The Internet of Things

Towards the future of the connected car

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Abstract

- The Internet of Cars
  - Towards the Future of the Connected Car

  - No doubt you have heard the phrase "**Internet of Things**" and the new buzzword "**IoT**" been used more and more these days, but what does that mean in practice? The **Tesla Model S** is probably the most well-connected car on the planet at the moment, and in this presentation we will use that vehicle as a case study of some practical usage of IoT concepts and technology that is already being applied to modern automobiles.
    How far away are we from a future "Internet of Cars" and what will be the social and privacy impacts of more connected-car scenarios?

Definition: Internet of Things

- "The **Internet of Things** is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment."

Source: Gartner IT Glossary

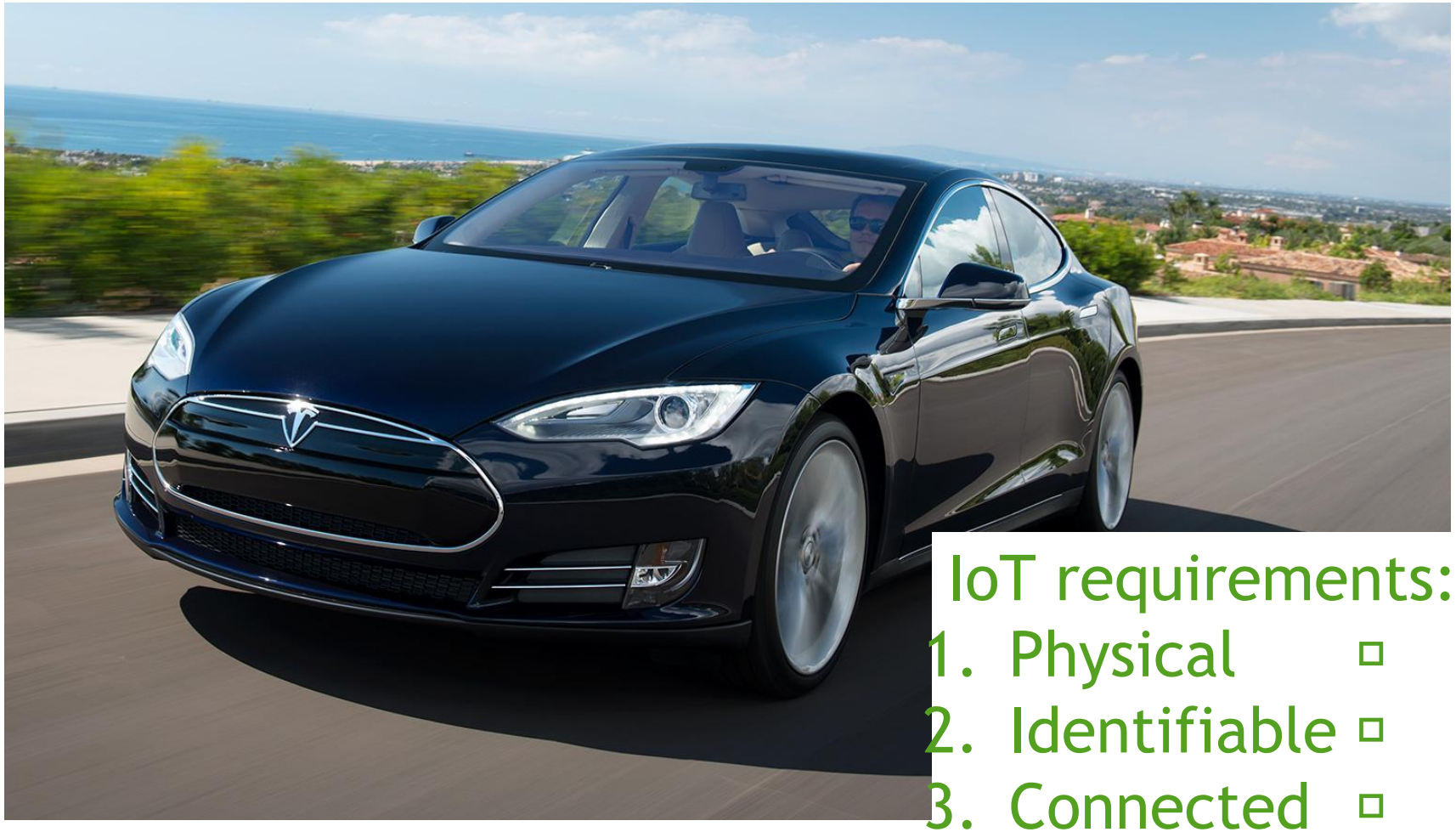
http://www.gartner.com/it-glossary/internet-of-things/

Core requirements:

1. Physical
2. Identifiable
3. Connected
4. Telemetry
5. Control

The Connected Car – Tesla Model S

Full Disclosure:
I am proud owner of TSLA stock since 2010 IPO, and Tesla Model S since 2013.



Tesla Model S

Source: Tesla Motors http://www.teslamotors.com/models/photo-gallery

IoT requirements:

1. Physical ▫
2. Identifiable ▫
3. Connected ▫
4. Telemetry ▫
5. Control ▫

Note: This is a technology case study, not a car advertisement!

Tesla Model S – Networking & Connectivity

- **Connectivity**
  - **GSM 3G** with HSPA+ using the AT&T's network (and others) and using Sierra Wireless AR8550 (TMC Forum)
  - The Model-S hardware supports HSPA+, which AT&T considers 4G. A software update may be available in the 2014 time frame to add 4G support. The hardware does not support LTE.
- **Display – Instrument**
  - **12.3" LCD, 1280 x 480 resolution**
  - NVidia Tegra 2 dual core CPU (Mercury News, 15-May-2013)
  - Software – Linux, QT and custom Tesla code (PC Word interview)
- **Display – Primary**
  - **17" LCD, 1080 x 1920 resolution**
  - Nvidia's Visual Computing Module VCM (Nvidia)
  - NVidia Tegra 3 quad-core +1 power-saving core (Nvidia blog)
  - Cypress MultiTouch controller (press release)
  - Software – Linux, QT and custom Tesla code (PC Word interview)

Source: Tesla Motors

Networked Data Services – New Possibilities

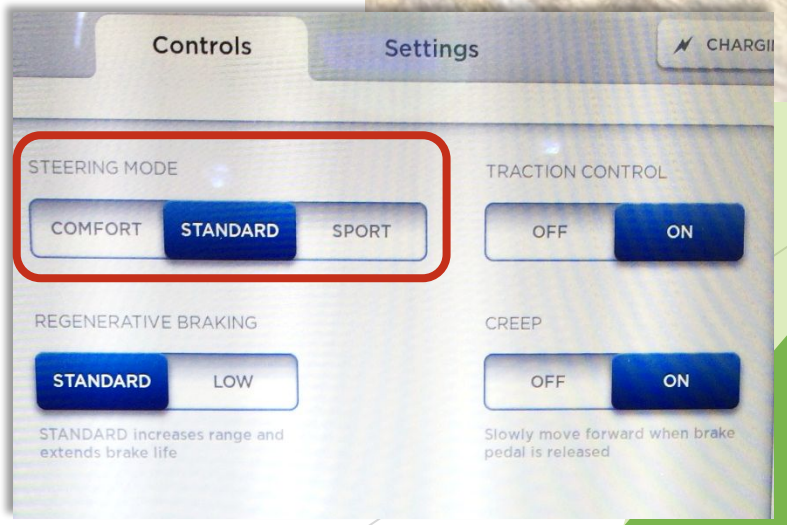
- Over-the-Air Software Updates & Patches
  - Add entirely new functionality to the car
    - For example: **Hill Start Assist**
      aka: *Seattle has longer & steeper hills than Fremont, CA*
  - Make feature updates
    - For example: improved cold weather range predictions
  - Fix any bugs in Car OS or Infotainment Apps
- Data feed of near real-time traffic conditions
  - Source: Google Maps
- Streaming Internet Radio
  - Slacker
  - TuneIn
- Real-time GPS location
- Transmit vehicle status telemetry

Source: Seattle Times

Sensors & Controls: Fly-By-Wire?

- Software controlled switches handle all vehicle control functions
  - Car can detects proximity of key fob, else drive train disabled.
  - Remote door unlock and extend door handles,
    handles auto-present as driver approaches with key fob
    if Tech Package is installed.
    https://www.youtube.com/watch?v=ucwo9hnLiU8
  - Steering, including steering mode setting
  - Gear selection: P-N-R-D
  - Braking, including regen-braking
  - Driving lights & turn signals
  - HVAC
  - Door sensors / unlock
    [with manual override for emergency use]
  - Battery compartment temperature & air-flow
  - Vehicle ride-height at highway speed,
    if Air-Suspension options is fitted.

Source: Scientific American



Source: JThelin

Telemetry – Many Different Uses

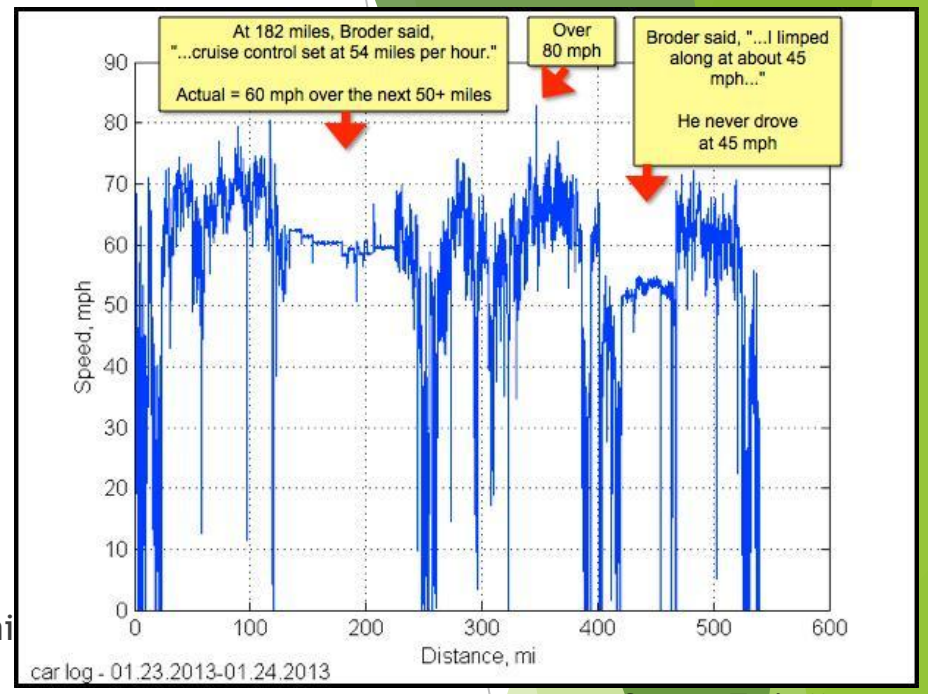
- Vast amounts for real-time status data produced by each car – rich data mining opportunities.

- Various Uses of the Data:
  - Complete fleet size and usage patterns data.
  - Analyze usage patterns for design of new features.
    - Example: Hill Start Assist functionality added in April 2014.
  - Safety monitoring
    - Examples: Any crashes detected, even if air-bags did not need deployment. http://www.gtspirit.com/2013/10/06/tesla-model-s-destroyed-in-the-usa/
  - Dude, Where's My Car?

Source: Tesla Motors

Telemetry – Fraud Detection

- **A Most Peculiar Test Drive**
  - New York Times article by John Broder
    http://www.nytimes.com/2013/02/10/automobiles/stalled-on-the-ev-highway.html
  - Public rebuttal of NYTimes article
    with full telemetry data analysis by Tesla Motors
    http://www.teslamotors.com/blog/most-peculiar-test-drive
    http://www.teslamotors.com/blog/most-peculiar-test-drive-follow



Source: Tesla Motors

- **When Life Gives You Lemons**
  - Milwaukee attorney Vince Megna filed "Lemon Law" case against Tesla Motors claimi
    vehicle.
  - Tesla released public statement detailing all the remedial steps they had attempted on that vehicle.
    http://www.teslamotors.com/blog/when-life-gives-you-lemons
  - The key to the rebuttal came from telemetry data:
    - Another issue was that the car's fuse blew on numerous occasions. Each time, our engineers explored all possible explanations and were never able to find anything wrong with the car. Still, just to be sure, we replaced several parts that could have been related to the alleged problem – all at no expense to the customer. When the fuse kept blowing despite the new parts, and faced with no diagnosis showing anything wrong with the car, the engineers were moved to consider the possibility that the fuse had been tampered with.
      After investigating, they determined that the car's front trunk had been opened immediately before the fuse failure on each of these occasions. (The fuse is accessed through the front trunk.)
      Ultimately, Tesla service applied non-tamper tape to the fuse switch.
      From that point on, the fuse performed flawlessly!

A Remote Control Car?

- Internet connectivity enables remote monitoring and limited control of the vehicle.
  - Safety interlocks disable remote control fucntions while car is in motion.
- But no RC driving!
  - Well, at least not yet ... !
    http://www.technovelgy.com/ct/Science-Fiction-News.asp?NewsNum=2627

Source: Tesla Motors

Tesla Model S -- REST API

- Vehicle Status
  - Is mobile access enabled
  - Charge state
  - Climate controls state
  - Driving state and location
  - GUI settings (preferences)
  - Vehicle state [Doors open
- Vehicle Control Commands
  - Open charge port door
  - Set charge mode to standard
  - Set charge mode to max-range
  - Set charge limit to X %
  - Start charge
  - Stop charge
  - Flash lights
  - Honk horn
  - Lock doors
  - Unlock doors
  - Sun roof control [open / close / vent]
  - Set AC target temperature
  - Start AC
  - Stop AC

Unofficial docs:
http://docs.timdorr.apiary.io/

Connected Privacy?

- Should we be worried about the type and amount of telemetry data our cars will soon start to reveal about details of our lives?
  - Rhetorical question: Is this any different than the data emitted by your cellphone & other mobile apps?
  - Even if your **car** does not tell anyone where it is, your cellphone probably already does through various location-based services.
    - iBeacon, Bing / Google Maps, Yelp, Facebook, etc

- According to **Jeff Jonas** (IBM Fellow & Chief Scientist for Entity Analytics)
  - **Space-Time Box** data from cellphones and other portable gadgets can already be used to fairly accurately identify individual "**habitrail**" signals.
    http://jeffjonas.typepad.com/jeff_jonas/2009/08/your-movements-speak-for-themselves-spacetime-travel-data-is-analytic-superfood.html

- Will the benefits of a connected car out-weigh any privacy concerns?
  - Only you can decide!

Source: Tesla Motors