CHARIOT - Tools And Algorithms for Enabling Resilient Extensible CPS

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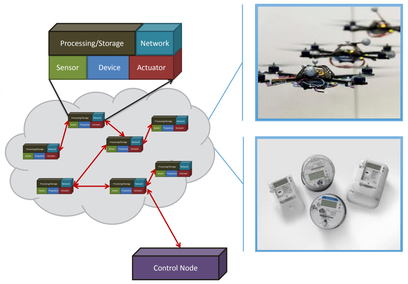
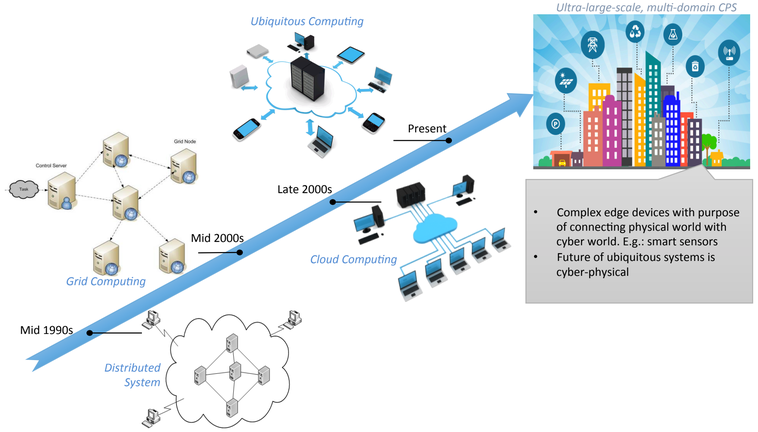
EXTENSIBLE SYSTEM

EXTENSIBLE SYSTEMS: CPS

- Ultra large scale ubiquitous software integrated distributed systems that interact with physical environment.
- A networked (wireless) platform that can be used by many, possibly concurrent applications
- Physical configuration/topology affects the available computational resources.
- Physics imposes timing constraints on the computational and communication activities.



EXTENSIBLE SYSTEMS: EVOLUTION

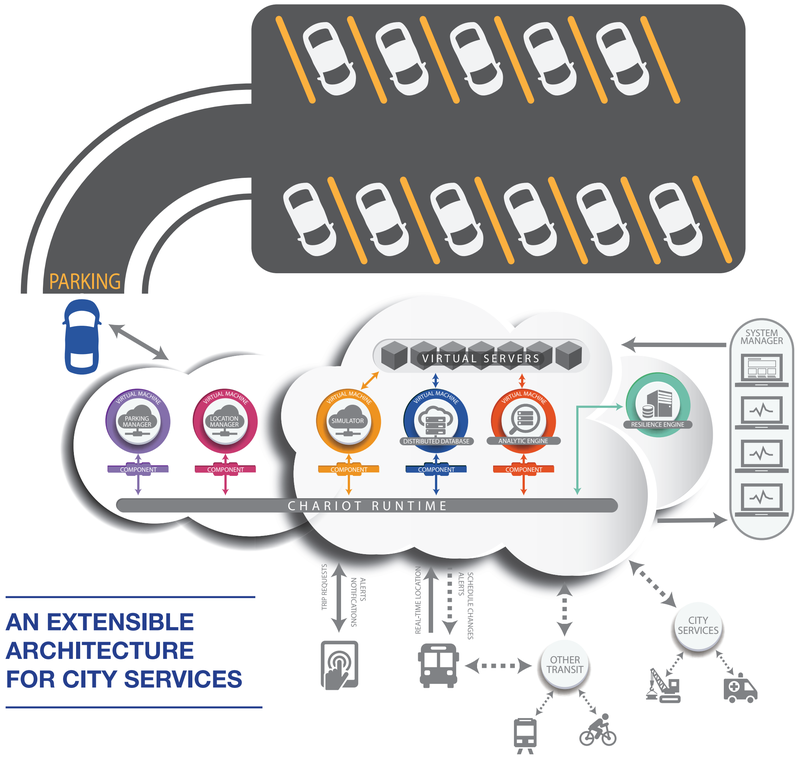


- Complex edge devices with purpose of connecting physical world with cyber world. E.g.: smart sensors
- Future of ubiquitous systems is cyber-physical

CHALLENGES IN EXTENSIBLE CPS

Property	Description
Multi-tenant	Extensible CPS are open platforms that can host multiple applications belonging to different organizations/clients
Dynamic	Functionality and resource extensibility results in a dynamic system that can expand or contract at any time
Remotely deployed	Some resources may be remotely deployed resultin in very limited or no opportunity for human interaction. e.g.: UAVs, satellites, etc.
Heterogeneous	Each subsystem of an extensible CPS platform can belong to different domain. Also, distributed ownership of entities in same domain.
Resilient *(Desired property)*	Susceptible to failures and anomalies during which functionalities provided by different systems should be maintained in order to be continuously operational as long as possible

CITY EXAMPLE

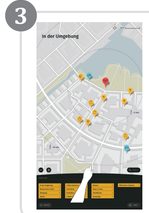


AN EXTENSIBLE ARCHITECTURE FOR CITY SERVICES

USE CASE

1. 
A car is looking for a place to park.

2. Hub prompts that the car go to the parking lot on Edge Street.


3. 

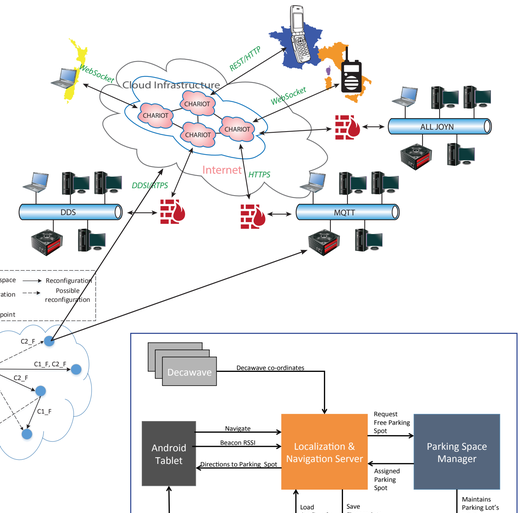
Hub interacts and reserves a parking spot.

4. 
Parking Management guides the car to the parking spot.

5. 
The car successfully parks in the reserved spot.

TECHNICAL APPROACH

UNIFIED APPLICATION MODEL AND RUNTIME MANAGEMENT



APPLICATION TO SMART PARKING

- The smart parking application relies on two indoor positioning technologies
  - Ultra-wideband (UWB) active tags
    - Requires specialized hardware (beacons and tags)
    - High accuracy (<10cm errors)
  - Bluetooth Low Energy (BLE) RSSI fingerprinting
    - Requires a beacon infrastructure (e.g. Intel Edison devices)
    - Tags are COTS devices, such as current generation smartphones and tablets
    - Positioning accuracy is ~3m
    - Requires training to create a mapping from RSSI statistics to positions (fingerprinting)
      - Training algorithm is running continuously as long as both UWB and BLE RSSI measurements are available
- Robust failover
  - If UWB subsystem fails or not available, the system will fall back to BLE RSSI based positioning
- Parking space manager
  - allocates parking spot
  - uses the positioning subsystem to track vehicle (BLE equipped tablet/smartphone with optional UWB tag)
  - computes and dispatches driving directions.

SUMMARY

- Supports Integration of Legacy and external applications
- Supports three consensus and voter redundancy patterns
- Support for multiple middleware transports
- Support for active monitoring of application (future)
- Support for Application Diagnosis (future)
- Support for other languages (future)
- Support for iOS (future)