Distributed Road Traffic Speed Monitoring

An EE4-T Final Year Project

Jeremy Chan

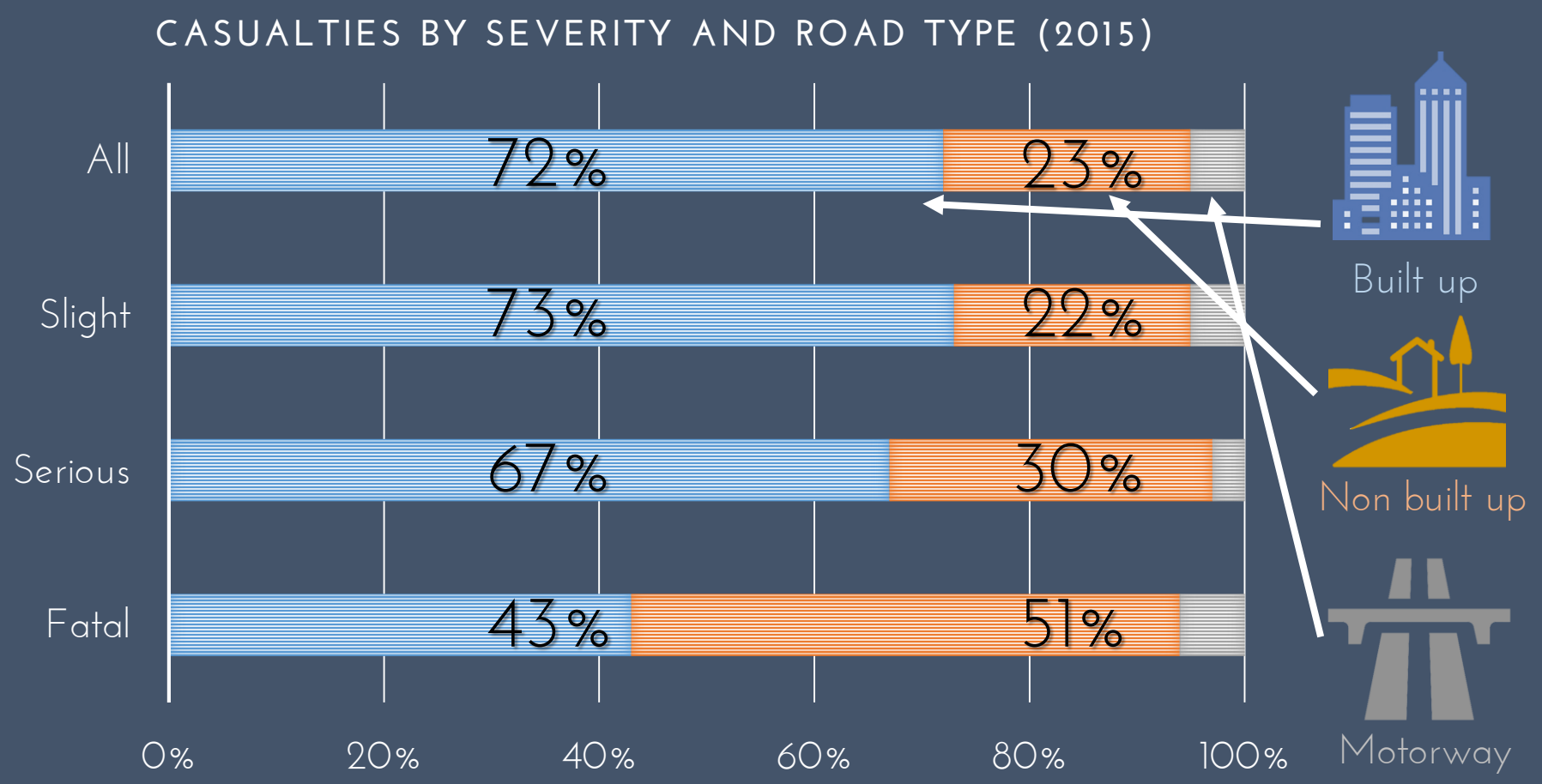
w/ Dr. Ed Stott

w/ Dr. Christos Papavassiliou

At a glance...

- Implementation based project
- Catch speeding motorists using a camera and Raspberry Pi
- Existing license plate recognition (LPR) technologies
- New peer to peer network (P2P)
- No government controlled central server, but social posting
- Motivation / Specification / High Level Design / Implementation and Testing / Demo / Evaluation and Conclusion

Motivation - Accident areas



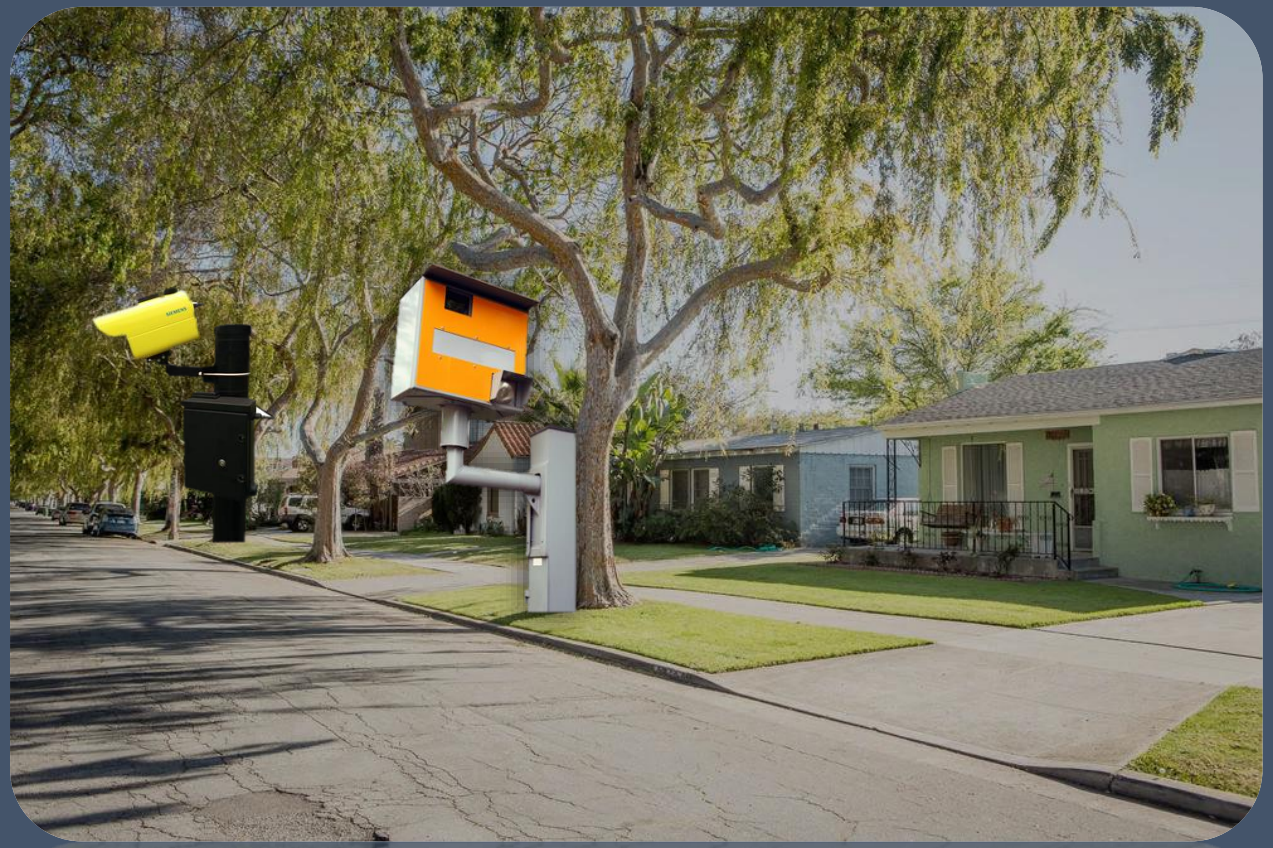
- 95% of accidents not on motorway
- Target residential areas

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/533293/rrcgb-main-results-2015.pdf

Motivation - Fixed point speed cameras

Motivation - Fixed point speed cameras

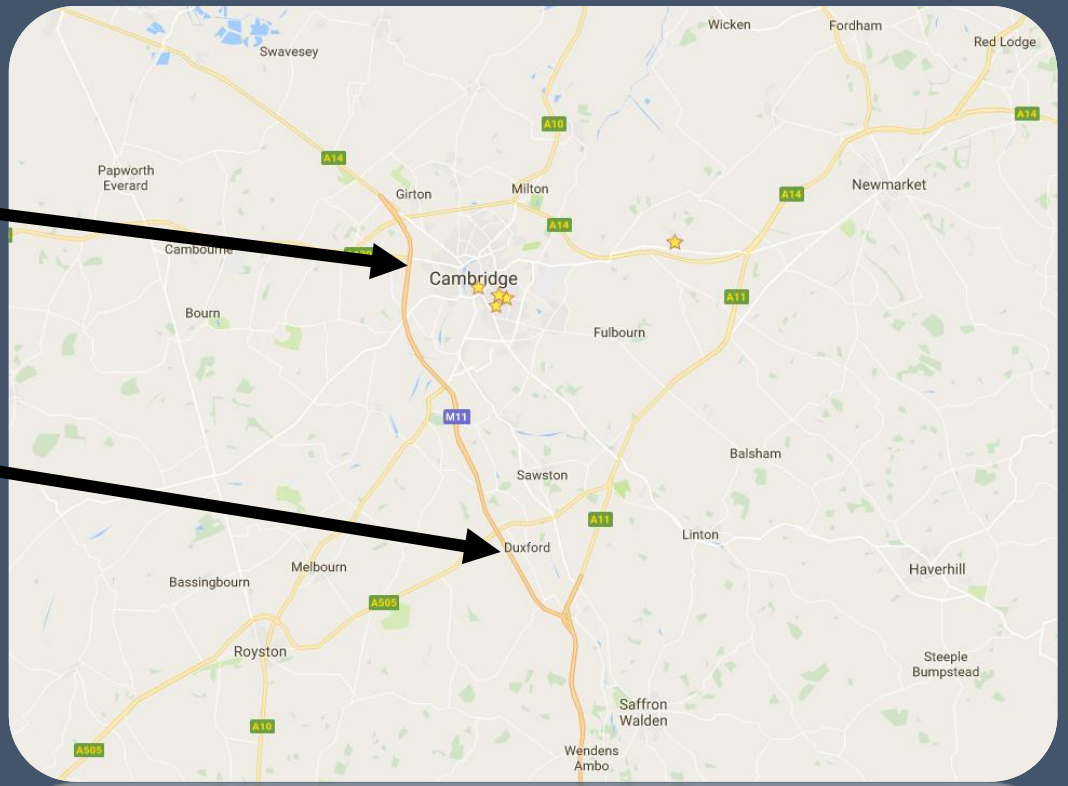
Motivation - Fixed point speed cameras



- Detrimental to streetscape
- Prefer discreet appearance
- Only take speed at a point
- Easily fooled

https://a1.muscache.com/locations/uploads/photo/image/22901/0_4200_0_2800_one_westside-los-angeles-quiet-residential-street-devon0289.jpg

Motivation - Average speed cameras



- None on residential routes

http://www.trents.co.uk/wp-content/uploads/2014/12/Average-speed-camera.jpg
https://ichef-1.bbci.co.uk/news/660/cpsprodpb/0202/production/_89841500_033220635-2.jpg

Motivation - Existing license plate cameras

- Hard to buy for general public
- >£ 1000

https://www.bhphotovideo.com/images/images1000x1000/bosch_f_01u_245_613_dinion_capture_5000_license_1163861.jpg
https://www.securitycameraking.com/securityinfo/wp-content/uploads/2013/01/License-Plate-Capture-Camera-vs-License-Plate-Recognition-Camera-21-300x300.gif

Motivation - Summary

New system should:

- Provide average speed check
- Target general public
- Priced reasonably
- Not aim to directly ticket offender
- Use as evidence and leverage for demands

Product Specification - Main Deliverables

1. Implement a UK number plate recognition system using existing computer vision algorithms on a low-cost, readily available hardware platform.
2. Set up a peer-to-peer network to share vehicle passing times and detect violations without the need for a central server.
3. Publish photo evidence of any violations

Product Specification - Main Deliverables

1. Implement a UK number plate recognition system using existing computer vision algorithms on a low-cost, readily available hardware platform.
2. Set up a peer-to-peer network to share vehicle passing times and detect violations without the need for a central server.
3. Publish photo evidence of any violations

Product Specification - Main Deliverables

1. Implement a UK number plate recognition system using existing computer vision algorithms on a low-cost, readily available hardware platform.
2. Set up a peer-to-peer network to share vehicle passing times and detect violations without the need for a central server.
3. Publish photo evidence of any violations

Product Specification - Main Deliverables

1. Implement a UK number plate recognition system using existing computer vision algorithms on a low-cost, readily available hardware platform.
2. Set up a peer-to-peer network to share vehicle passing times and detect violations without the need for a central server.
3. Publish photo evidence of any violations

Product Specification - Advanced Deliverables

- Have a standalone mode in case there is no one in the network
- Peers should join/leave/return to the network easily
- Make the network secure against rogue peers
- Package the system so that it can be easily installed in a home by an inexperienced user

Product Specification - Advanced Deliverables

- Have a standalone mode in case there is no one in the network
- Peers should join/leave/return to the network easily
- Make the network secure against rogue peers
- Package the system so that it can be easily installed in a home by an inexperienced user

Product Specification - Advanced Deliverables

- Have a standalone mode in case there is no one in the network
- Peers should join/leave/return to the network easily
- Make the network secure against rogue peers
- Package the system so that it can be easily installed in a home by an inexperienced user

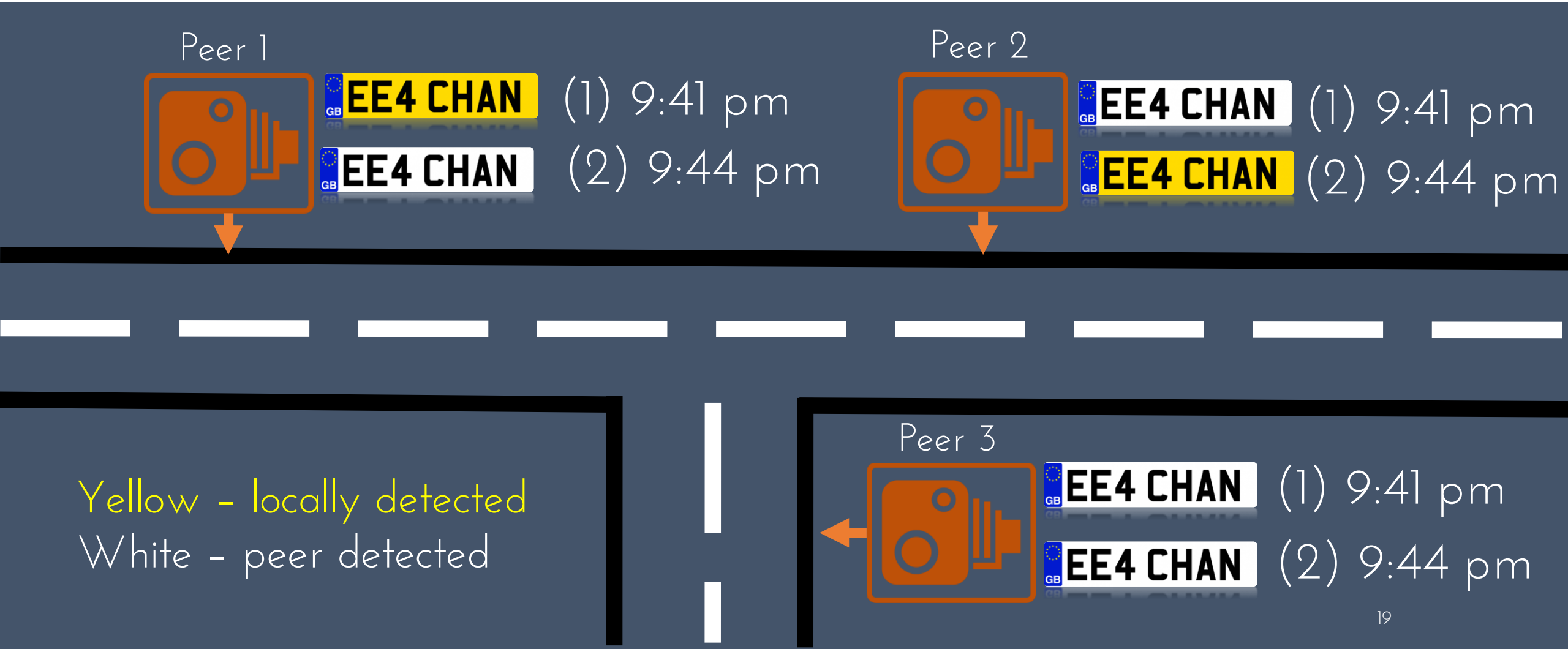
Product Specification - Advanced Deliverables

- Have a standalone mode in case there is no one in the network
- Peers should join/leave/return to the network easily
- Make the network secure against rogue peers
- Package the system so that it can be easily installed in a home by an inexperienced user

Product Specification - Advanced Deliverables

- Have a standalone mode in case there is no one in the network
- Peers should join/leave/return to the network easily
- Make the network secure against rogue peers
- Package the system so that it can be easily installed in a home by an inexperienced user

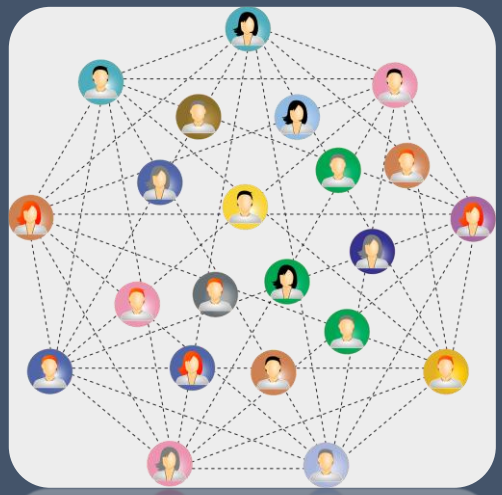
Envisioned System



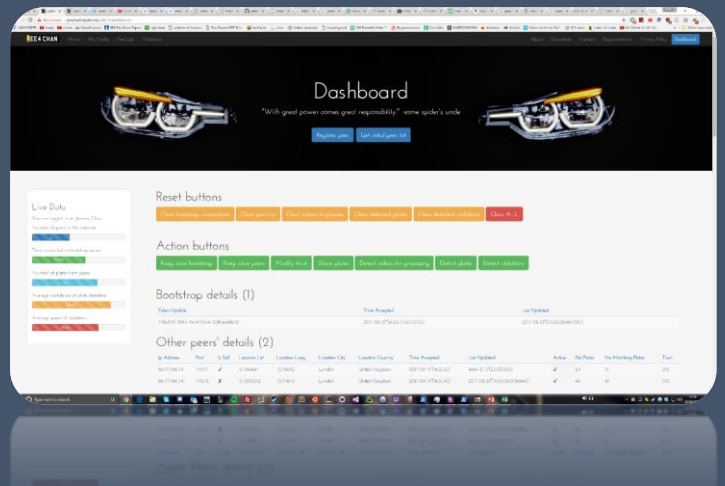
High Level Design

License Plate Detection

Peer to Peer Network

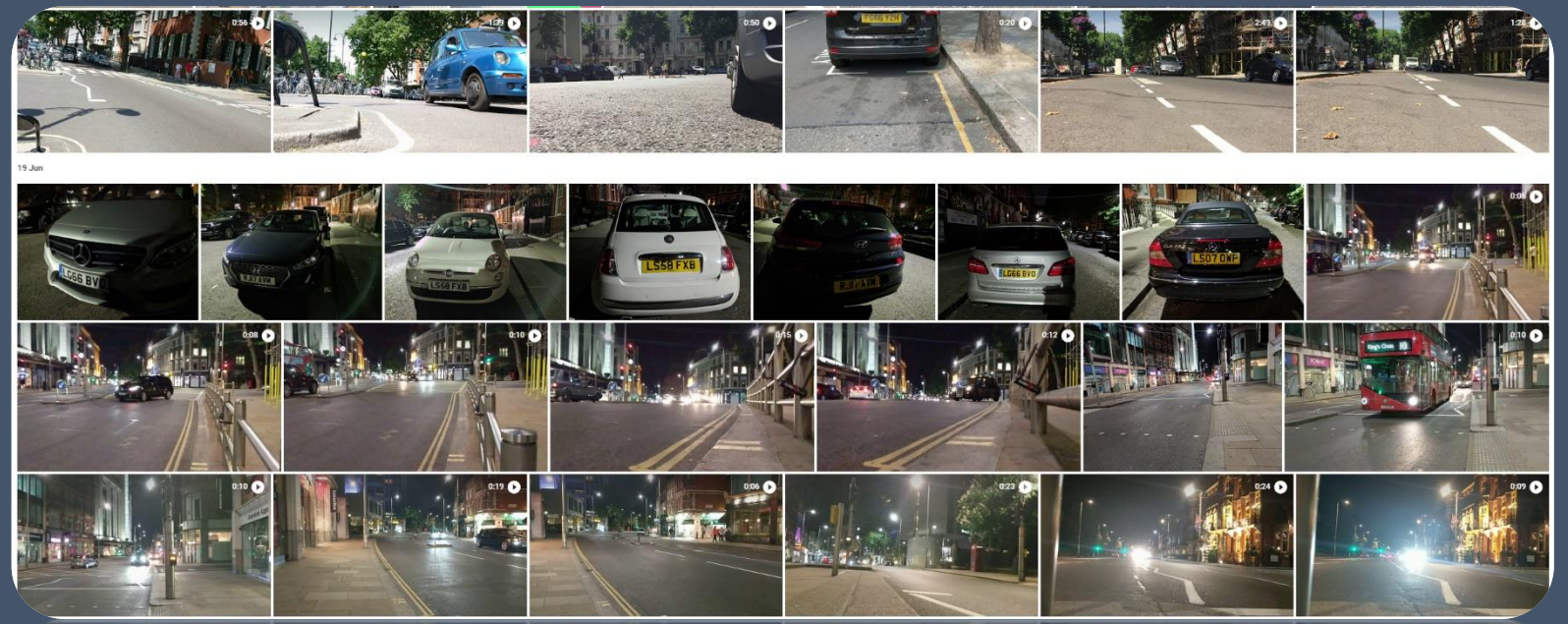


Web Interface



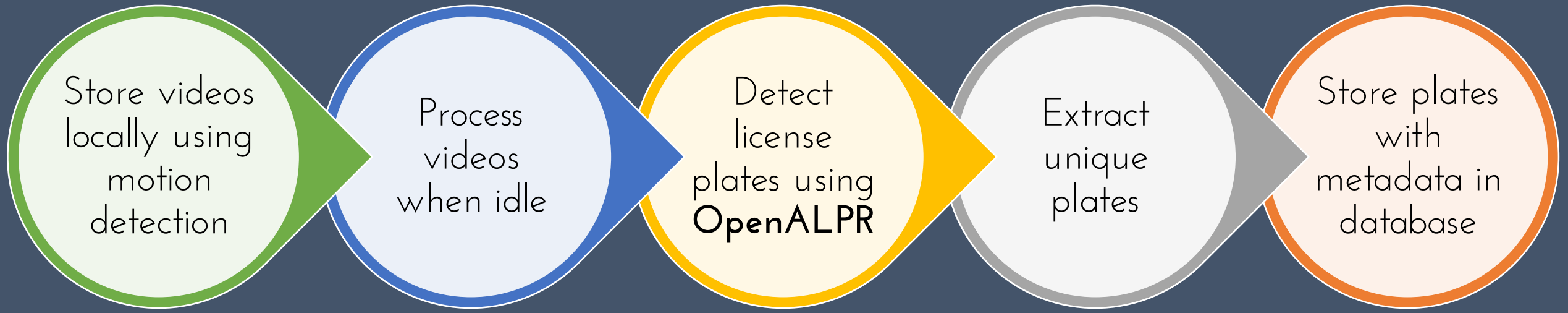
- 3 well defined modules
- Readily available components
- Users have control over data

License Plate Recognition - Aim



- Get license plates of cars
- Function in multiple angles and lighting conditions

License Plate Recognition - Design



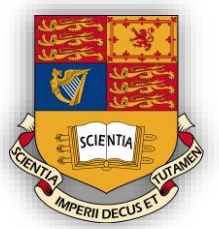
- Multiple parameters for tweaking

- Consecutive frames will likely be the same car

- Time
- Location

- OpenALPR computationally expensive
- Buffer videos
- Survive busy periods and power outages

License Plate Recognition - Fuzzy Grouping

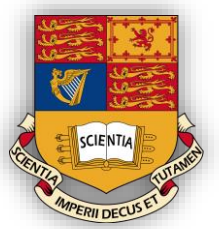


<<<<<<1< LG65FBO <2< LG65FBP <3< LG65FBO
<4< FE16RBX <5< LTZ1077 <6< LTZ077 <7< LTZ107

	Plate1	Plate 2	String Similarity (0.75)
1-2	LG65FBO	LG65FBP	0.857
2-3	LG65FBP	LG65FBO	0.857
3-4	LG65FBO	FE16RBX	0.285
4-5	FE16RBX	LTZ1077	0.143
5-6	LTZ1077	LTZ077	0.923
6-7	LTZ077	LTZ107	0.857

- Robust separation of unique vehicles
- Works with misreads
- Sort groups by confidence

License Plate Recognition - Fuzzy Grouping



<1< LG65FBO <2< LG65FBP <3< LG65FBO
<4< FE16RBX <5< LTZ1077 <6< LTZ077 <7< LTZ107

	Plate1	Plate 2	String Similarity (0.75)
1-2	LG65FBO	LG65FBP	0.857
2-3	LG65FBP	LG65FBO	0.857
3-4	LG65FBO	FE16RBX	0.285
4-5	FE16RBX	LTZ1077	0.143
5-6	LTZ1077	LTZ077	0.923
6-7	LTZ077	LTZ107	0.857

- Robust separation of unique vehicles
- Works with misreads
- Sort groups by confidence

License Plate Recognition - Testing

LF64FBO

LM55BCK

License Plate Recognition - Testing

BX66HHO

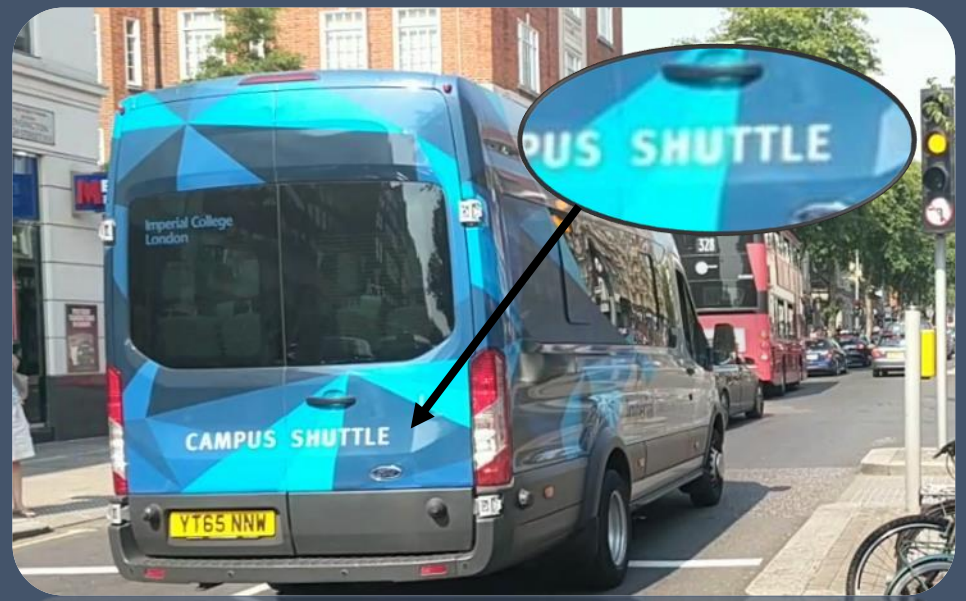
LTZ1077

License Plate Recognition - Testing

--

--

License Plate Recognition - Testing



5HUTTLE

18001

License Plate Recognition - Matching

@@##@@@ or @@@@####

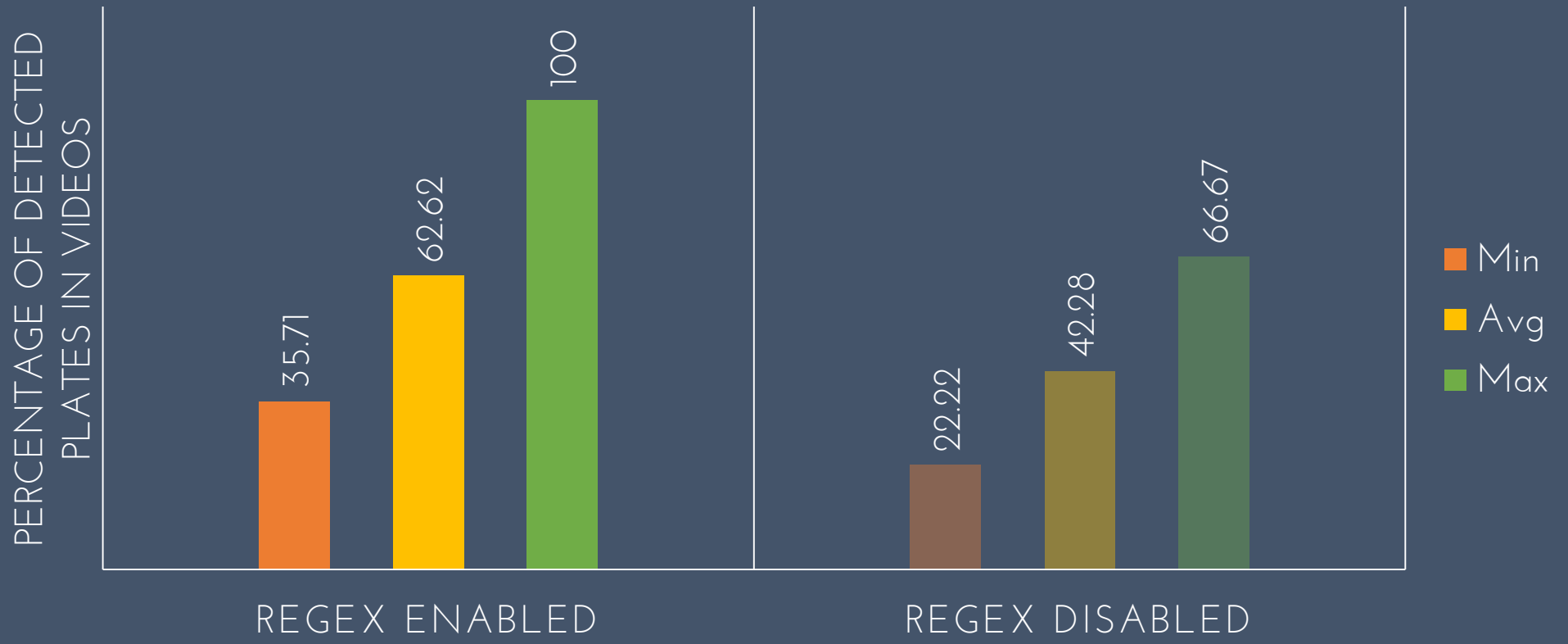
@ Letter
# Number

License Plate Recognition - Matching

@@##@@@@ or @@@@####

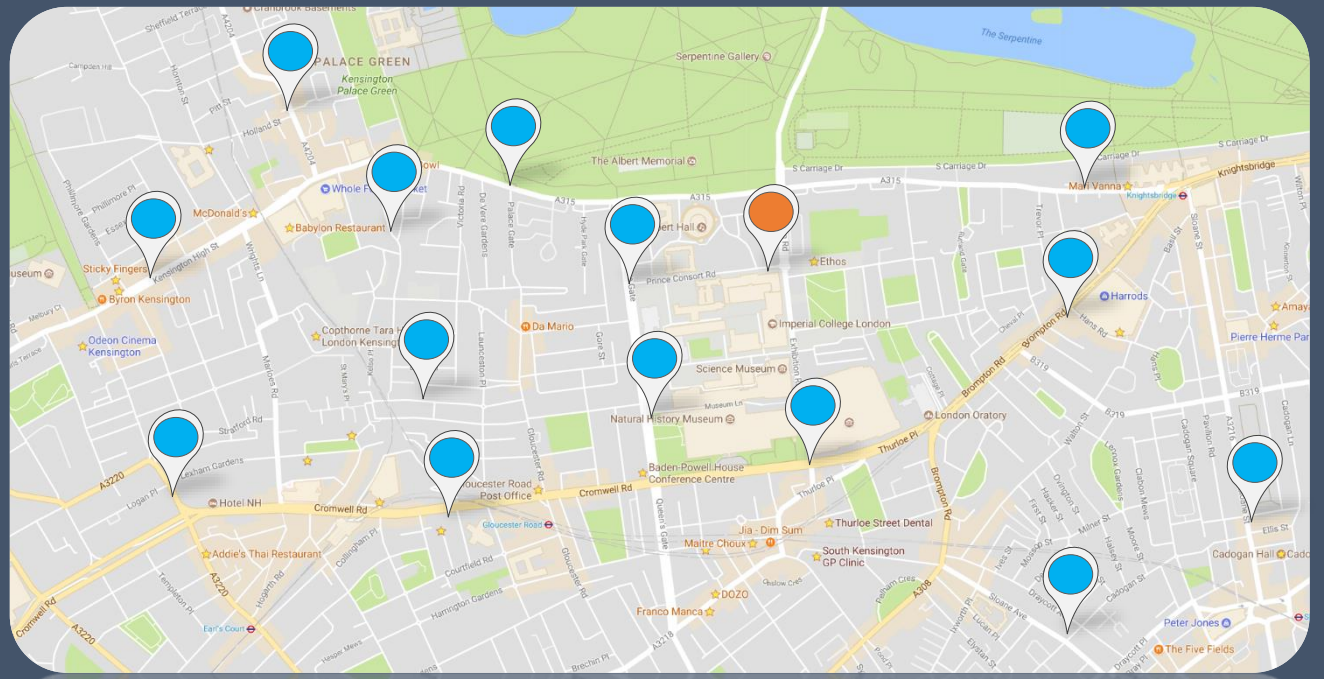
@ Letter
# Number

AUTOMATED TEST SUITE OF 20 VIDEOS



- LPR output compared with manual
- Max 100%

Peer to Peer Network - Aim



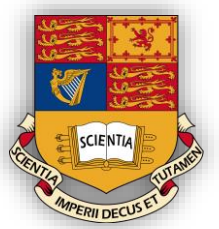
- Transmit detected plates to other peers
- Work out average speed between peer locations

http://pressednumberplates.co.uk/wp-content/uploads/2016/06/Pressed-Number-Plates.jpg

Peer to Peer Network - Design

- P2P on top of web server
- Tried, tested, scalable web framework
- Most security issues taken care of

Peer to Peer Network – Network transactions



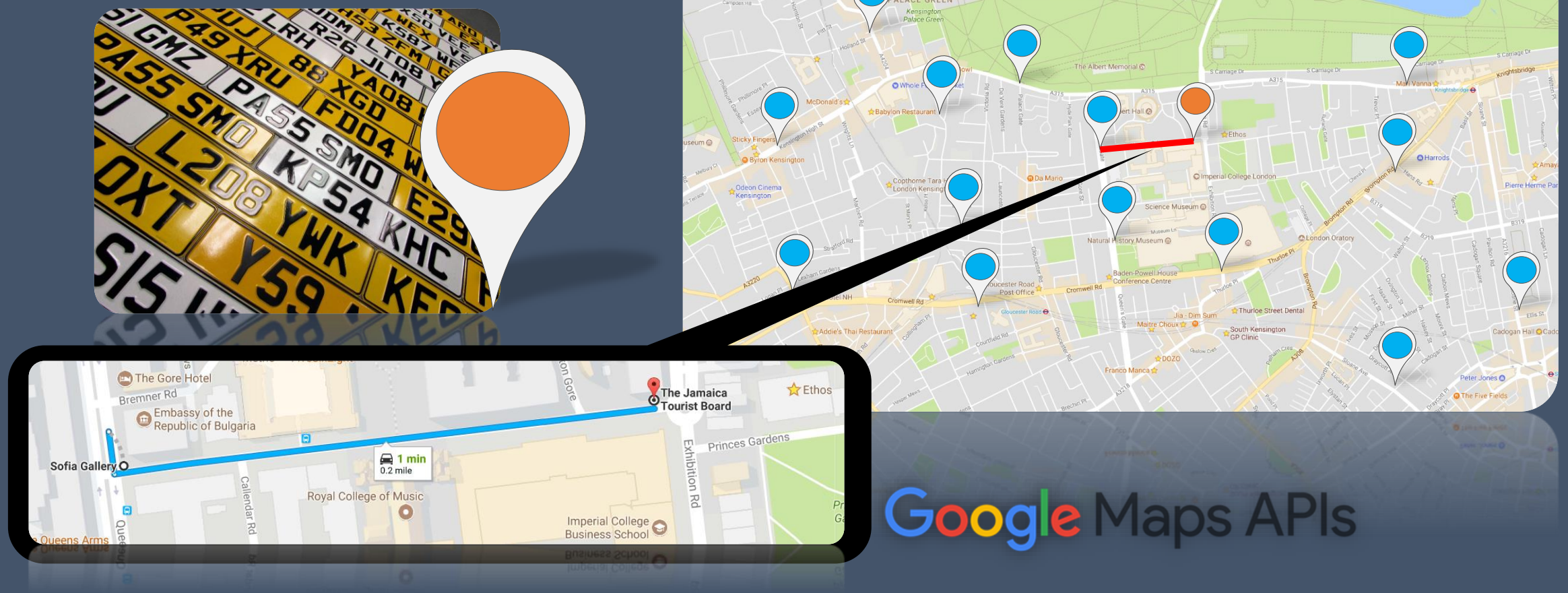
Register*
Get list of peers
Keep alive
Send plates
Detect violations
Modify trust of peer

*) Requires central server

- Bootstrap the network
- Maintain the network
- Security issues

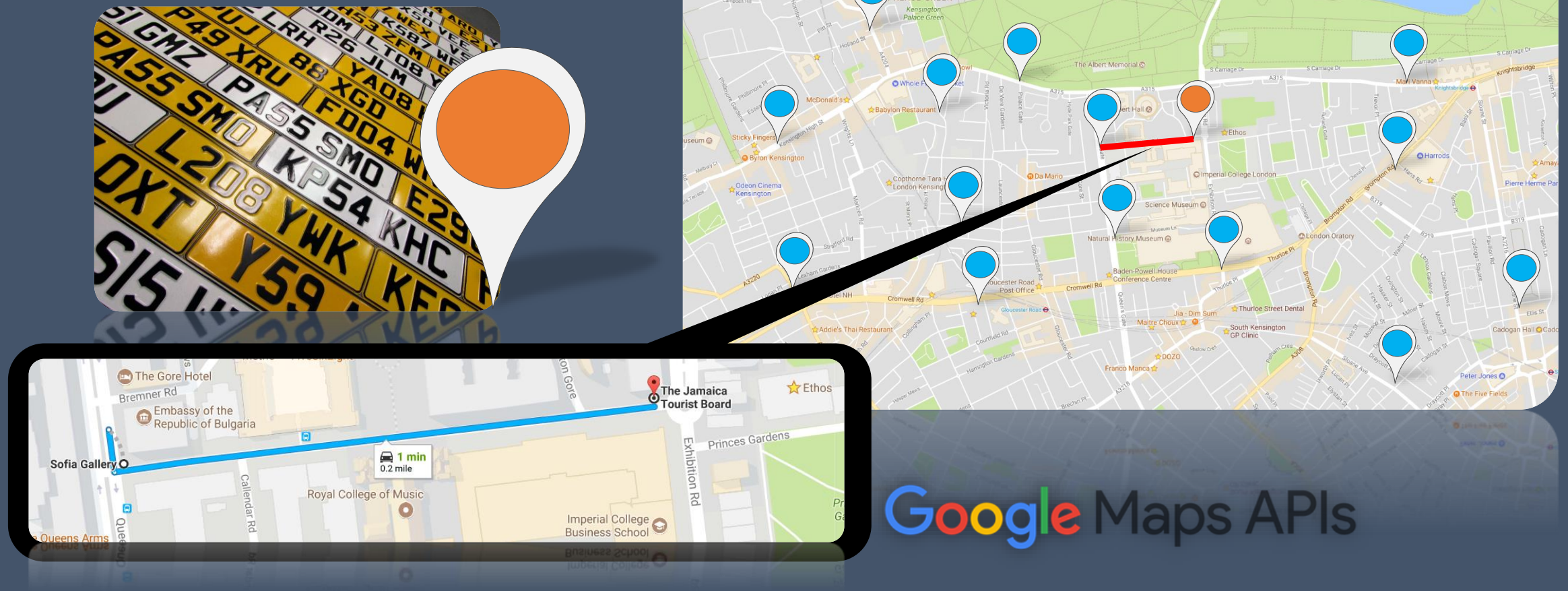
Adapted from https://en.wikipedia.org/wiki/Peer-to-Peer_Protocol_(P2PP)

Peer to Peer Network - Average speed



http://pressednumberplates.co.uk/wp-content/uploads/2016/06/Pressed-Number-Plates.jpg

Peer to Peer Network - Average speed



http://pressednumberplates.co.uk/wp-content/uploads/2016/06/Pressed-Number-Plates.jpg

Peer to Peer Network - Server

ID: fbbb1cbf-7887-4cc6-9bbf-16707e11367e

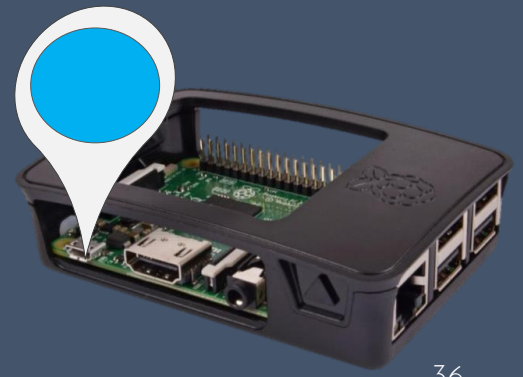
GET
POST
PATCH
DELETE

encryption
authentication

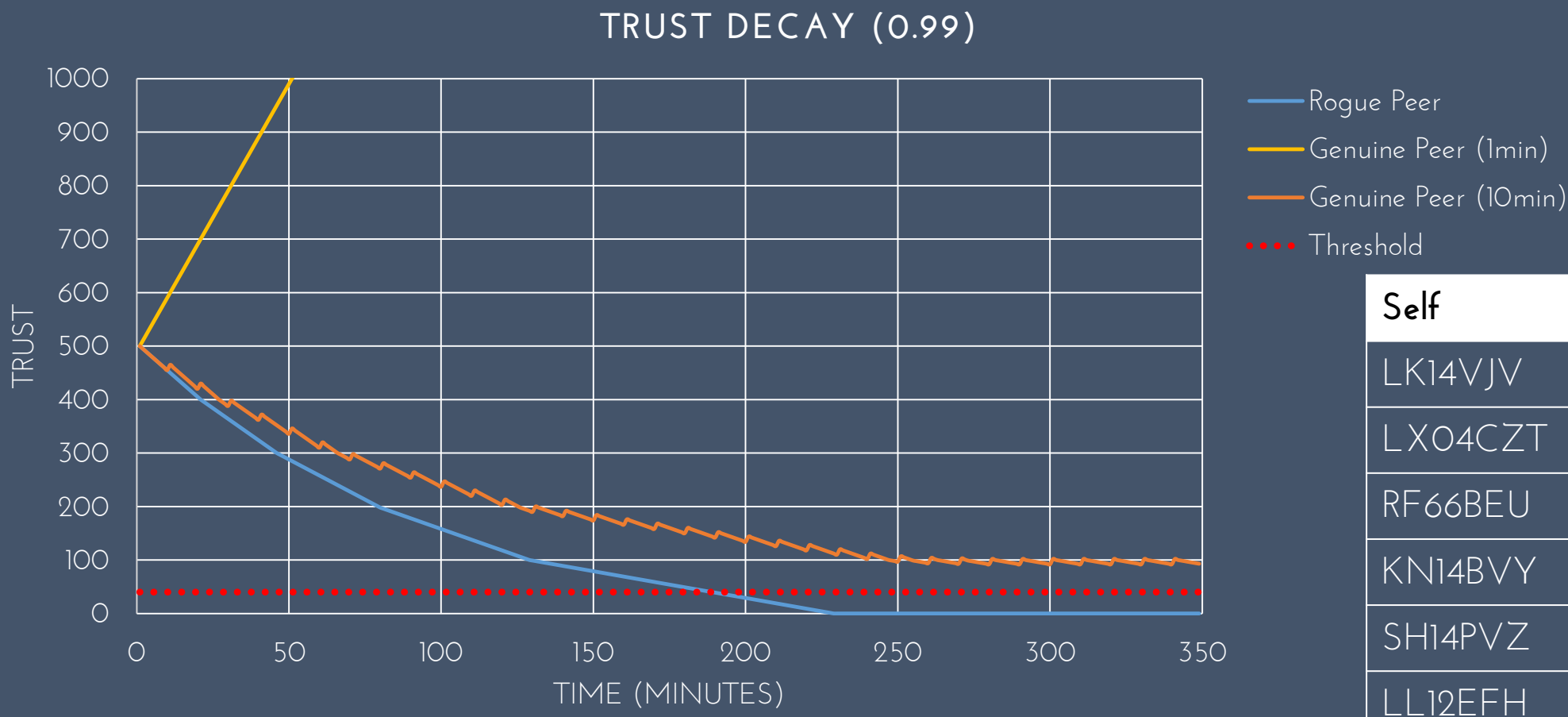
ID: 01ed4cfa-6c5b-476f-a6f8-4c6d0bcd5975

- API
- Unique ID authentication
- Local encryption

ID: 4feb662e-f50a-4088-bafe-ce75b421d50c

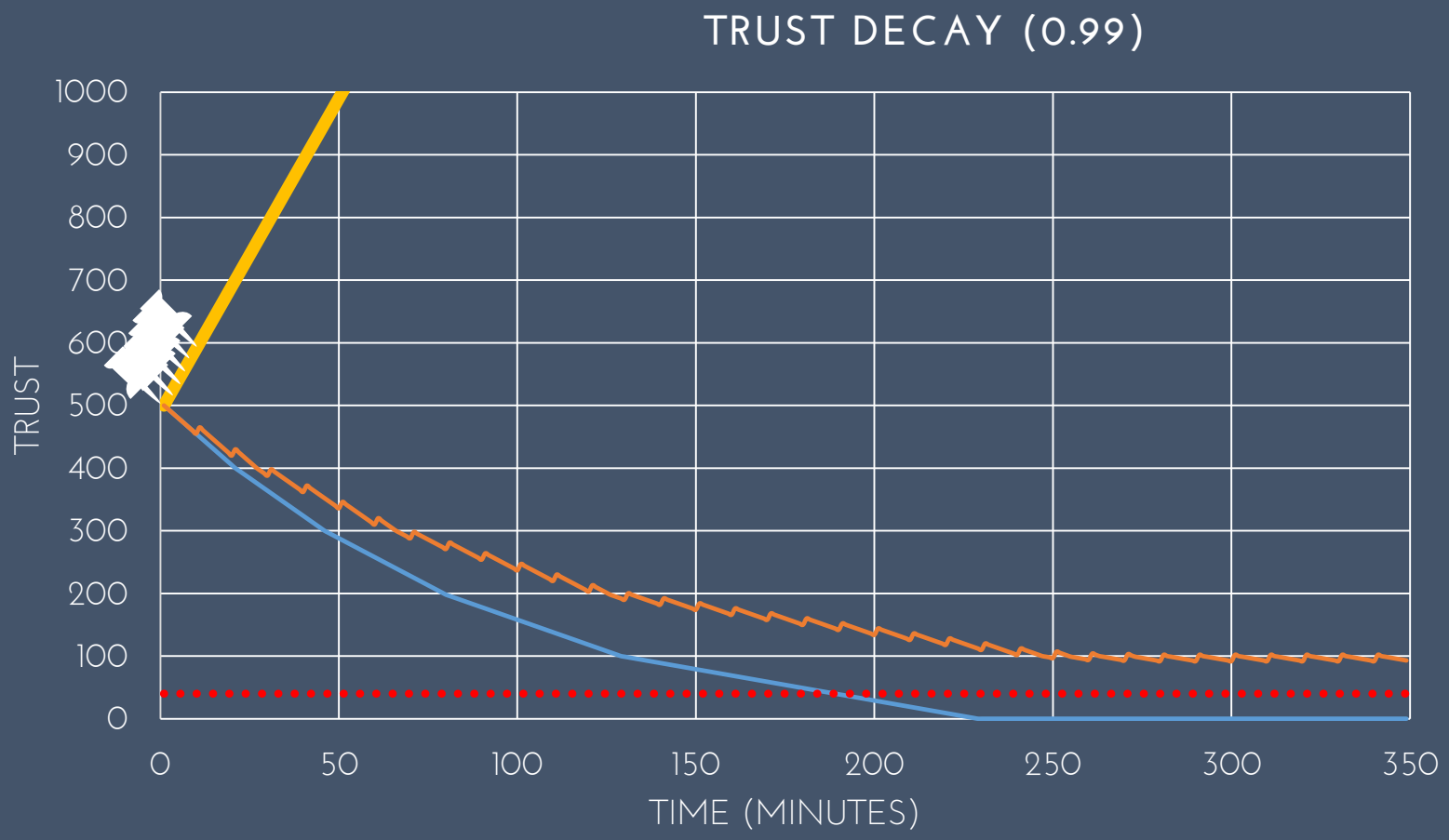


Peer to Peer Network - Trust system



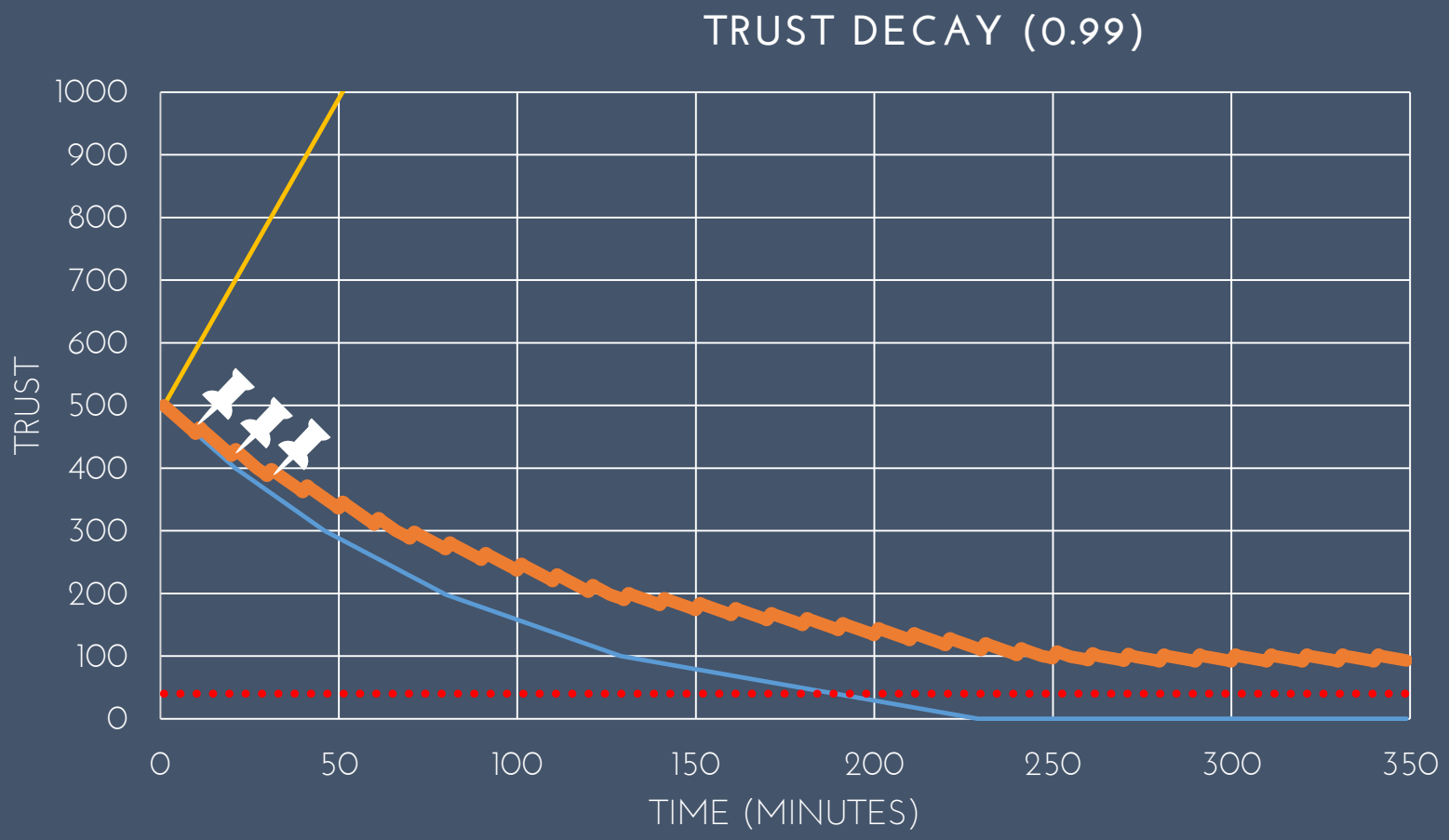
Self	Peer (1min)
LK14VJV	
LX04CZT	
RF66BEU	
KN14BVY	
SH14PVZ	
LL12EFH	

Peer to Peer Network - Trust system



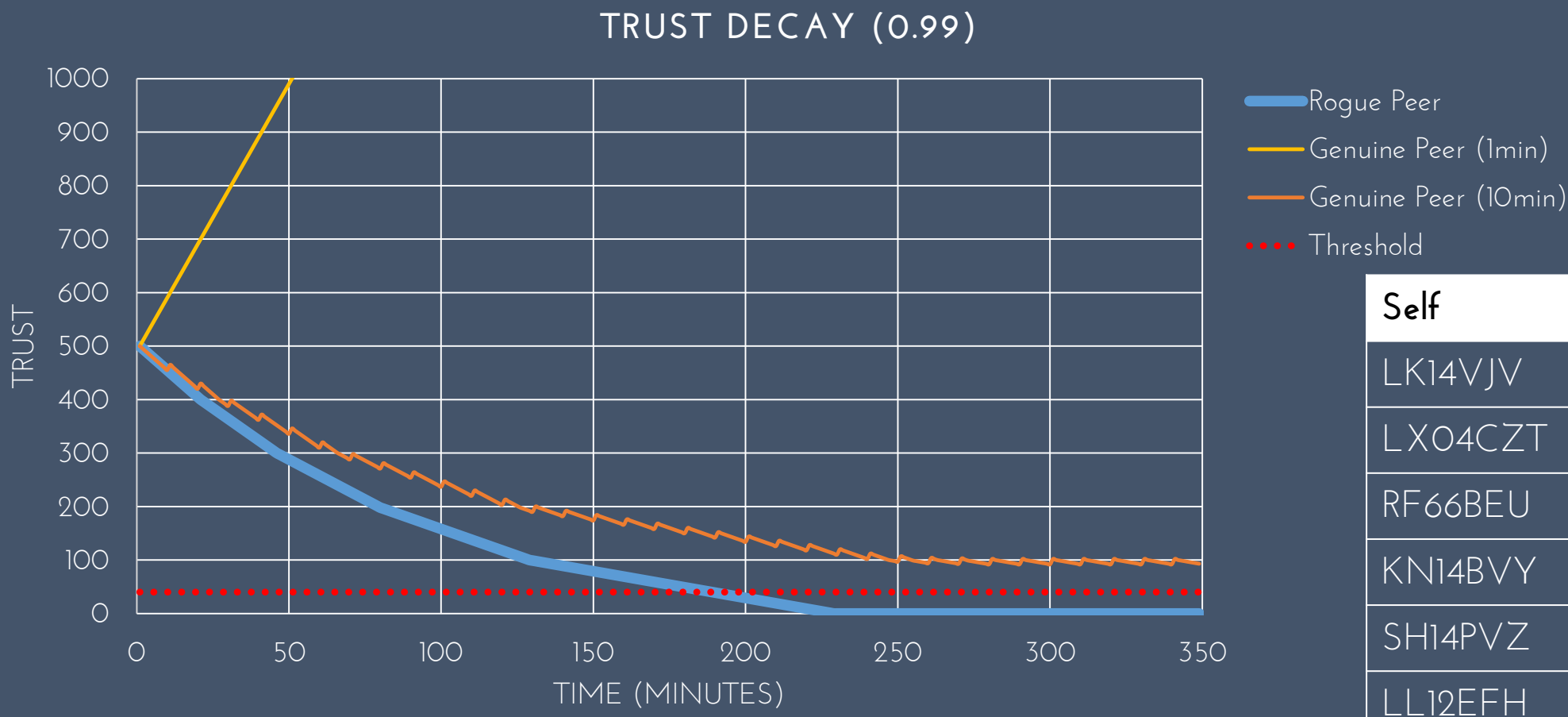
Self	Peer (1min)
LK14VJV	LK14VJV
LX04CZT	LX04CZT
RF66BEU	RF66BEU
KN14BVY	KN14BVY
SH14PVZ	SH14PVZ
LL12EFH	LL12EFH

Peer to Peer Network - Trust system



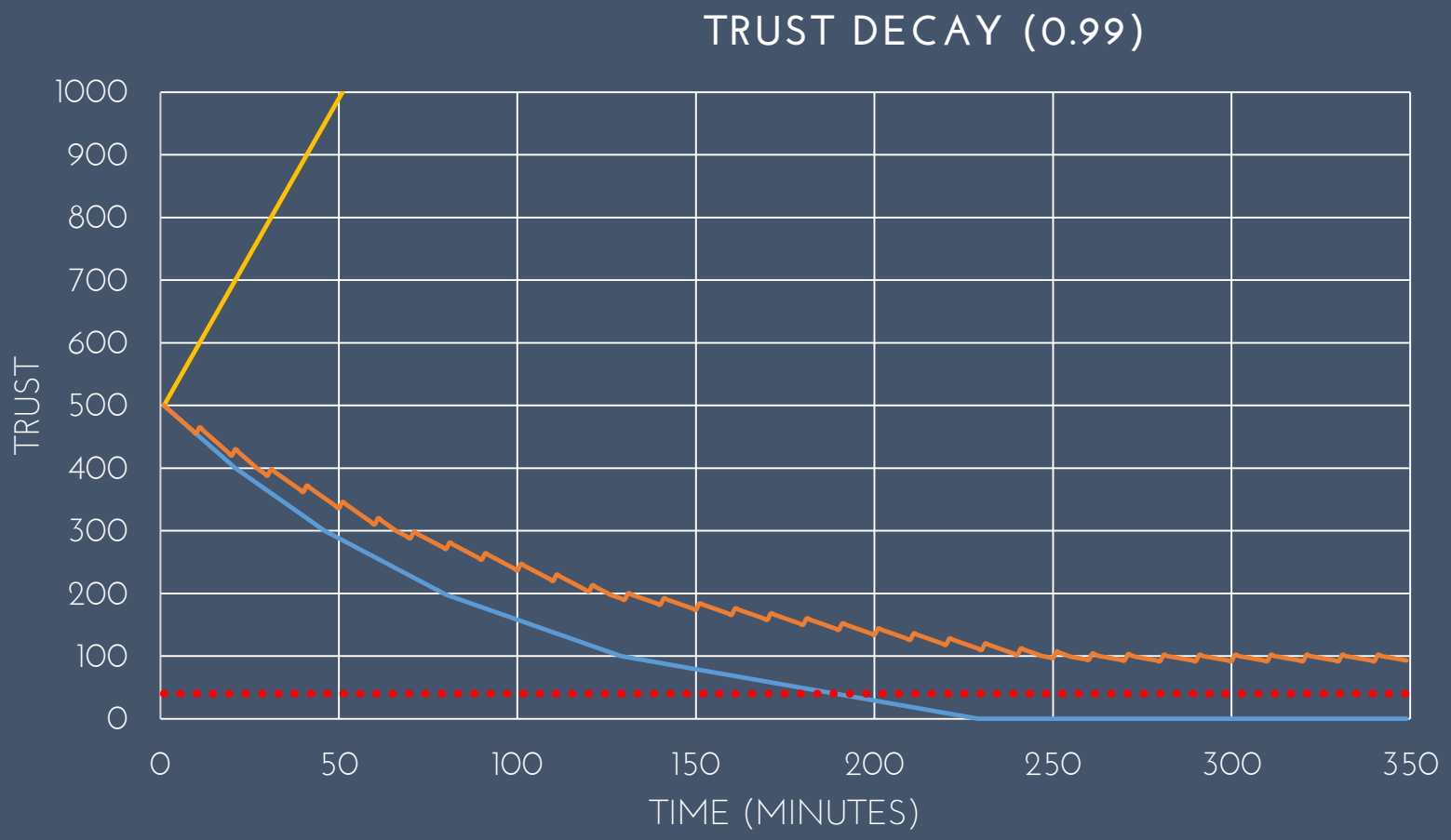
Self	Peer (10min)
LK14VJV	LK14VJV
LX04CZT	
RF66BEU	RF66BEU
KN14BVY	KN14BVY
SH14PVZ	
LL12EFH	

Peer to Peer Network - Trust system



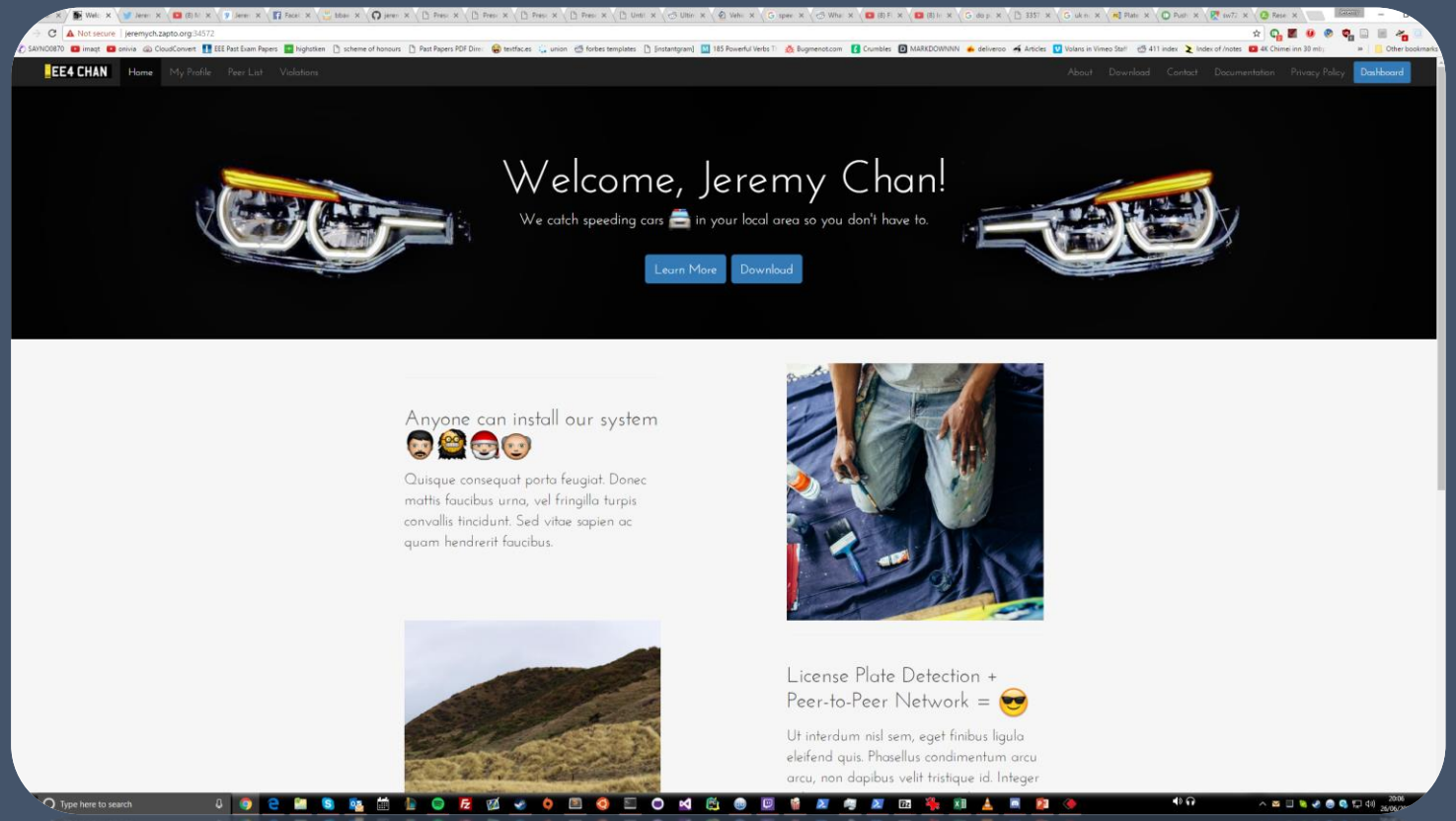
Self	Rogue Peer
LK14VJV	HI MOM
LX04CZT	!@$%^&**
RF66BEU	FAKE_FAKE
KN14BVY	AAAAAAA
SH14PVZ	
LL12EFH	

Peer to Peer Network - Trust system



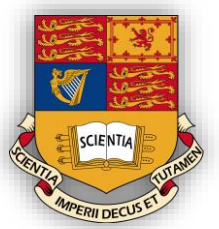
- Ignore rogue
- Reward genuine, matching plates
- Prevent fake plates
- Prevent leeching

Web Interface - Aim



- What the user sees
- Dashboard to control network
- Post detected violations on social networks

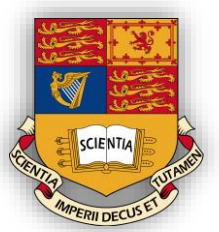
Demo



Modifications

1. Pre-recorded video
2. Live motion detection unused

Evaluation

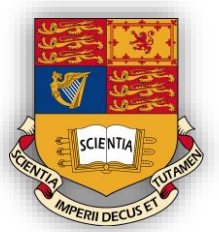


1. Implement a number plate recognition system using existing computer vision algorithms on a low-cost, readily available hardware platform.
2. Set up a peer-to-peer network to share vehicle passing times and detect violations without the need for a central server*.
3. Publish photo evidence of any violations

- All main deliverables achieved

*) Except when bootstrapping

Evaluation



- Have a standalone mode in case there is no one in the network
- Peers should join/leave/return to the network easily
- Make the network secure against rogue peers
- Package the system so that it can be easily installed in a home by an inexperienced user

- All but 1 advanced deliverable achieved

Conclusion

- Challenging project
- Very open ended on implementation
- Usable immediately

- Revisit performance and night time issues with LPR
- Consider refactoring P2P to be standalone
- Scalability test, overnight test

Thank you

http://github.com/jeremych1000/ee4-FYP/