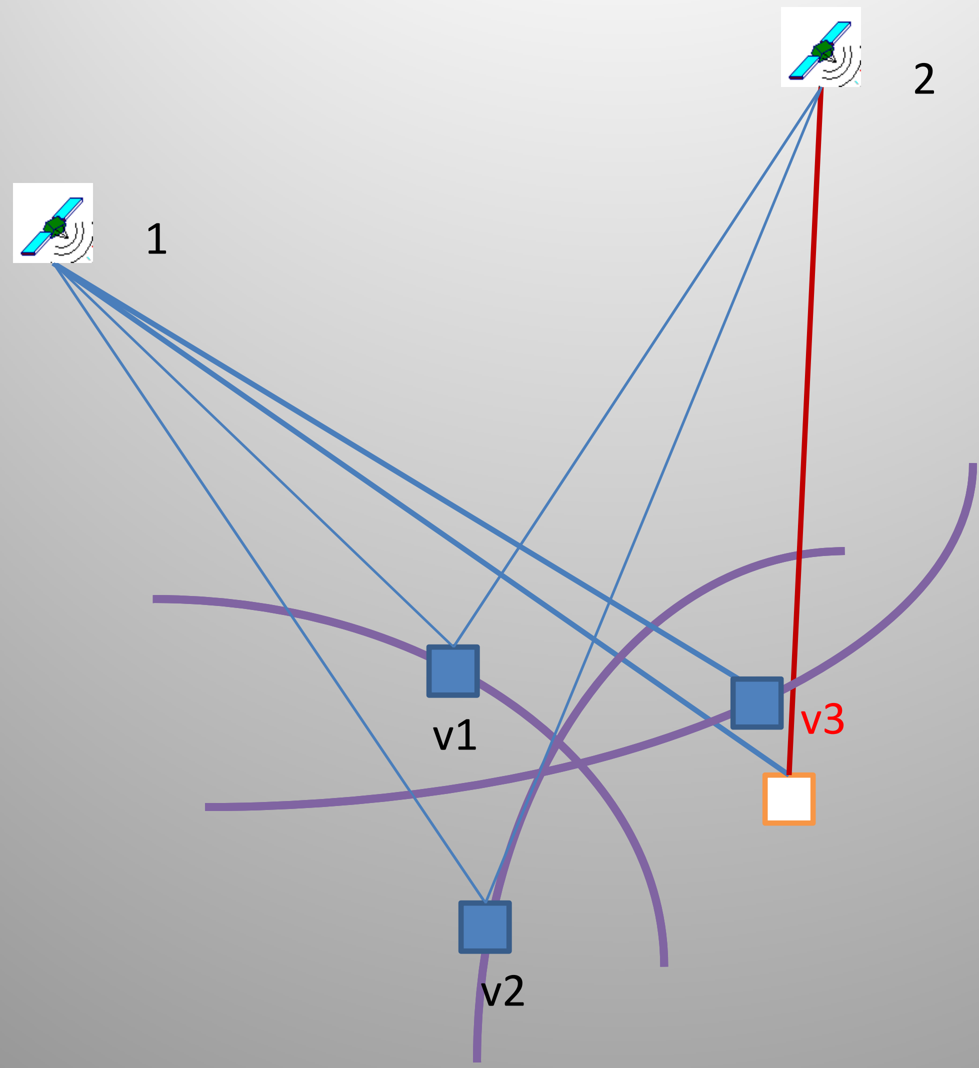
TDOA Line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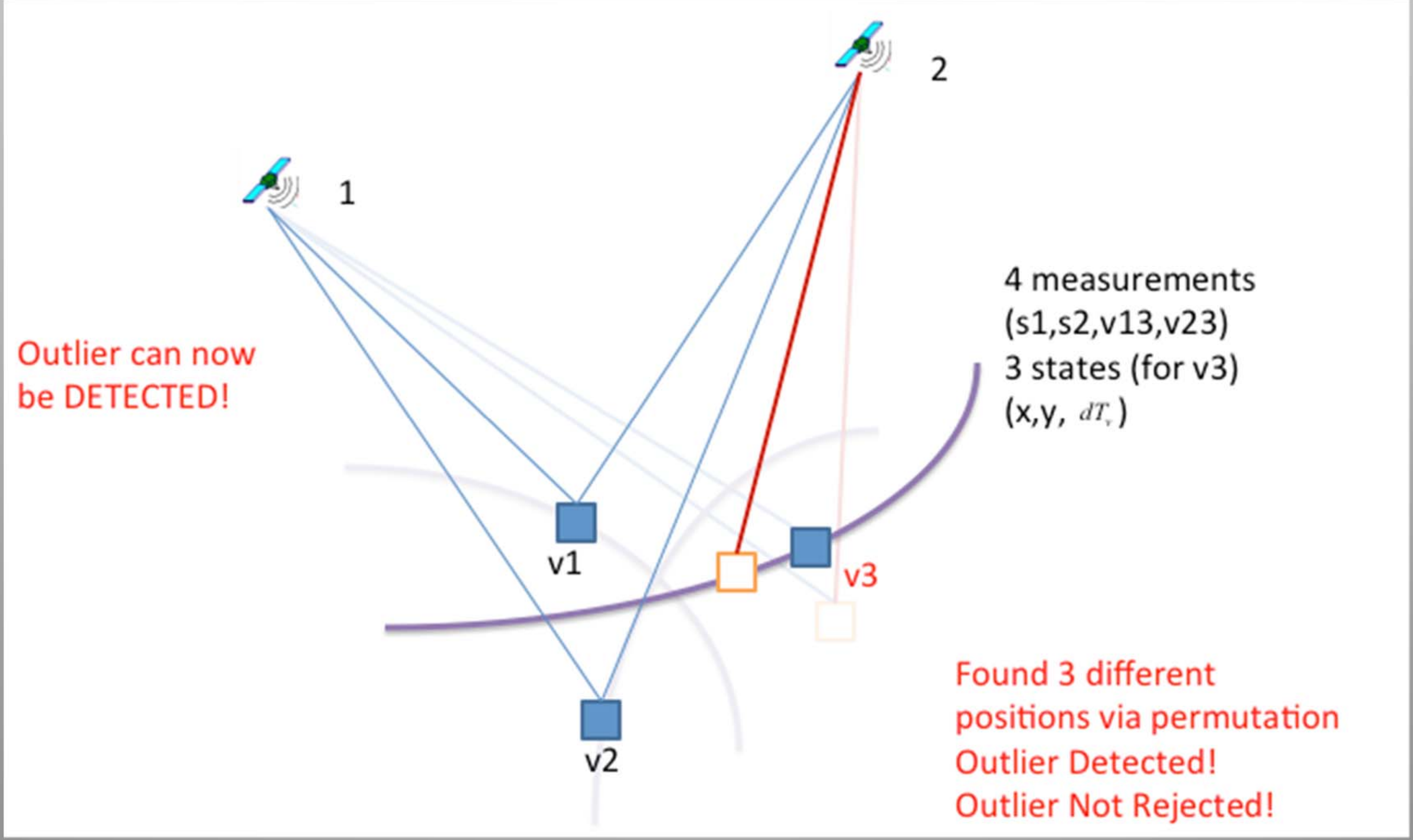
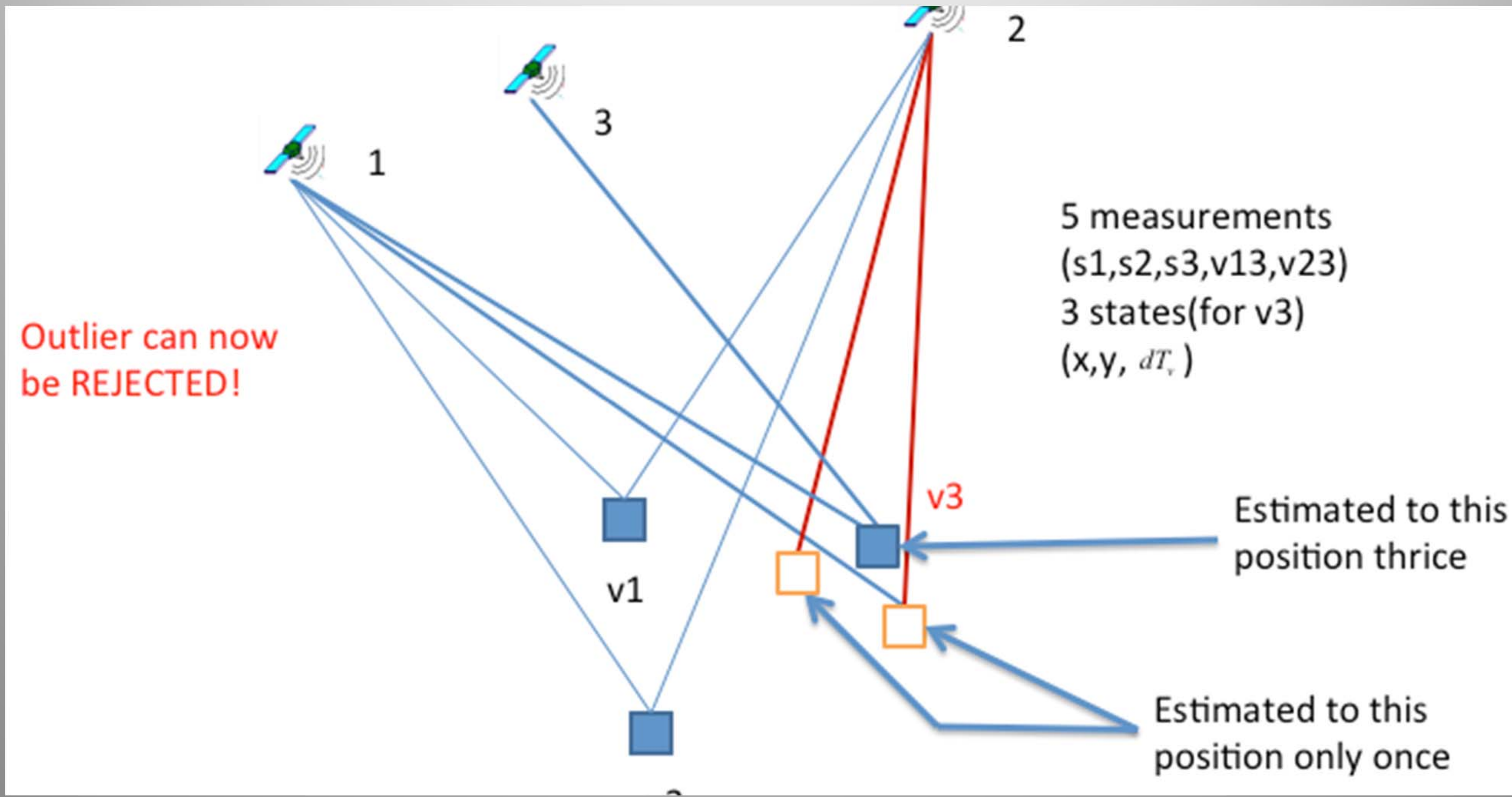
v1
v3
v2

Cooperative RAIM: Outlier Detection



Cooperative RAIM: Outlier Exclusion



Cooperative RAIM: Outlier Exclusion

- Cooperative RAIM – enhance positioning accuracy
- Existing GNSS/V2V integration literatures has only considered its improvement in accuracy but has not exploited outlier exclusion methods to reject multipath and NLOS affected measurements.
- Robust regression and outlier exclusion algorithms can be employed to suppress positioning errors due to multipath and NLOS by accounting for measurement redundancies in an integrated GNSS, V2V and MEMS inertial sensor system.
- Cooperative real-time autonomous integrity monitoring (C-RAIM) method conceptually analogous to Triple Module Redundancy (TMR)

Interference on ITS sensors

- Interference to vehicle sensors such as LIDAR has recently been reported.
- Such vulnerability represents a significant threat to CITS. Interference can take the form of naturally occurring interference, jamming, or spoofing.
- For each of the sensors proposed for CITS, we can examine its sensitivity to interference, its effects, and methods of mitigation.
- Redundancy of sensor measurements will be critical.

V2V/GPS Doppler and Inertial Sensor

- Improve velocity accuracy by accounting for V2V/GPS Doppler measurements and MEMS inertial sensors.
- This has not been previously explored before in a cooperative context.
- advanced V2V ranging and doppler can also be considered especially in urban environments.

Feasibility and Deployment Enhancement

- How it can utilise V2V communication bandwidth more efficiently so that the solution is ad-hoc and easily scalable?
- How to cluster nodes and isolate networks without compromising positioning performance?
- Applying distributed computing strategies such as the *majorizing function approach*.

Advanced Vehicular Safety Applications

- For example, accelerometers that detect sudden braking of the vehicle can provide useful information for the *collision warning system* of vehicles following behind it.

Summary

- Existing studies has not thoroughly covered the topic area of integrity in a cooperative context.
- Scopes of future research in C-ITS include:
  – Cooperative RAIM for integrity and enhanced positioning accuracy
  – Clustering nodes without compromising accuracy
  – Distributed computing techniques for C-RAIM

Questions?

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