21CSE429T

DATA SCIENCE FOR INTERNET OF THINGS

UNIT IV

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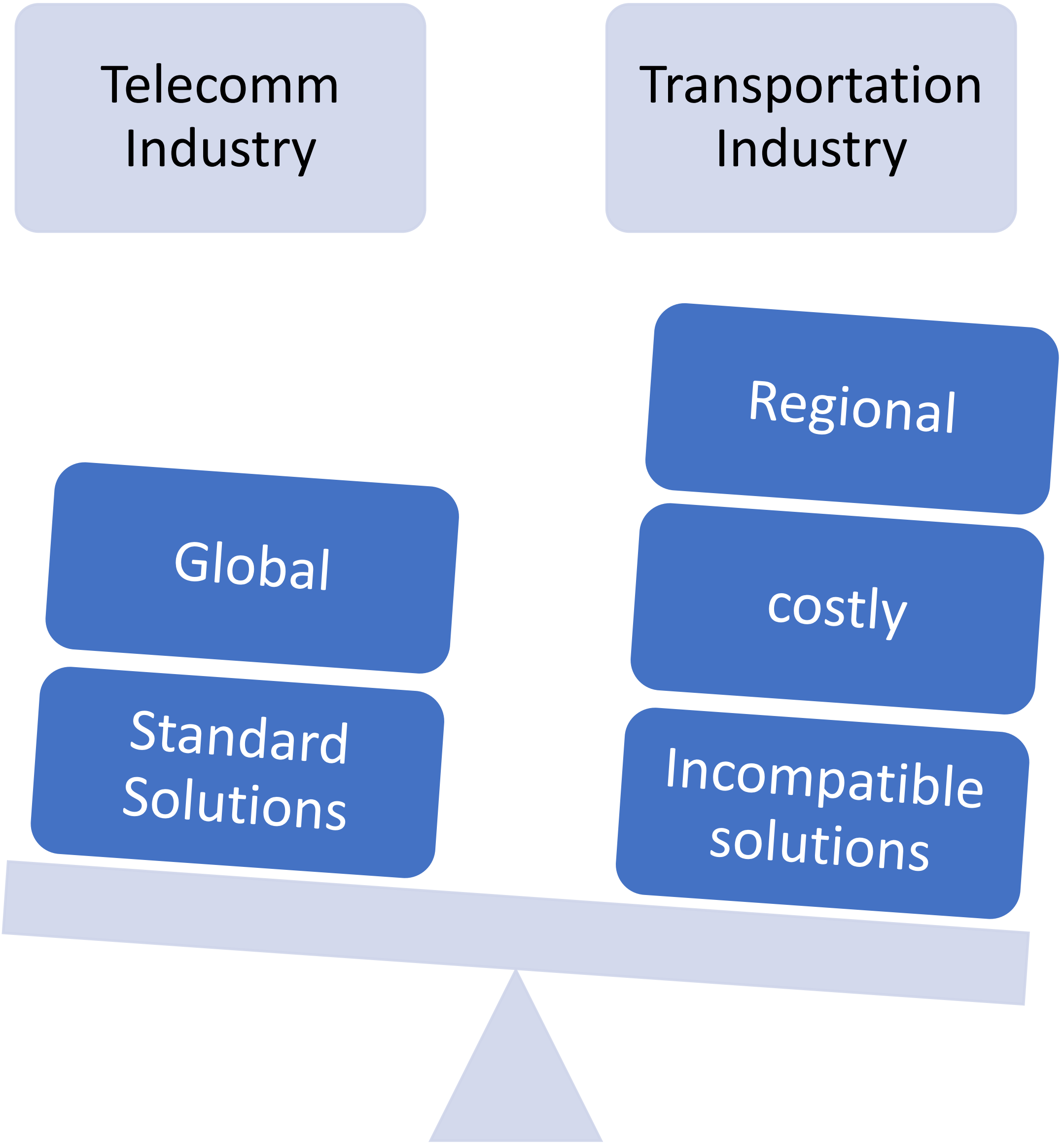
Syllabus

- ***Unit-4 - Smart Applications IoT with Data Analytics 9 Hrs***
- *Defragmenting Intelligent Transportation:*
- *A Practical Case Study -Connected and Autonomous Vehicles*
- *Transit Hub: A Smart Decision Support System for Public Transit Operations –*
- *Smart Home Services Using the Internet of Things*

- ***Reference Books:***
- Unit 4 - Smart Applications IoT with Data Analytics - T3

Defragmenting Intelligent Transportation: A Practical Case Study



THE TRANSPORT INDUSTRY

- No control on Traffic
- Microprocessor based control
- emerging coordinated traffic control systems were known as UTC (northern hemisphere) ATC (southern hemisphere)
- Optimize cycles, green splits, and offsets, NON Stop
- Split Cycle Offset Optimization Technique (SCOOT) –UK
- Sydney Coordinated Adaptive Traffic System (SCATS) - Australia.
- Proprietary suppliers –Siemens

- Chinese Traffic Product
- Urban Traffic Management and Control (UTMC)
- DATEX II adaptation
- End user
- Protective Suppliers
- Challenge - wider integration across the whole transport sector - complete citizen end-user experience.

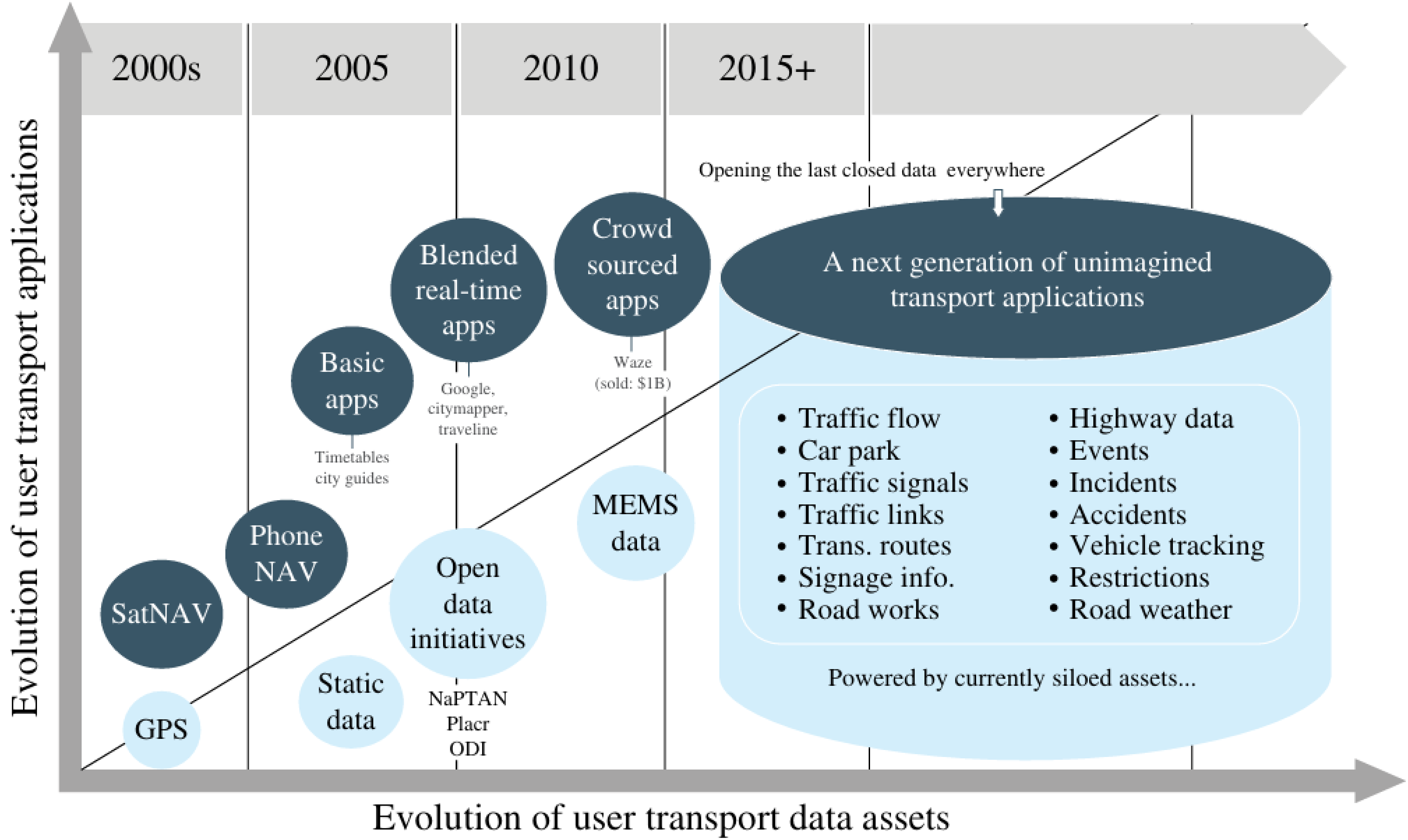


FIGURE 34.1 Evolution of transport applications and transport data assets. Courtesy of InterDigital.

- GPS was enabled in the Mobile results in
  - The new systems → Downloadable TT, City Guide, Navigations
- Later the Internet on Mobile evolved, results in
  - Service → Delivery Updates
  - City Maps
  - Google maps
- Supplementary Services
  - Compass
  - Gyroscope
  - Accelerometer
- These supplementary services enables the access to location even when the mobile devices are out of GPS converge

The Transport Industry: Current Status and Outlook

- Though the Emerging trends have opened many data, not all
- Transport System Vs Communication System
- Some important transport-specific and time-specific requirements
  - Local responsibility and accountability
  - Local authority trends
  - The role of data
- The challenge of opening up data
  - Valuing the data
  - Skilled staff
  - Commercial staff

oneTRANSPORT—A Solution to Today's Transport Fragmentation

- oneTRANSPORT solution is based on oneM2M
- OneM2M is a Service Enablement Layer standard whose core functionality is to provide a set of service capabilities that enable manage able data sharing for new services and application development from multiple parties
- Subscriber model
- Gives new functionalities to address issues on open data
- oneTRANSPORT makes the transport application highly transferable, delivering both local and interregional impact.
- The major challenge here is making it in economic way.
- oneTRANSPORT defines an innovative cloud based model of brokers that enable an "open once, sell to many" vision.

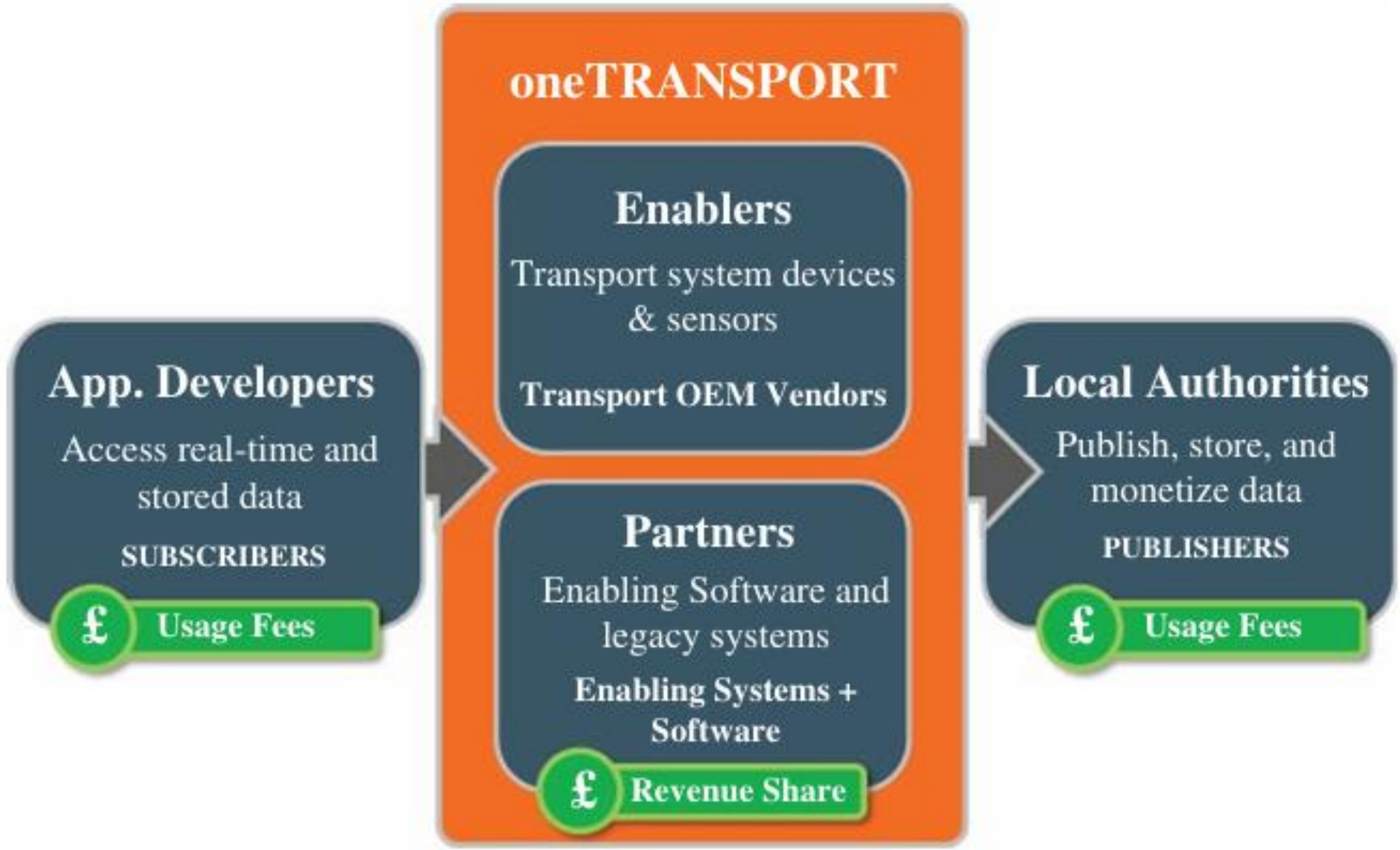
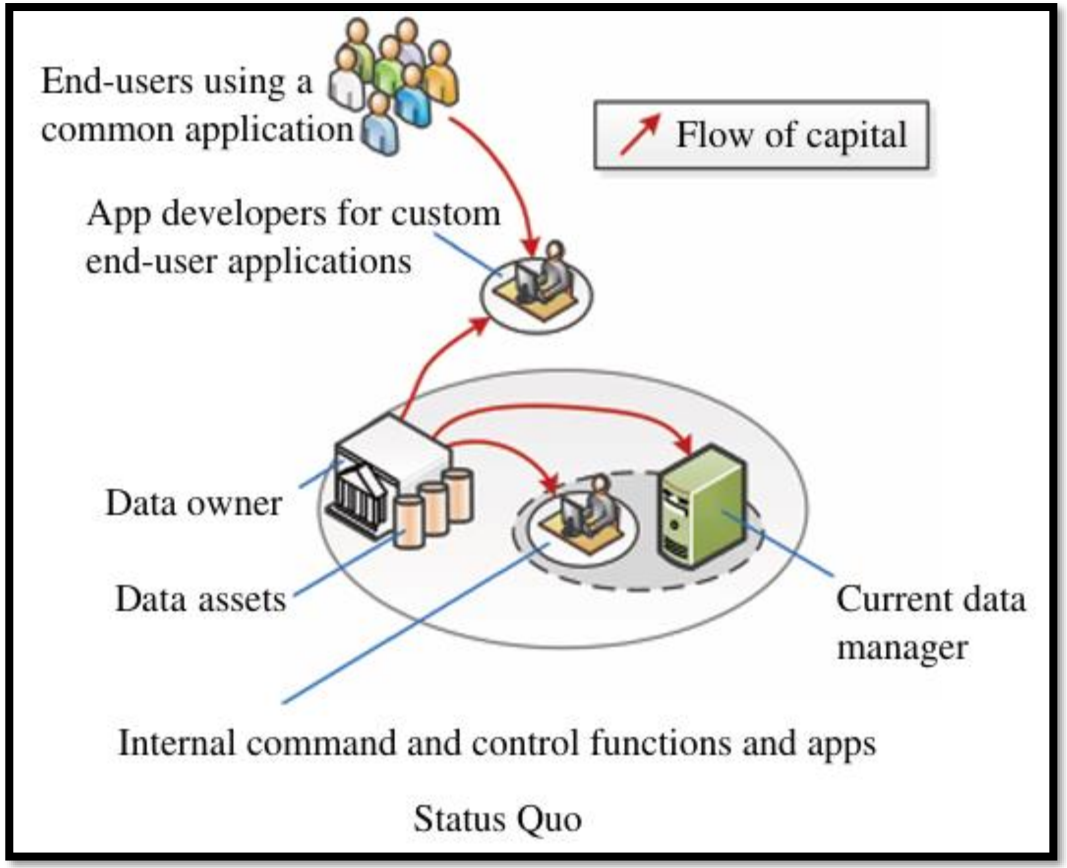


FIGURE 34.3 oneTRANSPORT platform vision. Courtesy of InterDigital. Use with Permission.

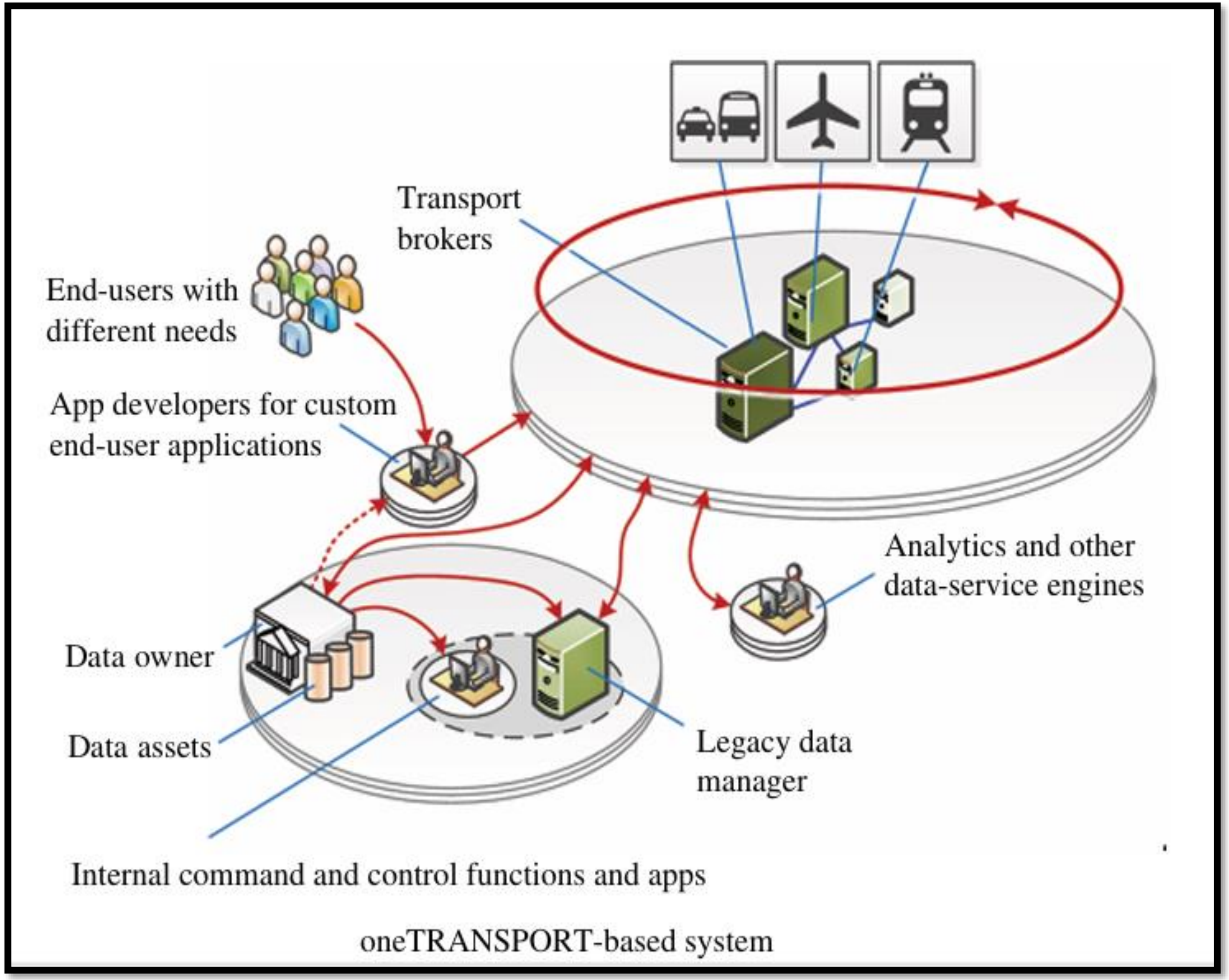
- The oneM2M Service Layer provides the “**core system services**” of oneTRANS PORT and full-featured M2M Service Delivery Platform (SDP) functionality.
- This includes **interworking** of transport data assets from other systems, **event management**, **gateway services**, **device management** and **discovery, configurable charging**, **filtering and semantic services**, and so on.
- All data that is made available to higher-layer entities flows through, and is exposed by, the oneM2M API
- The Higher layer supports RESTful API, enables the user to subscribe for the notifications on changes

- Two categories of premium service capabilities are currently anticipated
  - Transport data analytics
  - Transport application enablers
- oneTRANSPORT may be used to enhance and expand the value of current applications such as Citymapper or Waze through integration at the oneTRANSPORT API.

The Travel Avatar Experience



End-users using a common application
Flow of capital
App developers for custom end-user applications
Data owner
Data assets
Current data manager
Internal command and control functions and apps
Status Quo



Transport brokers
End-users with different needs
App developers for custom end-user applications
Analytics and other data-service engines
Data owner
Data assets
Legacy data manager
Internal command and control functions and apps
oneTRANSPORT-based system

oneTRANSPORT: BUSINESS MODEL

- a oneTRANSPORT Broker
- Phase 1: In-field trials
- Phase 2: Initial commercial stage
- Phase 3: Full commercial stage

CONNECTED AND AUTONOMOUS VEHICLES

- BRIEF HISTORY OF AUTOMATED AND CONNECTED DRIVING

- Mobile robotics
- Mobile Robots Vs Autonomous Vehicles
- First →a mobile robotic platform is not designed to operate on roads,
- Second→ while mobile robotic platforms can stop and wait to assess the current situation
- Low speed Autonomous vehicle
- After the IEEE802.11p many V2V and V2I initiatives were done by OEM

- In GCDC 2011 Using 802.11p the new autonomous vehicle was demonstrated with high way speed
- The development has paved the way to OEMs to make the development in phased manner, and started with active safety systems like
  - Electronic Stability Control (ESC) system
- Advanced Driver Assistance Systems (ADAS) like
  - Adaptive Cruise Control (ACC)
  - Lane Departure Warning and Keeping
  - Collision Risk Warning and Avoidance
  - using emergency braking, and so on
- This advancements brought in the lane centering control, and automatic parking even in the lower-priced models today

Automated Driving Technology

Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
• **Non Automated** • Fully controlled by human intervention, though warning system is available	• **Assisted** • mode-specific execution • Either acceleration or deceleration • Rest all will be by human driver	• **Partial automation** • lane centering control for steering automation and ACC and collision avoidance for longitudinal direction automation	• **Conditional automation** • Autopilot mode	• **Full Automation** • All aspects of driving done automatically	• **High Automation** • No driver intervention

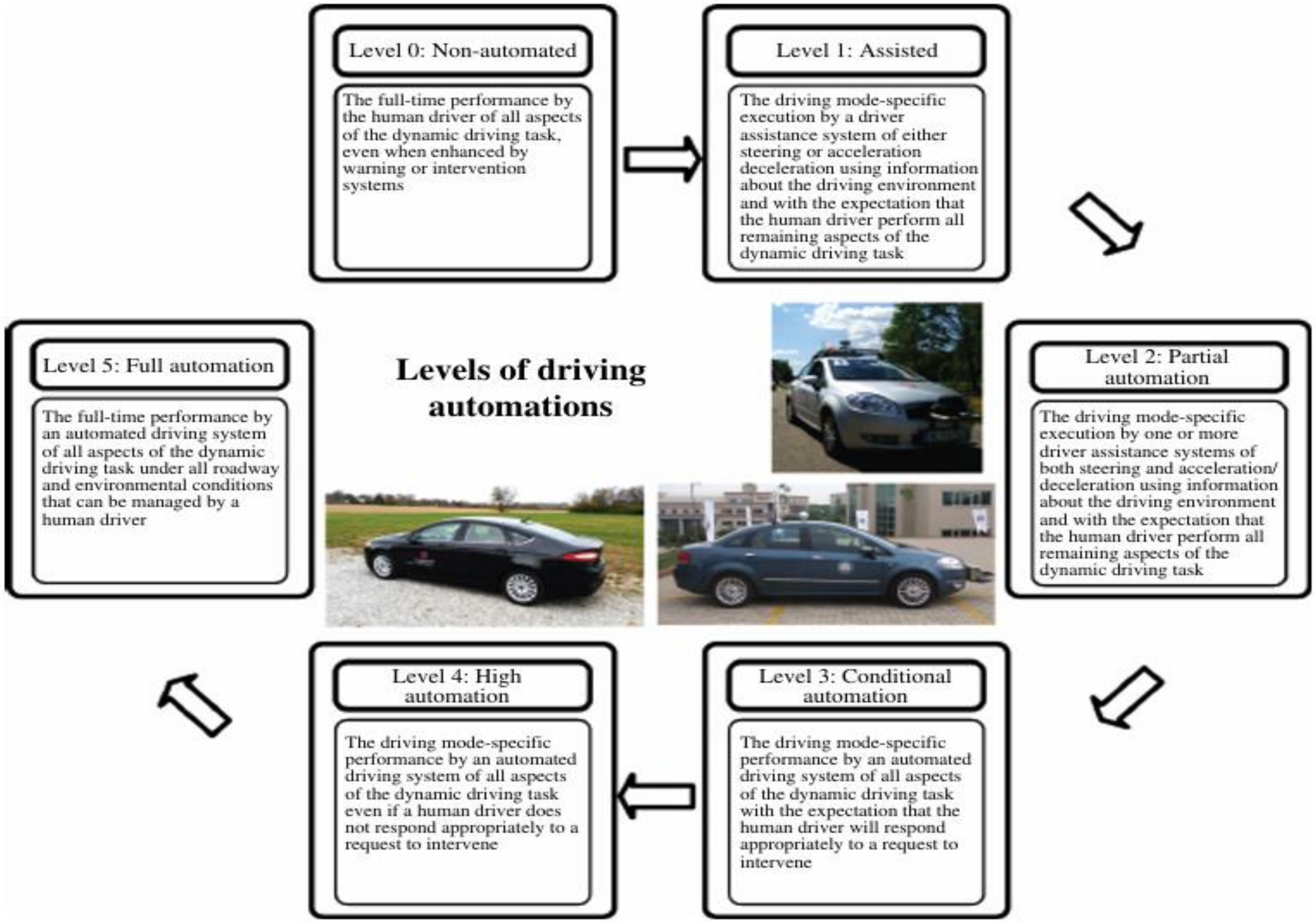


FIGURE 35.1 Categories of automated driving as defined in SAE J3016 are illustrated noting that level 5 full automation is the final goal. © Copyright by Levent Guvenc. Use with permission.

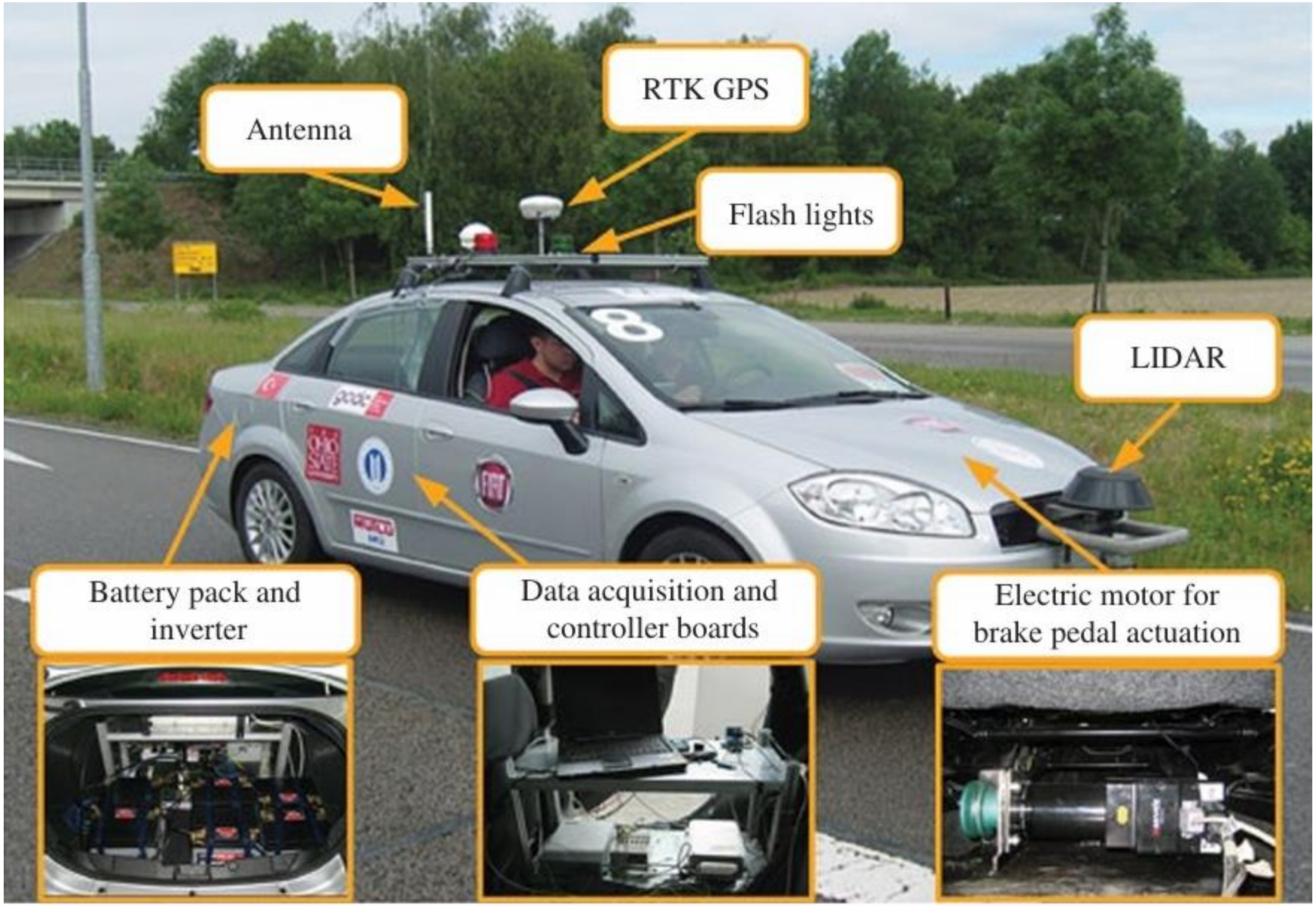
Regardless of the level of automation some common feature to be available are

1. The actuators in the vehicle in longitudinal and lateral directions have to be automated
2. Automation of throttle brake electronic throttle control (ETC), electronic brake force distribution (EBD) and interfacing to the brake pedal sensor
3. Gear Shifting (longitudinal) - electronic transmission controller needs to be accessible by software for automating gear shifting
4. Reverse Gear
5. Electric power-assisted steering (EPAS) electric motor can be used for autonomous steering

Access to all these actuators is available on the controller area network (CAN) bus in current road vehicles, hence interfacing and sending the correct CAN bus signals is now required

Recommendations

- Sensors like the speed, longitudinal and lateral accelerations, yaw rate, steering wheel position/velocity, and wheel speed sensors that can be used as part of the sensor suite needed for vehicle automation
- While shortage of GPS Signals, the IMU technique can be used
- Differential antenna real-time kinematic (RTK) GPS sensor
- An inertial measurement unit (IMU) with at least a 10 Hz update rate and 1–2 cm of accuracy
- Inertial navigation system calculations are used with the IMU readings to obtain correct position information
- On weak GPS signals – with Kalman filter


Antenna
RTK GPS
Flash lights
LIDAR
Battery pack and inverter
Data acquisition and controller boards
Electric motor for brake pedal actuation

- Intelligent cameras are used for cheap but reliable environment sensing
- The Radar sensors with built-in microprocessor
- Lidars
- 64-Plane Lidars used in Google driverless vehicles
- All of these vehicles will necessarily have a navigation system which will have a high resolution digital map providing electronic horizon information in real time
- In current scenario, different suppliers provide new/different interfaces results huge no. of ECUs.
- A new hardware architecture comprising of a smaller number of more powerful ECUs has to be adapted and utilized in the future
- Cost payoff
- Electric vehicle

Connected Vehicle Technology & CV Pilots

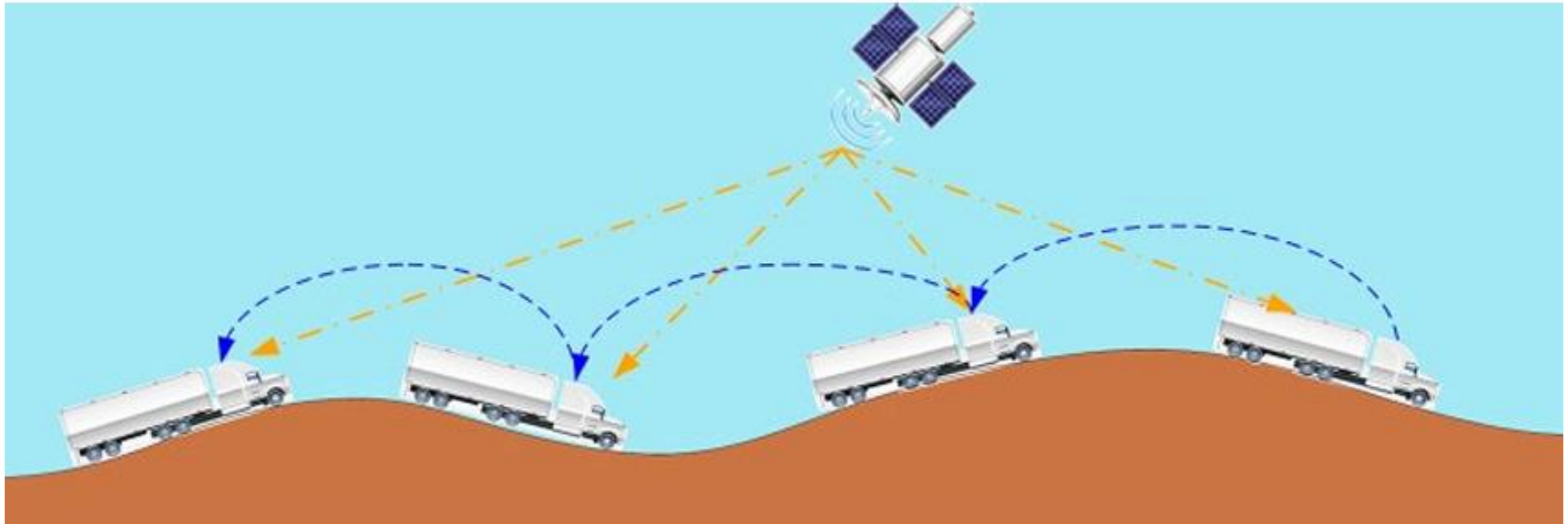
- Connected Vehicle Technology is an Enhancement on autonomous vehicle
- There exist a Modem in vehicle
- WAVE – Wireless Access in Vehicle environment based on IEEE 802.11p is used in intelligent transportation systems (ITS) band of 5.9 GHz
- V2v, V2I, V2X
- Picture

- ACC to control the gap between vehicle
- Speed limits, signals by roadside unit
- Cooperative Adaptive Cruise Control

- low-cost longitudinal cooperative driving system that uses communicated position/velocity/acceleration information with a low-cost GPS has been implemented and tested successfully [17] in the GCDC
- avoiding congestion during traffic shockwaves
- collision warning and curve speed warning
- warned of pedestrians and bicyclists who are nearby
- fuel minimization and through avoiding congested traffic
- The DOT in the United States has been funding CV test sites, CV application development efforts, and now large-scale CV deployments on real roads
- SPAT – Process dynamic information (weather, traffic, road condition)

Automated Truck Convoys

- Automotive OEMs will not develop new technological features unless there is a demand from the buyers or a mandate by the regulating authorities
- Interestingly, the biggest need and demand for driving automation comes from the logistics sector due to many reasons.
- The lack of skilled truck drivers, Slow paced loading/unloading
- Regulation of driver rest policy – makes the CV / semi automated driving attractive for track manufacturers and buyers
- It is basic implementation, they use radar and cameras
- camera is used for lane keeping control and the radar is used for longitudinal control.



- predictive cruise control – Slop detection, speed limit, fuel saving

Unified Design Approach

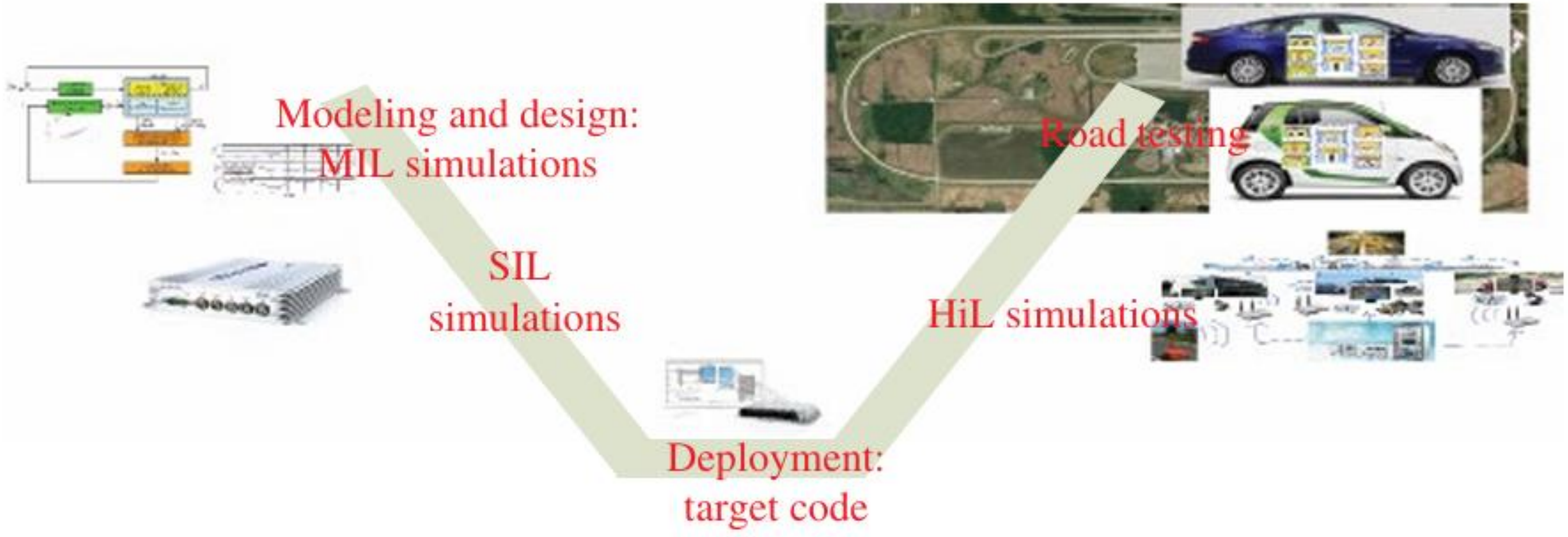


FIGURE 35.6 The V-diagram of a unified approach for developing connected and automated driving systems starting with model-in-the-loop simulations and ending in road testing. © Copyright by Levent Guvenc. Use with permission.

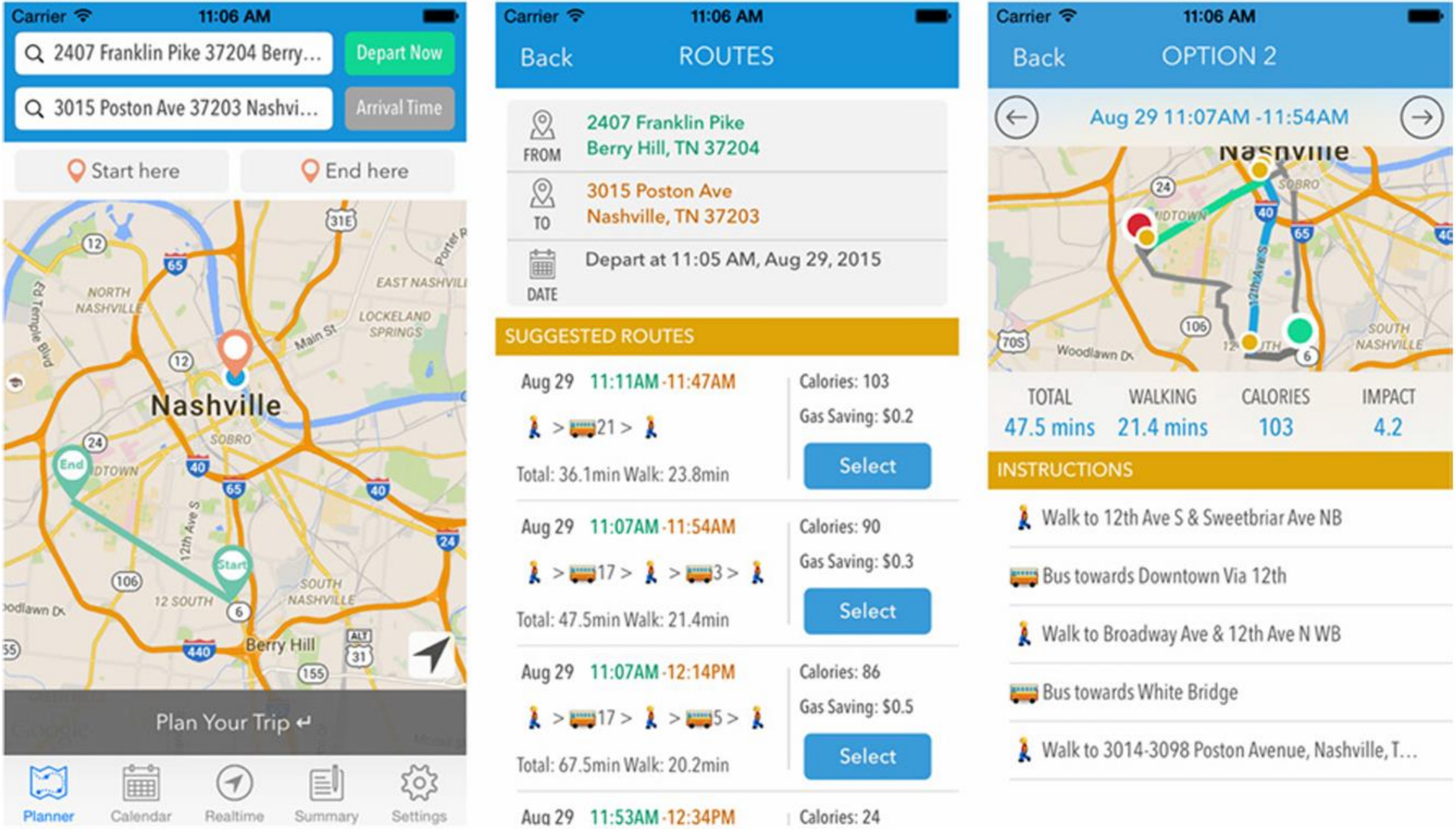
- Model-in-the-loop (MIL) simulations – Model
- software-in-the-loop (SIL) simulation - Code
- hardware-in-the-loop (HIL) – Real time simulation
- The rest of the vehicles and traffic situations will be virtually generated using real-time capable simulation computers
- vehicle-in-the-loop (VIL) - test vehicle with a synthetic test environment such as a traffic simulation.

The Transport Industry: Current Status and Outlook

TRANSIT HUB: A SMART DECISION SUPPORT SYSTEM FOR PUBLIC TRANSIT OPERATIONS

TRANSIT HUB: A SMART DECISION SUPPORT SYSTEM FOR PUBLIC TRANSIT OPERATIONS

- Big problem in smart city / large city is traffic
- Irony is that bus transport some time economy (Walk) (cost, time)
- Roads are design for earlier population (Many cities doubled)
- Restructuring the infrastructure/ Adding new (cost, time)
- shared mobility options like public transit
- Researchers from the Institute for Software Integrated Systems at Vanderbilt University have teamed up with the Nashville MTA and Siemens Corporate Technology to work on the Transit Hub [3] project
- This project aims to put accurate, real-time information about potential travel options into citizens' hands as soon as they choose their desired destination from their current or a specified location



Carrier
11:06 AM
2407 Franklin Pike 37204 Berry...
Depart Now
3015 Poston Ave 37203 Nashvi...
Arrival Time
Start here
End here
Nashville
NORTH NASHVILLE
EAST NASHVILLE
LOCKELAND SPRINGS
SOBRO
SOUTH NASHVILLE
12 SOUTH
Berry Hill
End
Start
Plan Your Trip
Planner
Calendar
Realtime
Summary
Settings
Carrier
11:06 AM
Back
ROUTES
FROM
2407 Franklin Pike
Berry Hill, TN 37204
TO
3015 Poston Ave
Nashville, TN 37203
DATE
Depart at 11:05 AM, Aug 29, 2015
SUGGESTED ROUTES
Aug 29 11:11AM -11:47AM
> 21 >
Total: 36.1min Walk: 23.8min
Calories: 103
Gas Saving: $0.2
Select
Aug 29 11:07AM -11:54AM
> 17 > > 3 >
Total: 47.5min Walk: 21.4min
Calories: 90
Gas Saving: $0.3
Select
Aug 29 11:07AM -12:14PM
> 17 > > 5 >
Total: 67.5min Walk: 20.2min
Calories: 86
Gas Saving: $0.5
Select
Aug 29 11:53AM -12:34PM
Calories: 24
Carrier
11:06 AM
Back
OPTION 2
Aug 29 11:07AM -11:54AM
TOTAL
47.5 mins
WALKING
21.4 mins
CALORIES
103
IMPACT
4.2
INSTRUCTIONS
Walk to 12th Ave S & Sweetbriar Ave NB
Bus towards Downtown Via 12th
Walk to Broadway Ave & 12th Ave N WB
Bus towards White Bridge
Walk to 3014-3098 Poston Avenue, Nashville, T...

- The static info about the transport is already available (TT)
- The MTA use Automated Vehicle Location (AVL) System, which is a fleet-wide Tracking System. (Tracking, mgmt, software, Geofencing)
- User can consider options (biking, walking, public transit, driving)
- This project Transit Hub project as a large-scale distributed human cyber–physical system (CPS) (Sensors in the environment provides Info)
- Data collected also used in predictive analysis to improve the model.
- This papers analysis about the technical background and backend data services.

Challenges :

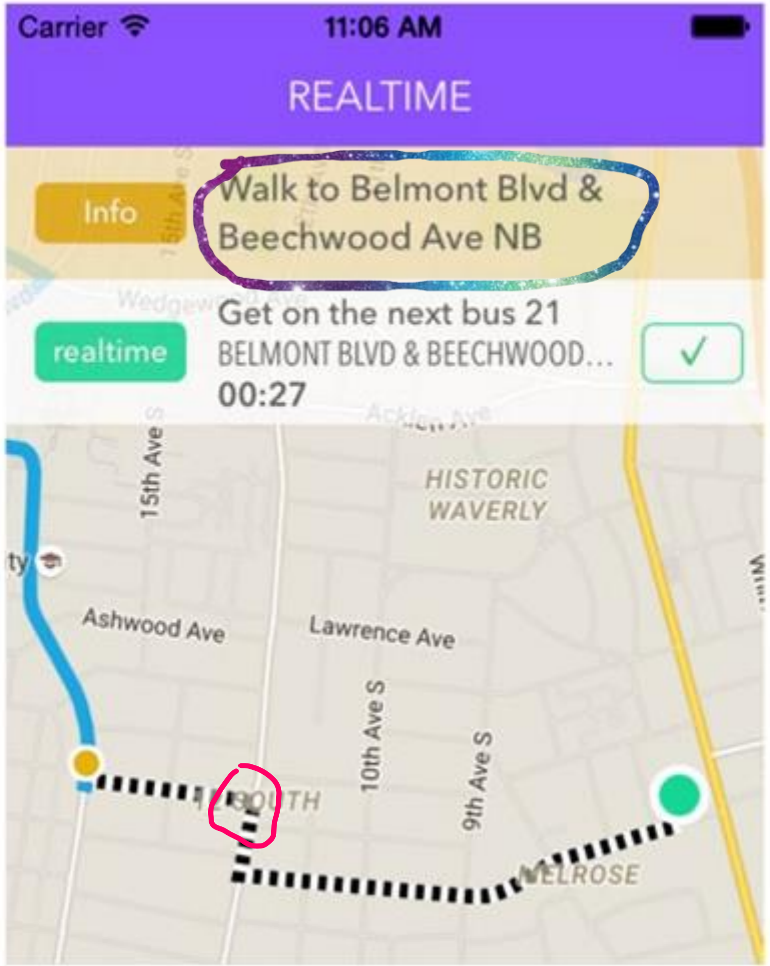
- Scale and Heterogeneous
  - Sensor collects data –Large data exchange, network (LTE, Bluetooth, Wireless HART, Wi-Fi LAN (e.g., DSRC/802.11p)
- Data dissemination
  - Needs modern middleware technology that can seamlessly allow configuration and management of distributed application across heterogeneous networks
  - AMMO —Android Mobile Middleware Objects (DARPA)
  - Supports broadcast publish–subscribe with content filtering and Client/Server
- Architectural framework for the decision support system
  - Recommended to use multi-model simulation approach
  - High-Level Architecture (HLA), address the integration of distributed heterogeneous simulators using distributed discrete-event semantics
  - Command and Control Wind Tunnel (C2WT) (This work tend to use their previous word)

Integrated Sensors

- GPS antenna and receiver located onboard (for AVL)
  - (vehicle odometer readings)
- RFID
- Fare box (Based on AVL)
- Infrared-based Automated Passenger Counter (APC)

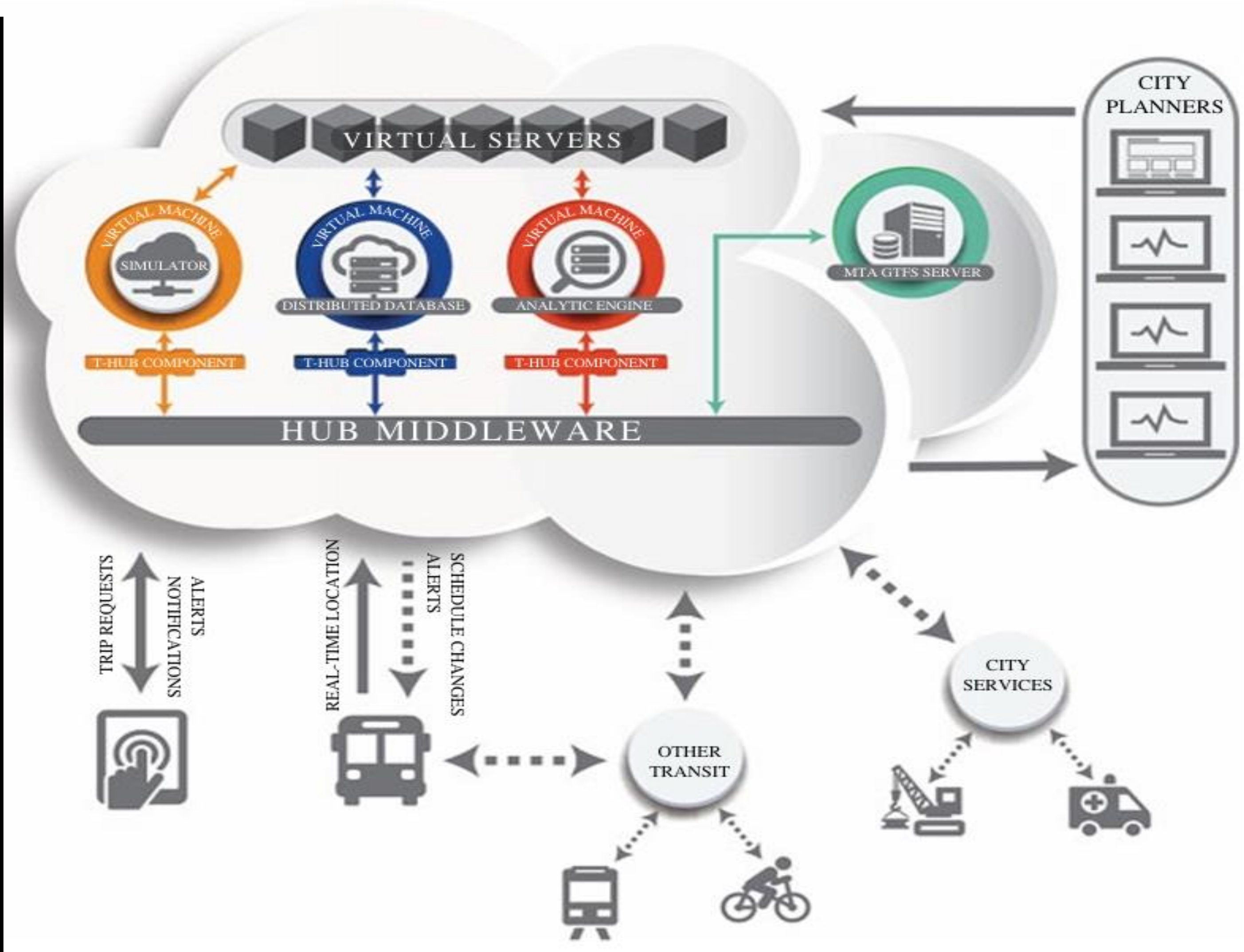
TRANSIT HUB SYSTEM WITH MOBILE APPS AND SMART KIOSKS

- It is a mobile app (Trip Planner)
- Used Start and destination Points (User friendly)
- Provide real time data (go/Get down)
- Later use ML
  - Recommend add/alter stops



Transit Hub Information Architecture

- Overall Transit Hub decision support system which enables the smartphone application
- Hub middle ware responsible for coordinating all the Transit Hub activities.
  - Runs data collection service
  - Analyze the collected data
  - Runs simulations to provide a decision support framework in response to client requests
- The data collection service collect the data from various fields and places in distributed DB.
  - This service ensure the timeline and data quality.
  - Places in multiple (Master/ Slave)



IGURE 36.3 Transit Hub design. Reproduced with permission from Abhishek Dubey.

Three Types of data (being collected)

- Real-time feeds from Nashville MTA—
  - Google has defined the General Transit Feed Specification (GTFS) [7] for transit authorities to release transit data feeds.
  - The authorities publish their transit data using this GTFS format
  - TransitHub Mobile app collects this info
- Traffic-related feeds
  - In Nashville city the below org publish the Traffic related info
  - The Tennessee Department of Transportation **(TDOT)**
  - **HERE API** [8] is another source for traffic congestion information
  - TransitHub uses HERE API
- Trip information
  - Data from Transit Hub mobile application (base on user permission) can be used for data analysis
- The TransitHub uses MongoDB, a distributed NoSQL database to manage and store the data

- **Data Collection and Storage**:

- Real-time transit data from Nashville MTA –
  - The TransitHub gets data from Nashville MTA and stores
  - The size of the data being stored in the database is about 3 GB per day.
- Real-time traffic flow information from HERE API
  - The data collected from Nashville MTA is raw (2.8GB per day)
  - To optimize (static info →static point, layouts, Speed limit)
  - The TransHub adopt a time series format →only stores the traffic condition which changes since last update
  - Reduce 10% of space
- Static bus schedule dataset:
  - Updates when use public transport is added
- Crowd-sourced data from Transit Hub App
  - Collected from user(with permission) (user plans for bus routes, or user options on recommended bus routes)
  - Size depends on user (mobile quality)

Decision Support Framework for Transit Hub

- For better performance it collects data in 2 aspects
  - Global (historic information)
  - Local (user)
- Analyzing the Collected Data Feed
- Analytical engine of Transit Hub consists of a
  - simulation-based predictive model,
  - a data-driven statistical model, and
  - a real-time prediction model.
- Simulation-based model works with the real-time feed and current traffic delay information to simulate bus movement on various routes and predict delays
- Simulation of Urban MObility (SUMO) [9] microscopic simu lator for simulating city traffic

- A pool of VMs are maintained to run simulation to get and update the real time traffic information.
- The historic information like traffic congestion (jam factor-> contain level at road segments) are considered while optimizing info
- The statistical model, uses the K means cluster
  - to group traffic info for the day , optimizes the outlier with real time data and find the delay (bus) in routes and
  - It runs at the backend always
  - Used to find the delay and causes of delay
- Real-time prediction model utilizes
  - Incorporates the real time feed and find the short delays
  - Since it is a real time raw data there may be errors in the data,
  - Kalman filter to reduce the noise
  - So that the when estimating the arrival time at each bus stop-it is near accurate
  - It also incorporates traffic congestions, special events of a day

Dashboard and Recommendation Engine for City Planners

- Showing the options to choose route
- Shows the route options
- Delay
- outliers

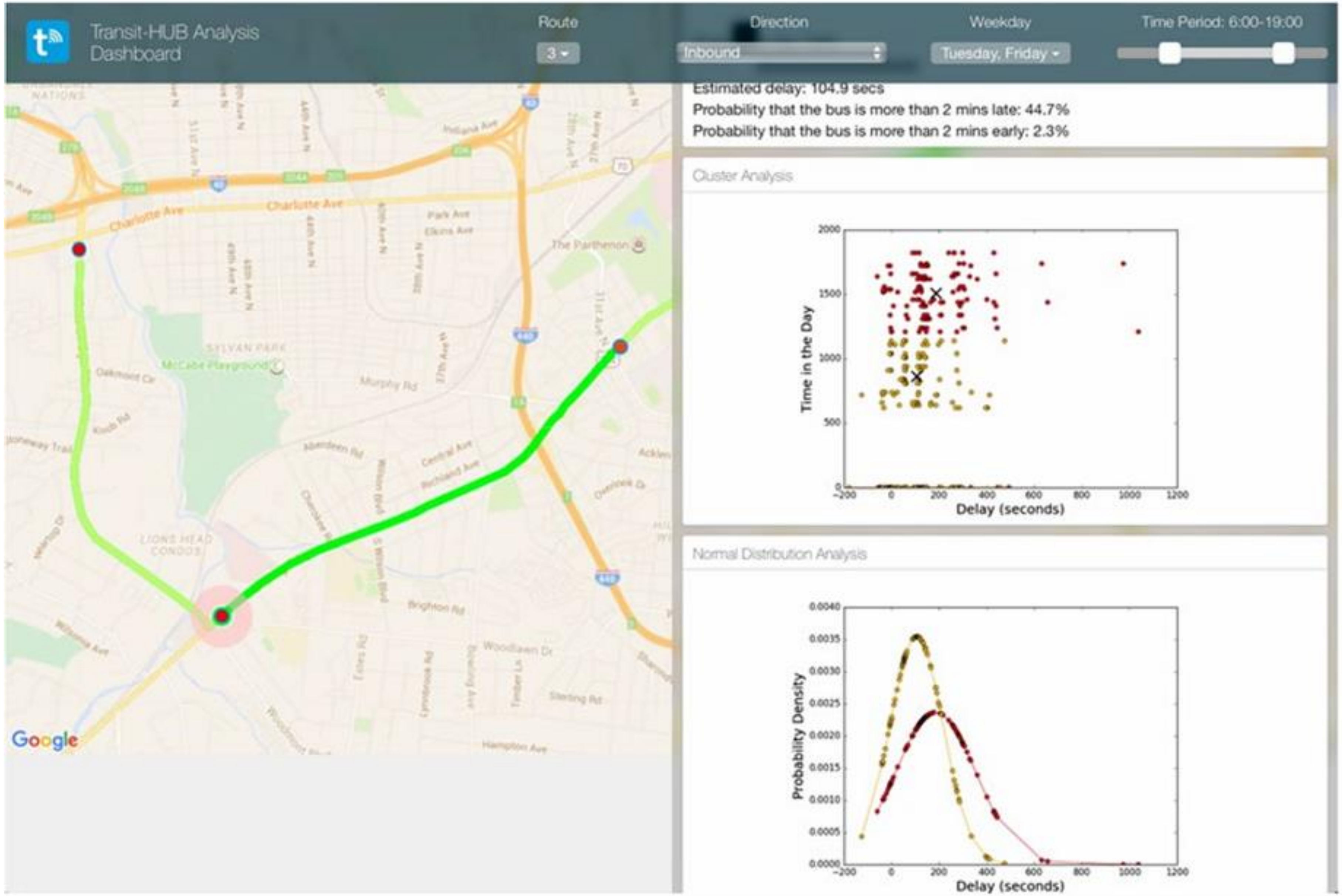


FIGURE 36.4 Transit Hub analytics dashboard. Reproduced with permission from Abhishek Dubey.

- **Infrastructure Requirements for Transit Hub**
  - Uses Nashville MTA’s scheduling and planning services.
  - User SLA is required
  - Large source of VM to run the real time simulation
- **Kiosk Systems for Human–CPS Interaction**
  - Considering the elderly and differently abled people
  - Low socio-economic status
  - And people who do have access to such services
  - Kiosk Systems enable new ways of interaction between humans and CPS. Touch based computers and terminals have been placed in public settings

ᶠIGURE 36.5 Example of a Kiosk System—Siemens smart city hub. Reproduced with ›ermission from Abhishek Dubey.

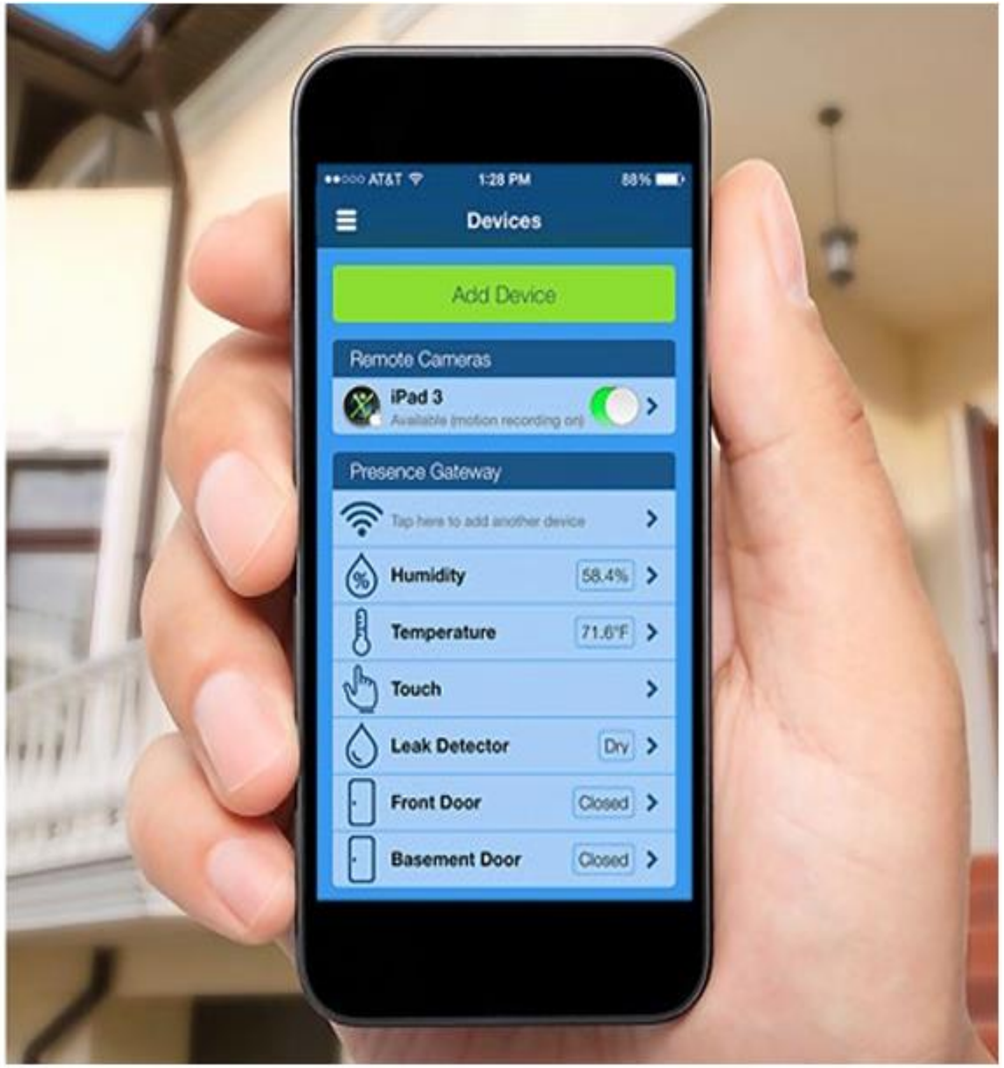
Smart Home Services using IoT

- As people concern and their life is around home, many IoT applications are around the Smart Home
- The smart phone can be used as Hub and there are many sensors inside smart phone, can be used in IOT projects
- Uses and burglars alarm
- Water Sensors
- Touch Sensors
- Motion Sensors
- Smart Plugs
- Robots (Cameras)
- Ecosystem of Devices (Interconnect the devices for common task)

- MARKET SIZE
  - Every 3 years smart home services market size increases by 50%
- Homes and Home Security
  - United States has 133 million housing units, and China had almost 456 million households in 2012.
  - These two country have 61% of market share
- Home Security Market Challenges
  - Targets middle and upper income groups
  - Rental – Tenants don’t want to invest
- The IoT Solution and IoT Market
  - More low cost DIY home security system will rule the market
- IoT Challenges
  - Many devices related to home security is being used already, and lack of awareness in the challenge

CHARACTERISTICS OF AN IDEAL SYSTEM

- Mobile usage
- Sensor integration
- Can control from your palm
- Out of Box experience
  - Make one to setup home security independently



Presence Security Pack

- Social engagement

FIGURE 37.4 This screenshot shows an example of an app that is customizable to the end user's needs. The user can add or delete devices at the touch of a button.

IoT Technology

- People Power's IoT Suite includes
- **Presto**, which connects IoT devices to the Cloud for free (Figure 37.6);
- **Symphony**, which provides social engagement, data analytics, and a blazingly fast mobile rules engine;
- **Virtuoso**, which allows telcos and utilities to offer compelling apps for home security, energy, healthcare, and more, under their own brand;
- **Maestro**, which enables service providers to technically support end users; engage them with challenges, points, and rewards;

FIGURE 37.6 IoT software architecture.

Presto:

- Open API (Manufacturers)
- Using the application the device may connected to cloud
- 2048-bit SSL
- 12 updates per hour can be made
- cloud-to-cloud integrations and OAuth 2.0 and can even connect with devices that are already existing
- **Features**
    - HTTP GET and POST to send measurements and receive commands.
    - Both JSON and XML support, it’s the developer’s choice.
    - Bidirectional data streams, usually less than 50 bytes per minute.
    - NAT and firewall penetration
    - Synchronization in 0.25–0.50 second latency
    - Online and offline recognition of devices and people
    - Automatic data correction and filters
    - Manage dropped connections, reliably deliver missed messages
    - Marshal message delivery to low-capability devices
    - Broadcast and unicast messaging, sharing a single pipe

Symphony

- Deployable cloud server (to connect your IOT devices)
- Harmony delivers an engaging customer experience that encourages sharing, competition, cooperation, and social commerce
- It has a Social Engagement Layer (can share the smart home reading to trusted neighbours)
- Harmony also bridges IoT with popular social networks, such as Twitter and Facebook
  - **Motivational bridges (** Appreciations, word-of-mouth advertising with points)
  - **Goal setting and public commitment**
  - **Incentives and competition** - Competitions can range from living healthier lives or being in touch with your home environment to being an active promoter of smart home service to others.

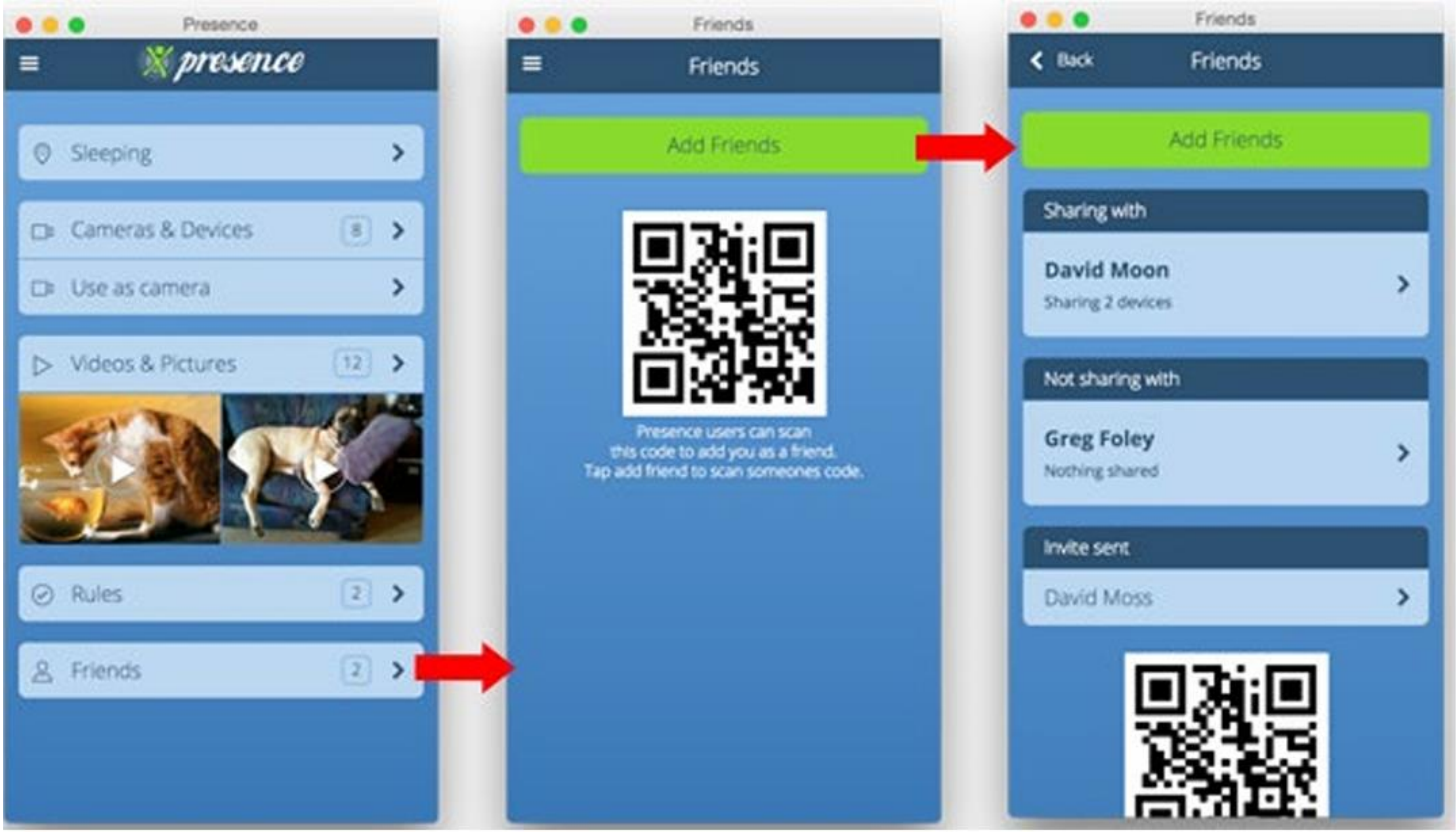


FIGURE 37.7 Harmony social engagement layer.

Composer: Smart Learning Analytics and Automation

- Smart Analytical engine for IOT

Virtuoso

- An app framework for iOS, Android, and Web enable the rapid deployment

Maestro

- Monitors the Connected IOT devices and control them remotely.
- It Diagnostics, dashboards, and predictive analytics simplify
- Maestro can facilitate large-scale community engagements
- Device status monitoring and troubleshooting
- In-app messaging to groups or individuals
- Gamification with Points and Rewards

- **Geofencing**
- Make a virtual boundary
- Away registration
- Away service gets on (Shutdown of power gas etc)

UNIT 5

- ***Unit-5 - Case Studies in IoT Healthcare 9 Hrs***
- *Big Data Analytics for Healthcare and Cognitive Learning* ***T2-Ch7***
- *Machine Learning for Big Data in Healthcare Applications* ***T2-Ch7***
- *Healthcare Problems and Machine Learning Tools* ***T2-Ch7.1***
- *IoT-based Healthcare Systems and Applications -* ***T2-Ch7.2***
- *Emotional Insights via Wearables –* ***T3-Ch 38***
- *Structural Health Monitoring -****T3-Ch 40***
- *Home Healthcare and Remote Patient Monitoring -* ***T3-Ch 41***