A SITUATIONAL AWARENESS APPROACH TO INTELLIGENT VEHICLE AGENTS

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MOTIVATION

- How can future technology be integrated with existing users?
- Future (autonomous) vehicles on public roads provides a challenging context
- What assistance can institutions offer?
  - Law vs Highway Code vs Human reasoning
  - Guiding behaviour – Local vs Global trade off

BACKGROUND

- Situational Awareness
  - Perception, Comprehension, Projection
  - What needs to be communicated and at what frequency?
- Distributed Simulation
  - Jason BDI (Beliefs, Desires, Intentions) Agents
  - RDF based information exchange
  - SUMO simulator providing traffic representation
    - Need for variable autonomy (background traffic vs agent vehicles)
    - Need for ‘bad’ behaviour – crashes, congestions waves

INSTITUTIONAL FRAMEWORKS

- Institutional Action Language (InstAL) describes:
  - Regulative (event-based) norms; two aspects:
    - Recognising world events as having institutional significance – known as "count-as"

      ```
      external_event(...) generates institutional_event(...) if
      condition
      ```

    - Establishing the consequences of the institutional_event

      ```
      institutional_event(...) initiates institutional_facts if
      condition

      institutional_event(...) terminates institutional_facts if
      condition
      true until terminated
      ```

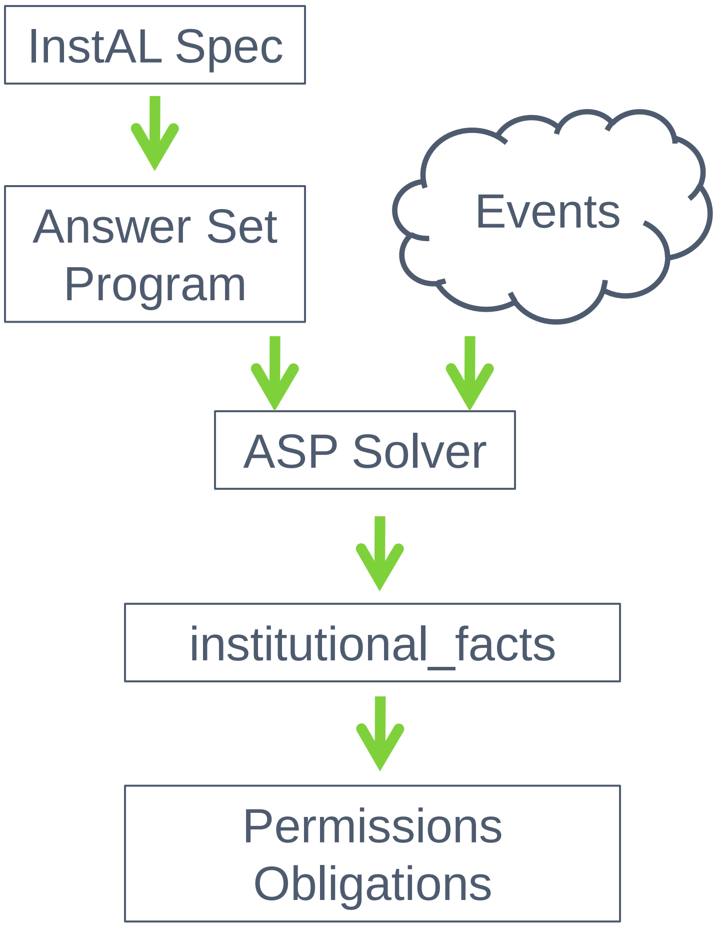
  - Constitutive (state-based) norms; recognises conditions over institutional_facts:

    ```
    institutional_fact when if1, not if2
    true while condition holds
    ```

Further reading: North (economics), Ostrom (social sciences)

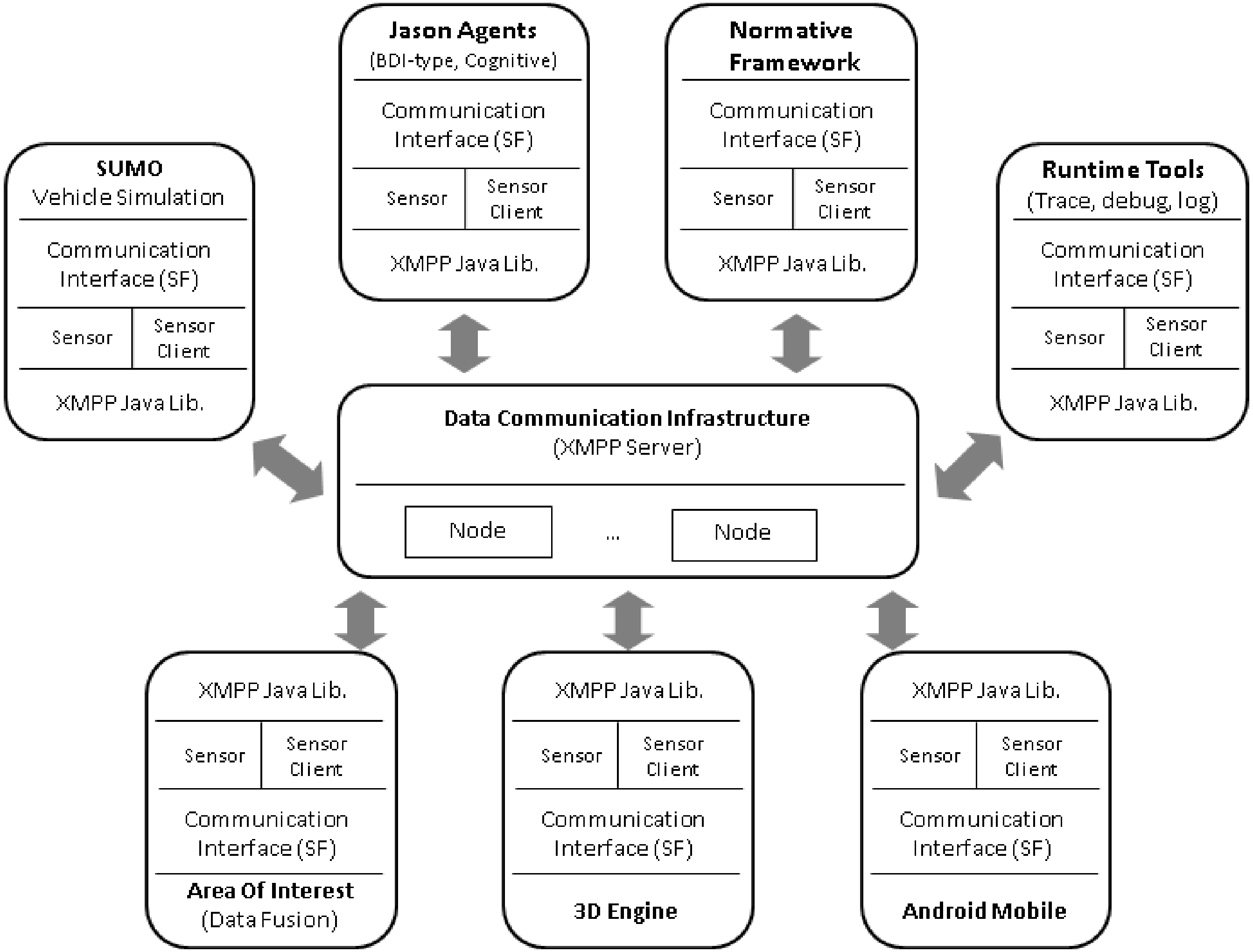
INSTITUTIONAL FRAMEWORKS - IMPLEMENTATION

- Functions as a high-level sensor:
  - Actions are observed and may be recognised
  - Facts are initiated/terminated
  - Permissions are created/revoked
  - Obligations are issued
  - Actors **choose** whether to meet obligation



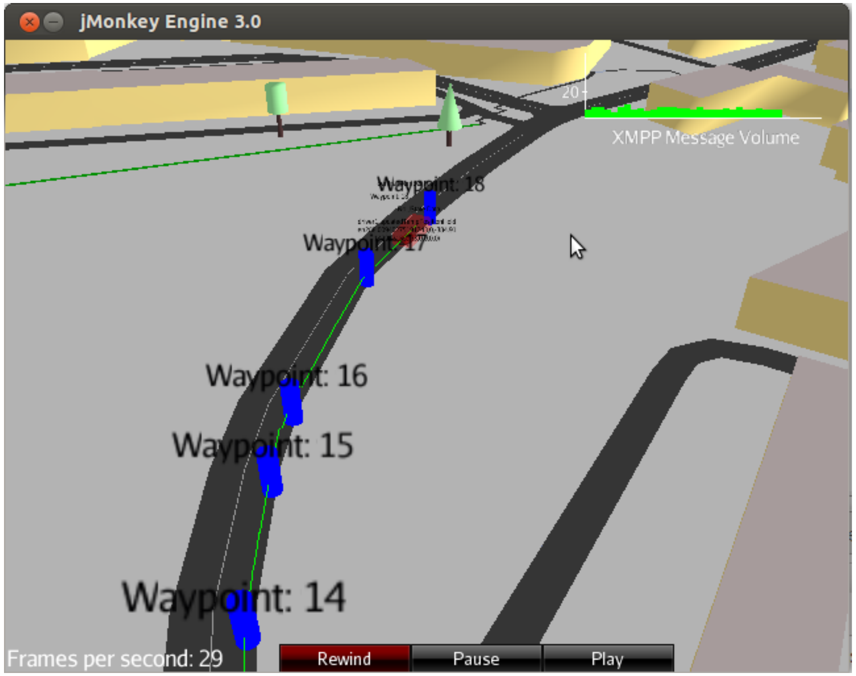
In general, actor should/ought meet the obligation by some deadline or suffer some sanction

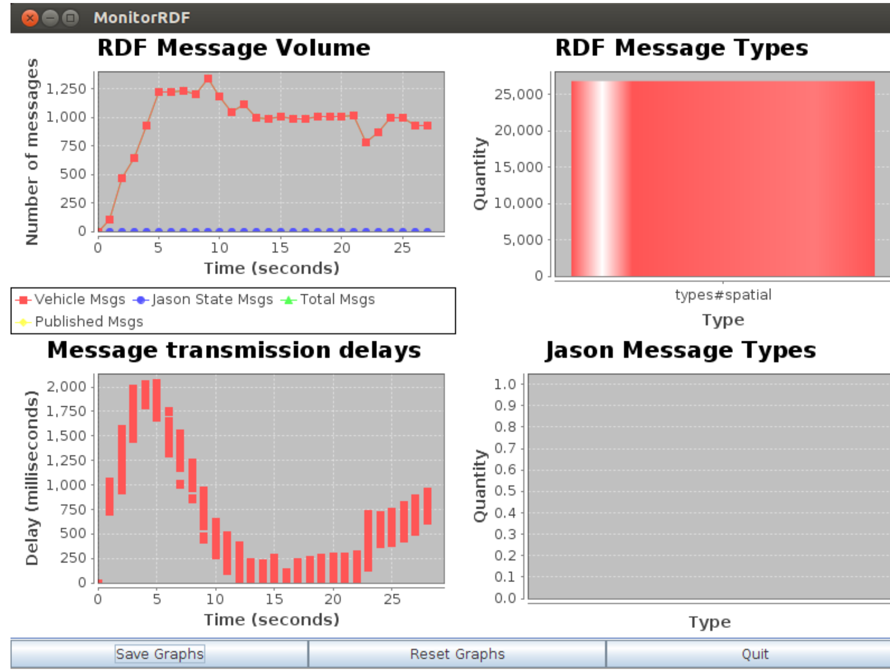
ARCHITECTURE – BATH SENSOR FRAMEWORK



Open exchange of semantically annotated data – subscribers able to 'do what they want' with data

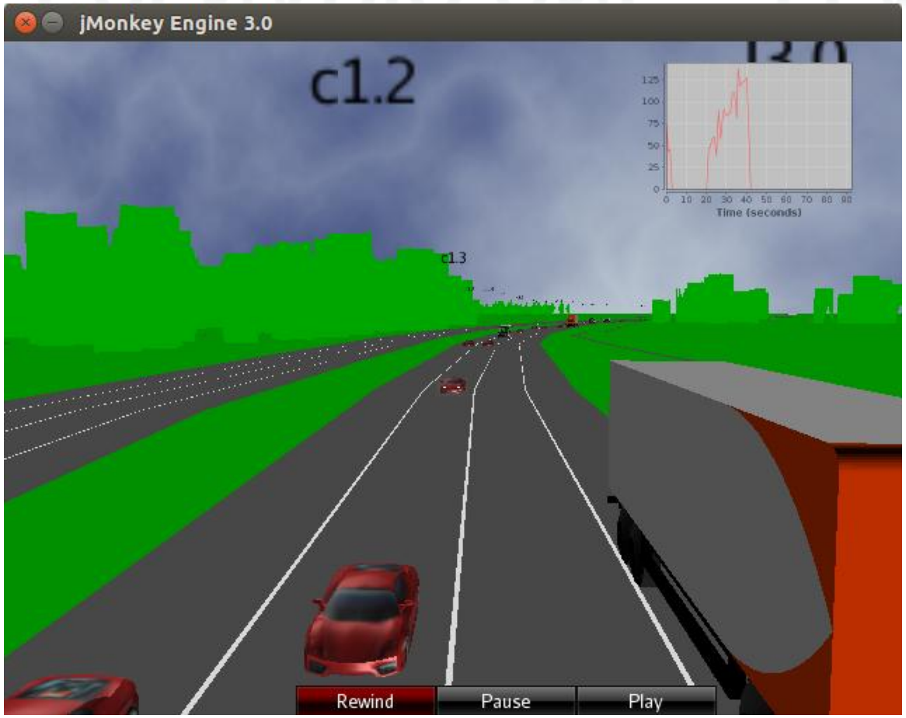
KEY COMPONENTS – DEBUGGING





- 3D Engine – Ability to overlay multiple data sources:
  - Agent beliefs (e.g. position of waypoints as added)
  - Vehicle Sim states (brake lights, front lights)
  - Other modules (area of influence zones)
- Information exchanged via RDF, so can analyse in realtime:
  - Network / XMPP performance
  - Vehicle metrics – e.g. fuel consumption, congestion

SCENARIO ONE – FLASH LIGHTS



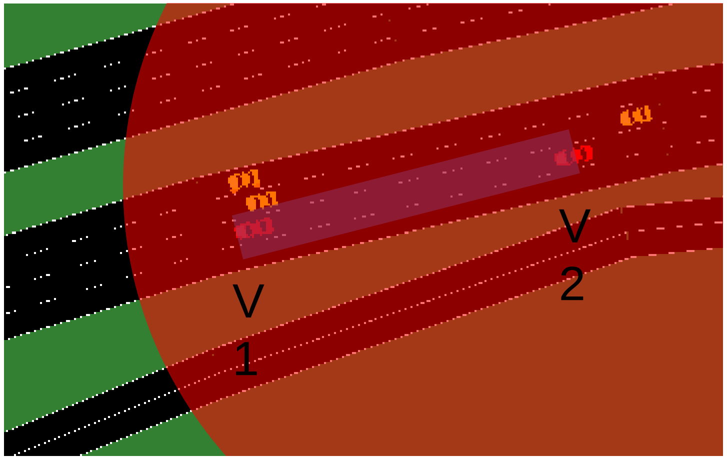
Aim: Provide late-binding mechanism to resolve (culturally/geographically) ambiguous situations via issuance of norms

Background: No UK Law governs use of front lights

Highway Code: *“Only flash your headlights to let other road users know that you are there. Do not flash your headlights to convey any other message or intimidate other road users”*

SCENARIO ONE – EVENTS AND VIDEO

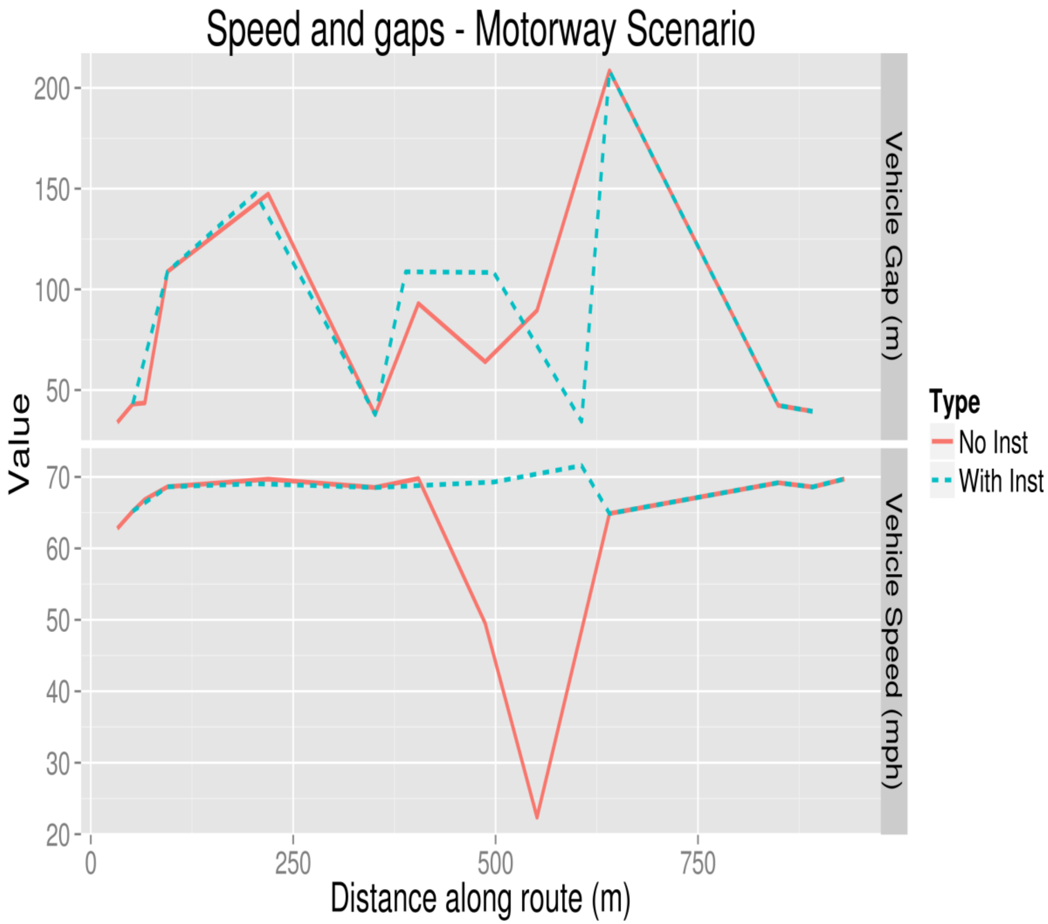
1. Jason agents insert vehicles into SUMO, shown in SUMO GUI in red
2. AOI module subscribed to Jason vehicle creations, and creates volume of interest (dynamic size)
3. Agents receive position and speed from SUMO, calculate collision volume
4. Agents informed of vehicles within AOI volume
5. On receipt of AOI detected vehicle, agent checks detected vehicle in collision volume, flashes lights if detected ahead
6. If institution running, it will send obligation to vehicle ahead to change lane



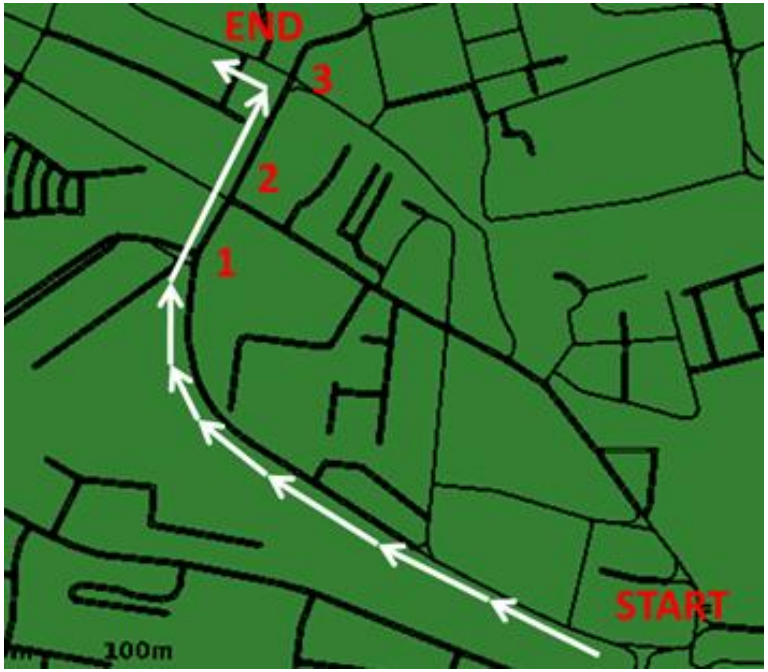
N.B. Zones shown only for V2

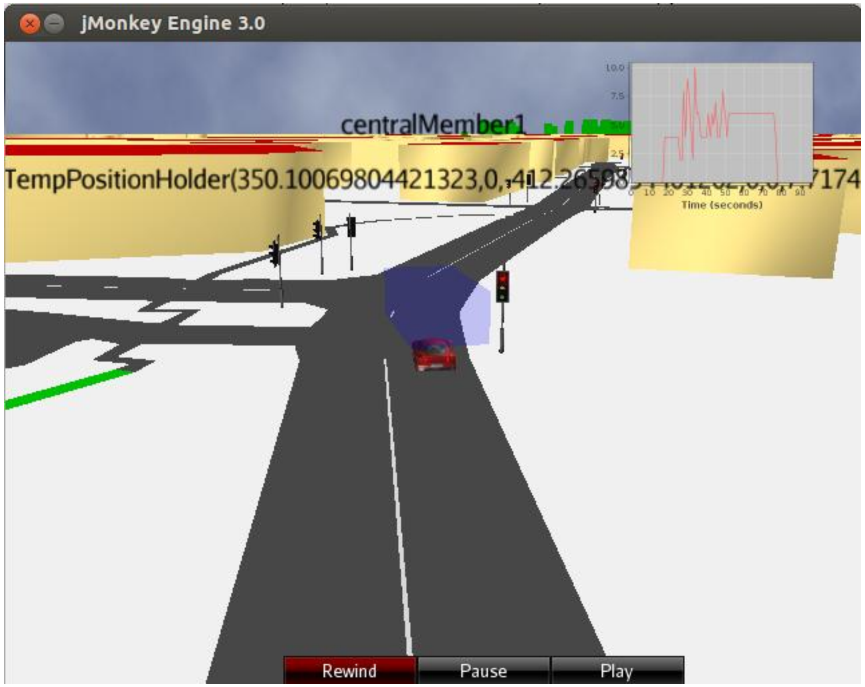
SCENARIO ONE - RESULTS

- Met expectations
  - Clear difference in speed profiles
  - Difference emerges in gaps
- Establishes metrics for future scenarios



SCENARIO TWO – LIGHT MANAGEMENT





Aim: Provide guidance to vehicles to manage their speed based on state of upcoming traffic lights

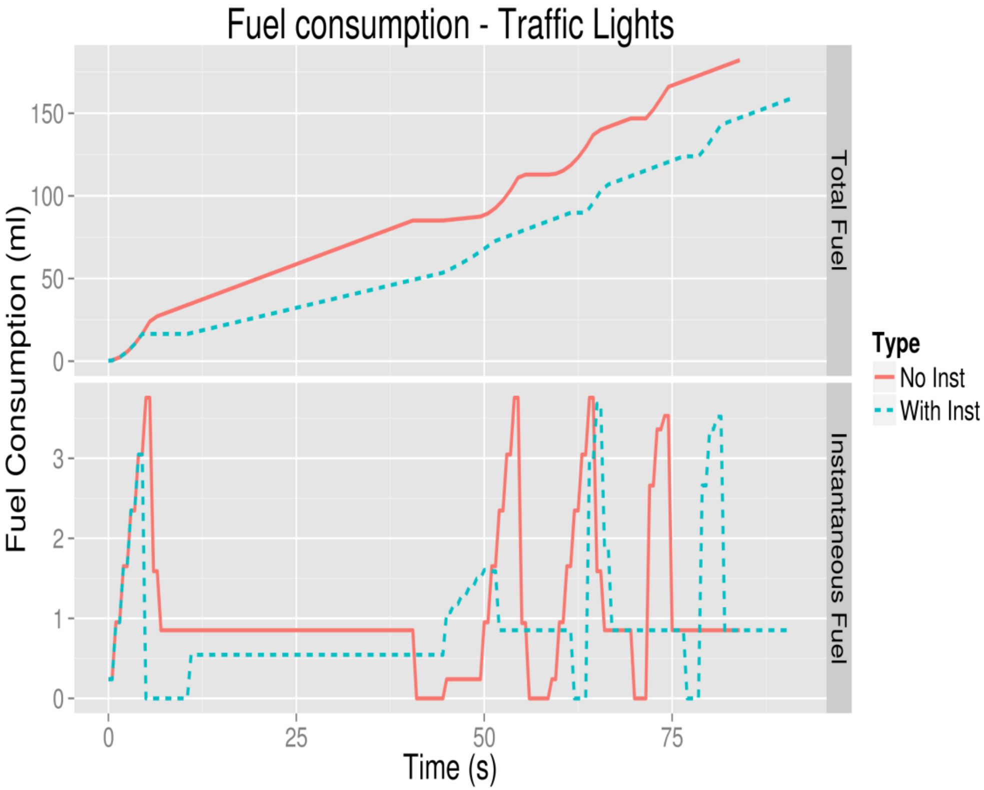
Background: Various approaches looking at interaction between traffic lights and vehicles, here norms are explored with influence from ‘projection’ element of situational awareness

SCENARIO TWO – EVENTS & VIDEO

1. Jason agents insert vehicles into SUMO, shown in SUMO GUI in red
2. AOI module subscribed to Jason vehicle creations, and creates volume of interest
3. AOI module queries SUMO for all traffic lights along Jason vehicle route
4. AOI module receives position updates, and if an upcoming traffic light is detected, action is taken to ensure arrival on green (currently, distance between 100m to 300m and light on red)
5. This action is the institution issuing an obligation to the Jason agent to slow down for 35 seconds

SCENARIO TWO RESULTS

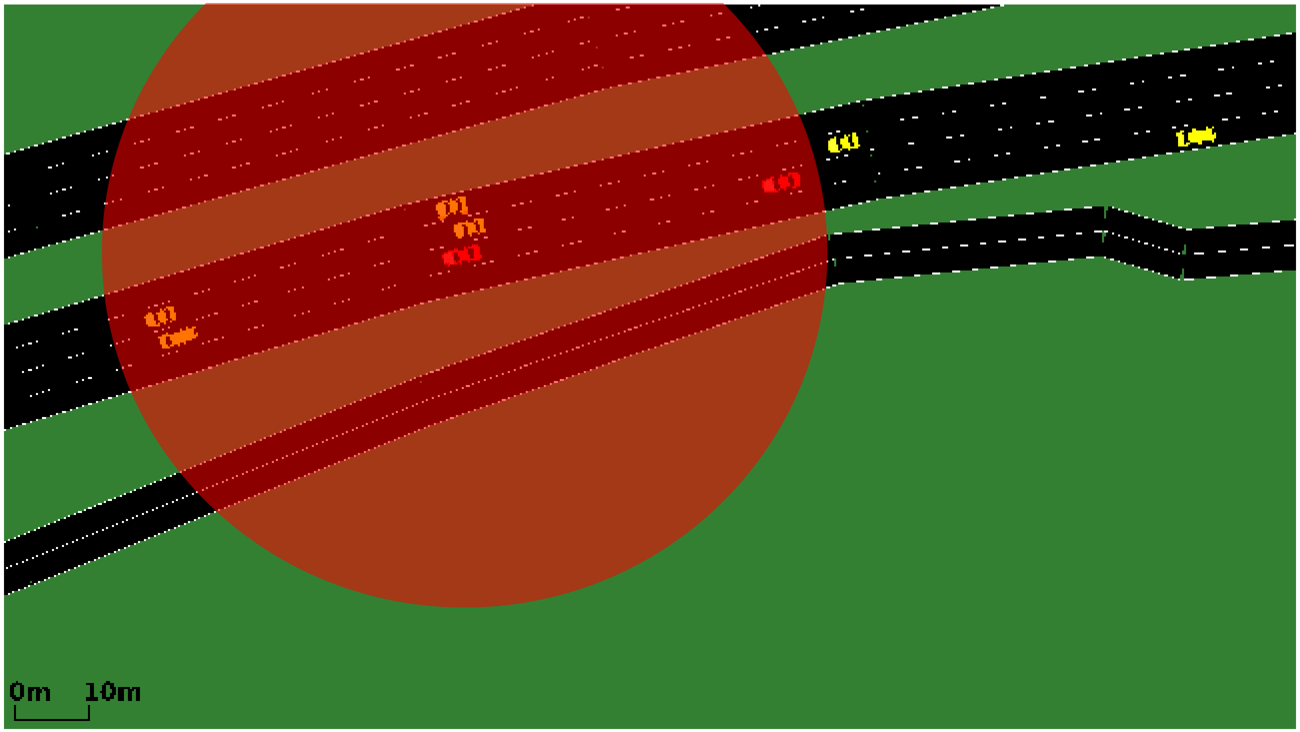
- Differing fuel consumption profiles
  - Cost of acceleration
  - Benefit in lower speed
- Similar journey time
- Establishes additional metrics



CONCLUSIONS

- Coordination tackled through distributed Multi Agent System combined with normative framework
- Mix of institution focus
  - Vehicle-centric – resolve ambiguity
  - Traffic light centric – regulate traffic flow
  - Society-centric – reduce emissions
- Application to larger scenarios
  - Scalability – volumes
  - Richer SUMO scenarios
  - Increasing maturity of framework
  - Pub/Sub approach to swap components or add new

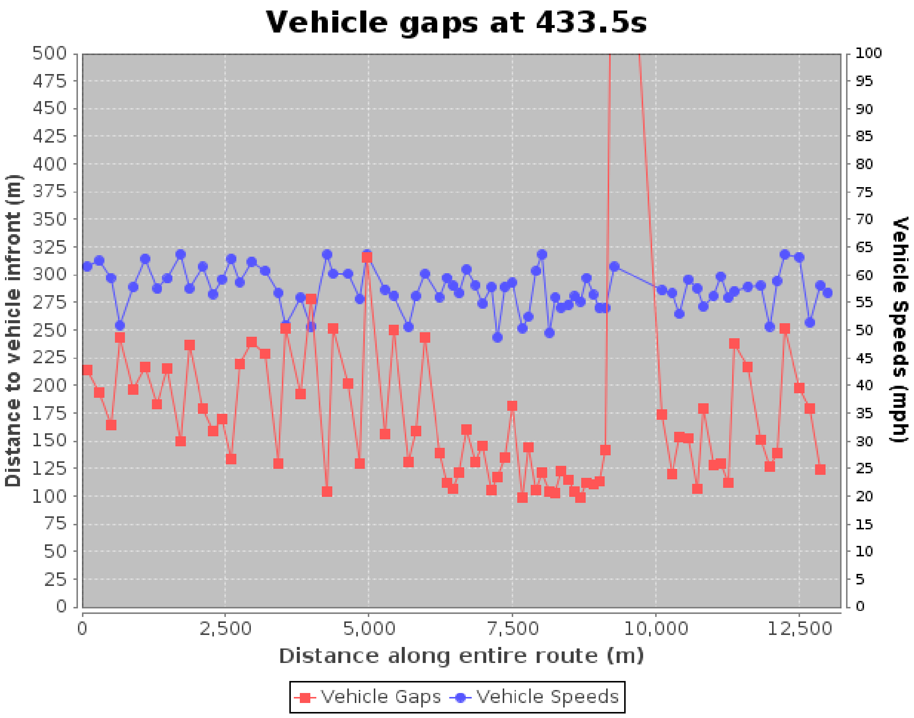
FUTURE WORK – VSL SCENARIO



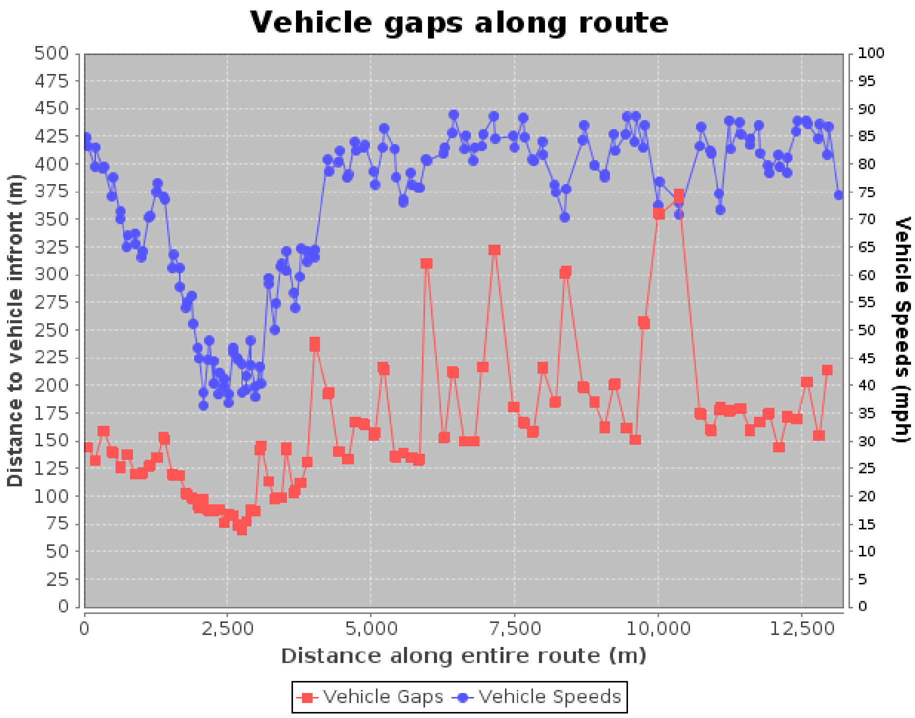
- On slowdown trigger, AOI established
- Institution established to reduce speed(s) at local level, instead of global VSL

FUTURE WORK – VSL SCENARIO

Standard Scenario

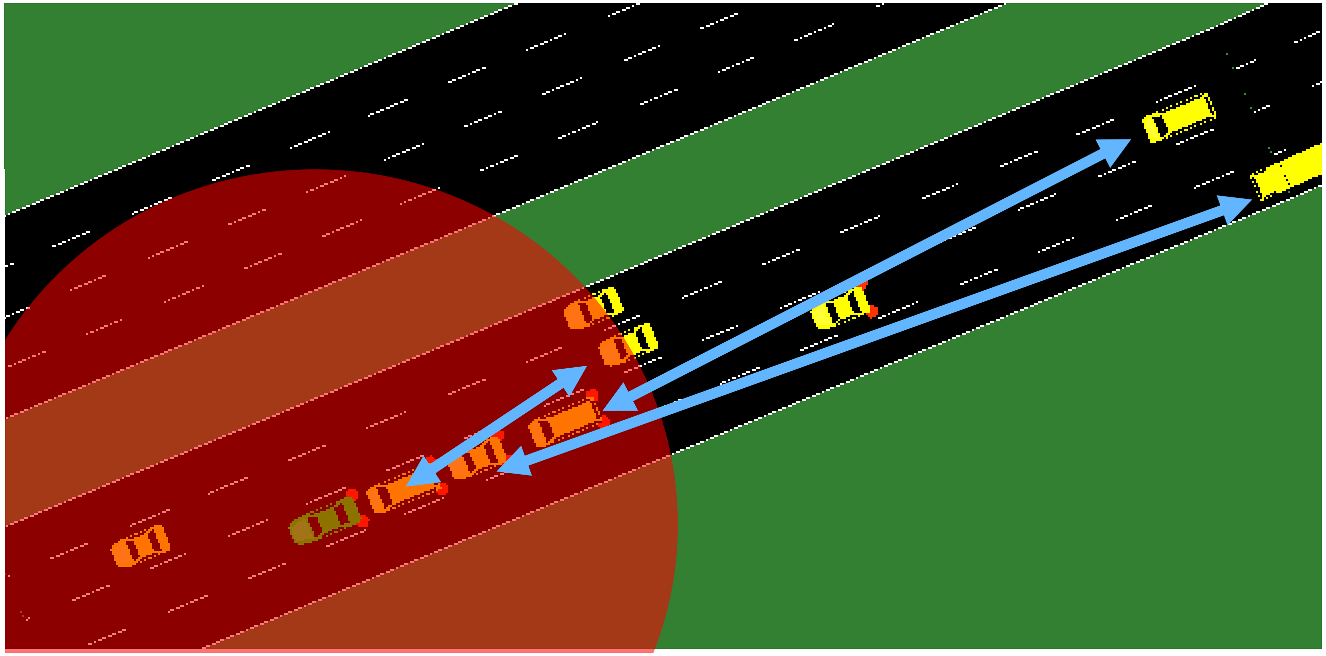


Congested Scenario



Can local institution approach improve congestion seen at 2500m mark?

FUTURE WORK – ACCIDENT SCENARIO



- Crashed vehicle establishes AOI
- Multiple institutions established for coordination

QUESTIONS / DISCUSSION

Project available at: https://code.google.com/p/bsf
Questions at: v.f.baines {at} bath.ac.uk