

Low-cost Versatile Tracking Device and Technology for Logistic Applications



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for Logistics and Supply
Chain Management
Enabling Technologies**



Outline



- Market demand
- Objectives & challenges
- Functionality and design
- Core innovations
- Competitiveness
- Potential applications
- Pilot projects



Market Demand



- Huge market of location-based services (LBS)
 - USD 15.04B in 2016 to USD 77.84B by 2021, 38.9% compound annual growth rate (Research & Market 2016)
- Problem of existing technologies
 - GPS and RFID represent the two ends of the tracking technology spectrum
 - No existing technologies for seamless and continuous tracking at goods level for transit from indoor to outdoor, from goods to container



Objectives & Challenges



- To develop versatile low-cost tracking devices and ubiquitous tracking technologies for logistics applications
- Challenges
 - How to realize ubiquitous positioning?
 - How to decrease TCO and increase ROI?
 - How to improve the flexibility to support various kinds of apps?



Functionality and Design



- Leverages the strengths of different positioning and wireless technologies
- Modular design and service-oriented architecture (SOA)
- Internet-enabled and web-service interface



Core Innovations



- Hybrid & collaborative mechanisms
 - Hybrid & collaborative positioning
 - Hybrid & collaborative communications
- Device technologies
 - Power optimization mechanisms
- Service technologies
 - Service-oriented structure



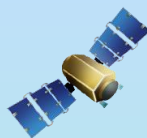
Hybrid Mechanism



| Positioning Technology | Indoor or Outdoor | Accuracy | Range & Coverage | Deployment Cost | Mobile Unit Cost | Operation & Maintenance Costs |
|------------------------|----------------------------------|----------------------|----------------------------|----------------------|------------------|-------------------------------|
| GPS | Outdoor | Medium | Long Global | N/A | Low | Low |
| Wi-Fi | Indoor & Outdoor | Medium | Long | Medium | Low | Low |
| Cellular Network | Indoor & Outdoor | Low | Long | N/A | Medium | High |
| RFID | Indoor | High | Short Room level | Medium | Very Low | Low |
| ZigBee | Indoor & Confined Outdoor | High | Medium Enterprise Level | Medium | Low | Low |
| Hybrid | Indoor & Outdoor | High Adaptive | Long & Global | Low to Medium | High | High |



Collaborative Mechanism



I can see the satellite!
So I know where I am!



I can also!
But how about we work
in turn to save power! ☺

I can not! ☹
Please help!





Hybrid + Collaboration



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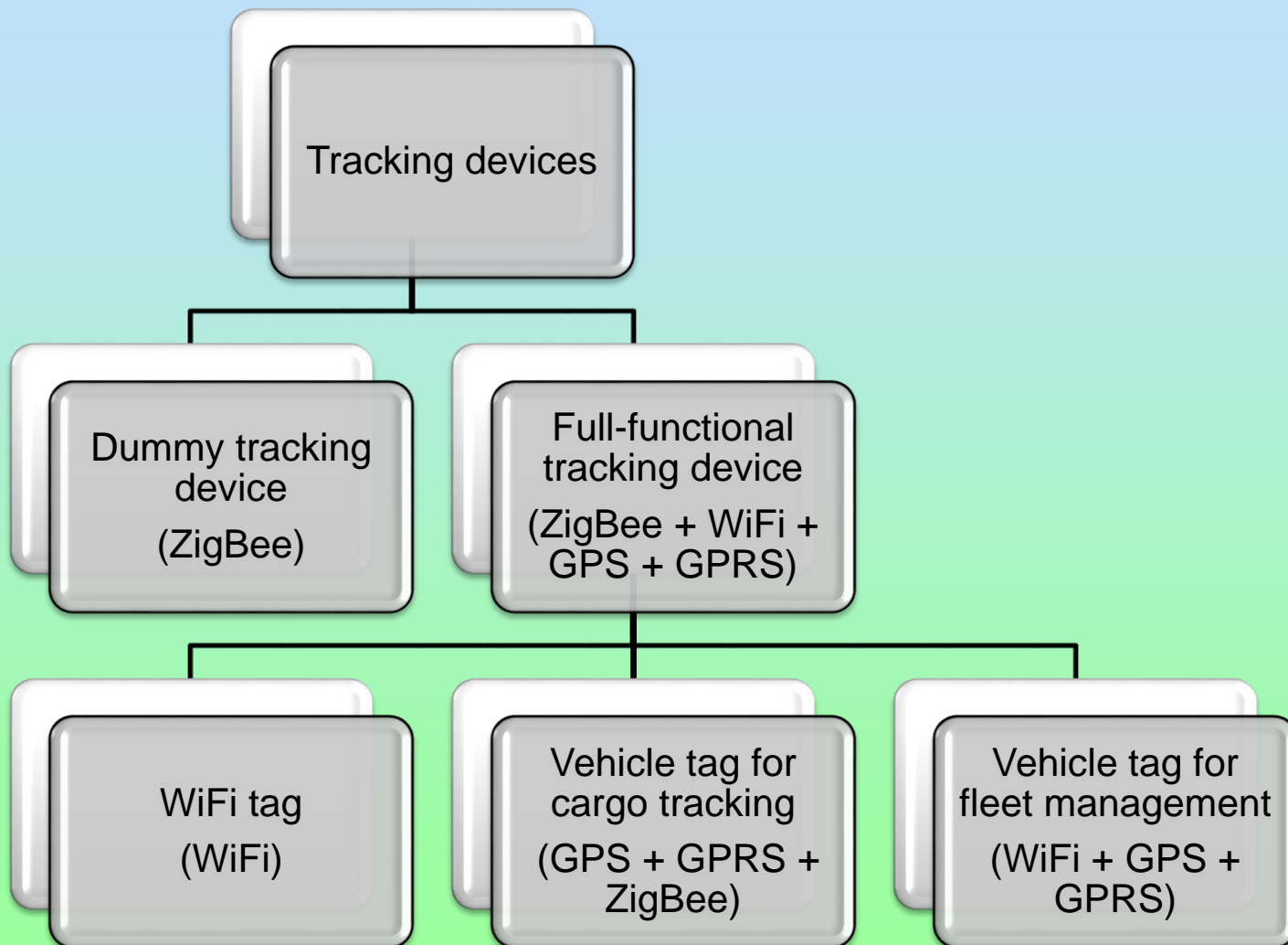
Tracking Device Characteristics



- Reliable & durable
- Compact & modular design
 - Reusable
 - Easy for customization
- Low power consumption, low maintenance cost
- Low manufacturing cost
 - BOM cost of full-functional tag is ~50USD (in quantity)
 - BOM cost of dummy device is ~8USD (in quantity)



Tracking Device Classification





Power Optimization



- Intelligent power management mechanisms
- Context-aware power optimization
- Low-power modules
- Battery life



Power Optimization

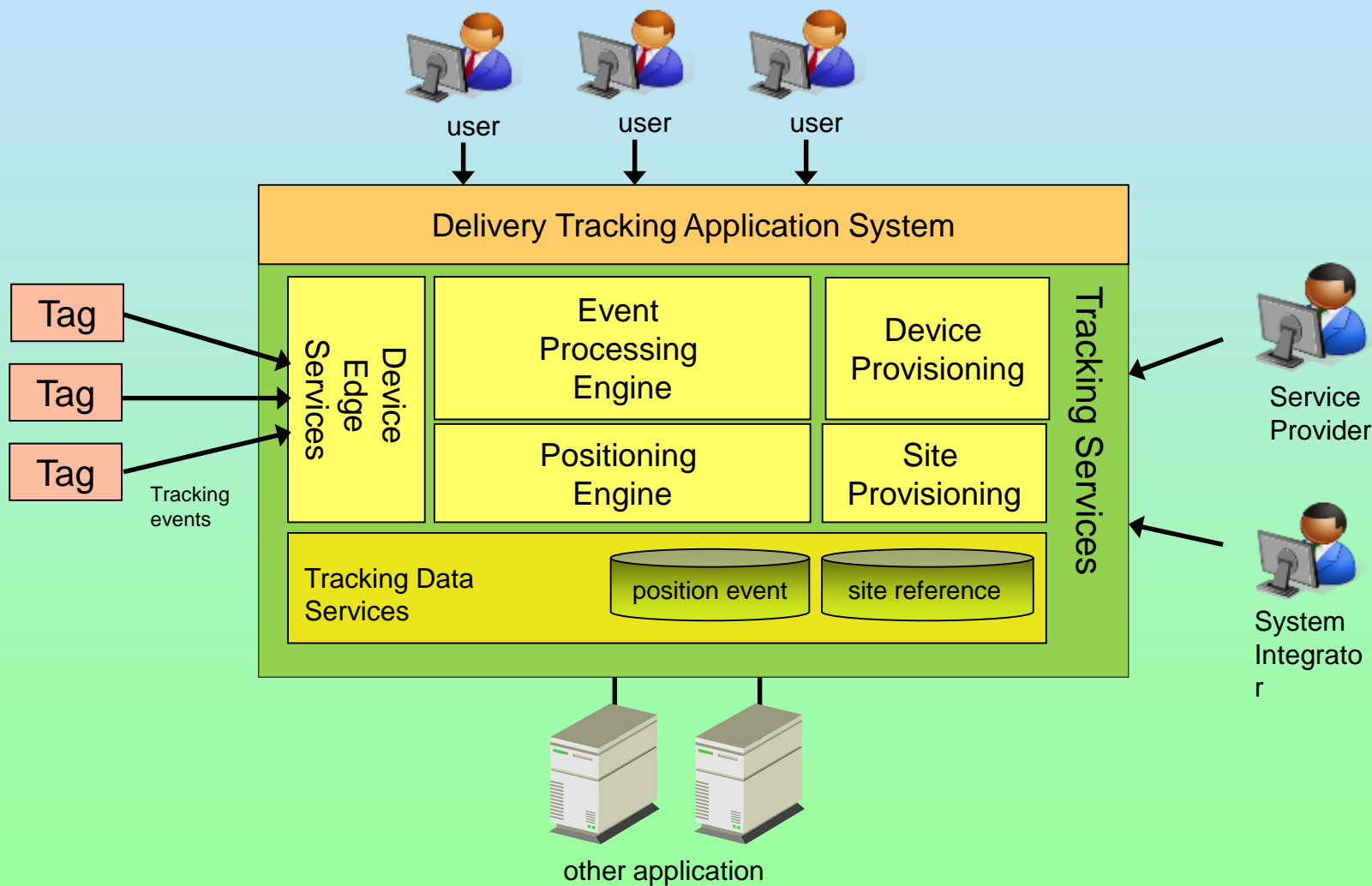


- Battery life

| | Battery capacity (mAH) | Mode (refresh interval) | Battery life |
|-----------------------------------|------------------------|------------------------------------|---|
| Item tag | 800 | Standby (10min) In motion (10s) | 2 years 2 weeks |
| WiFi tag | 1000 | Standby (10min) In motion (10s) | 120 days 2 days |
| Vehicle tag (cargo tracking) | 1000 | Standby (10min) In motion (10s) | 30 days NA (powered by vehicle DC power supply) |
| Vehicle tag (fleet management) | 1000 | Standby (10min) In motion (10s) | 30 days NA (powered by vehicle DC power supply) |
| Operator tag | 1800 | Standby (10min) In motion (10s) | 10 days 12 hours |



Tracking Application and Services





Competitiveness



- Better service availability
 - Versatile: from cargo to container, from people to vehicle
 - Pervasive: Indoor & outdoor, end-to-end location tracking
 - No similar product available in the market
- Lower cost
 - Only a small percentage of the total are full-functional tags
 - Collaborative working mode helps to lower the average costs on development, deployment, maintenance and operation
 - GPS tracker in the market costs from 500HKD to 2000HKD per piece for hardware, and around 100HKD per month for operation



Potential Applications



- **Logistics**
 - Assets tracking, fleet management
- **Transportation**
 - Tracking and navigation, location-based traffic control
- **Healthcare**
 - Equipment and staff tracking, patient navigation
- **Safety**
 - Location-aware monitoring and control, emergency services
- **Business**
 - Location-enabled shopping and advertising
 - Location-aware resource discovery
 - Location-aware smart home and smart building



Pilot Projects



- Multi-mode cargo tracking
- Fleet management in city canyons



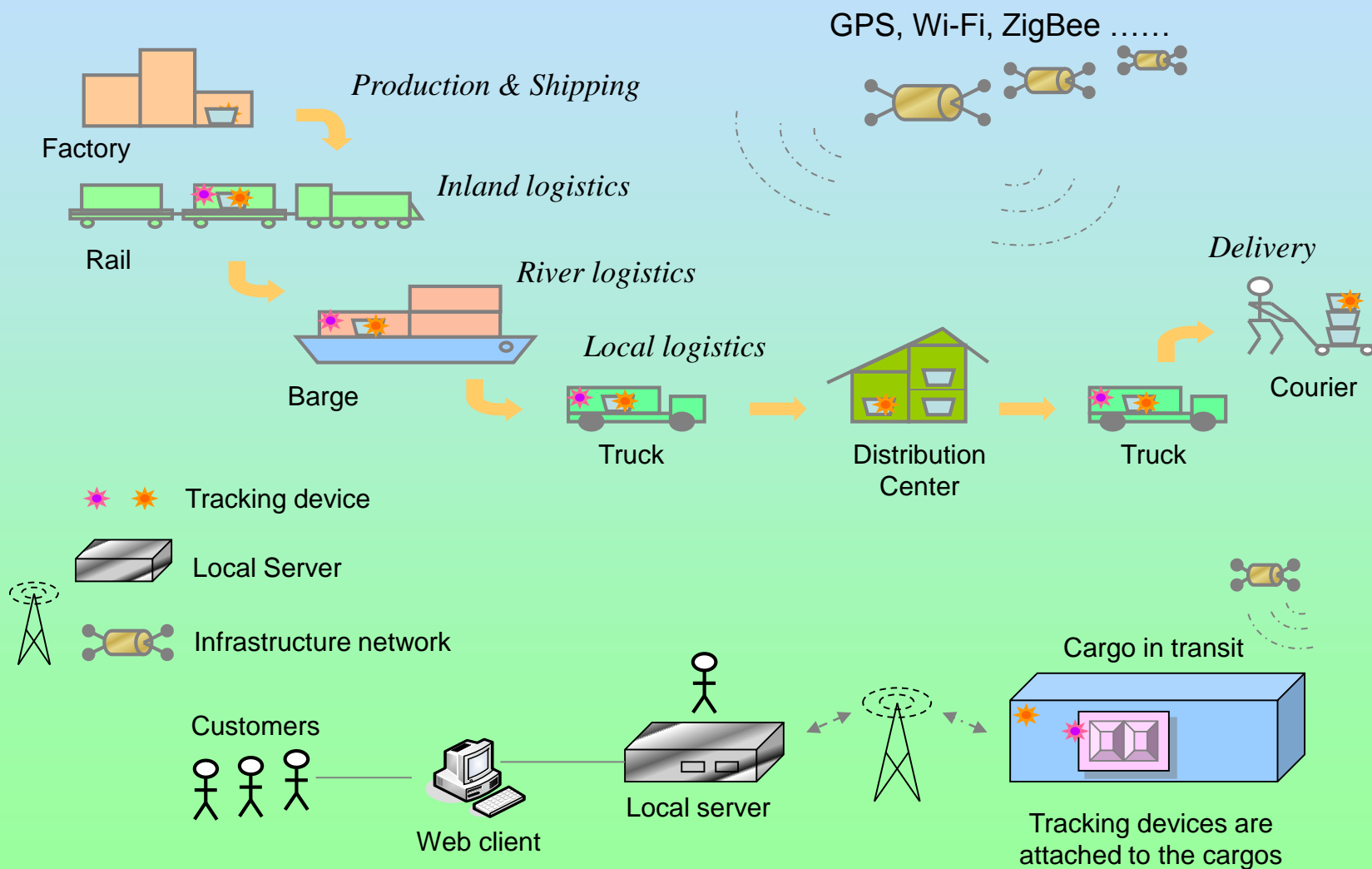
Multi-mode Cargo Tracking



- Project user: A global logistics service provider
- Objective
 - Achieve Hub-DC-Customer security as well as total visibility and traceability all the way from logistics hub to end customers
- Deliverables
 - Tracking devices used for Hub-DC-Customer cargo tracking
 - Web-based cargo tracking application system, supporting
 - End-to-end cargo tracking, seamlessly from indoor to outdoor
 - Abnormality detection and user warning

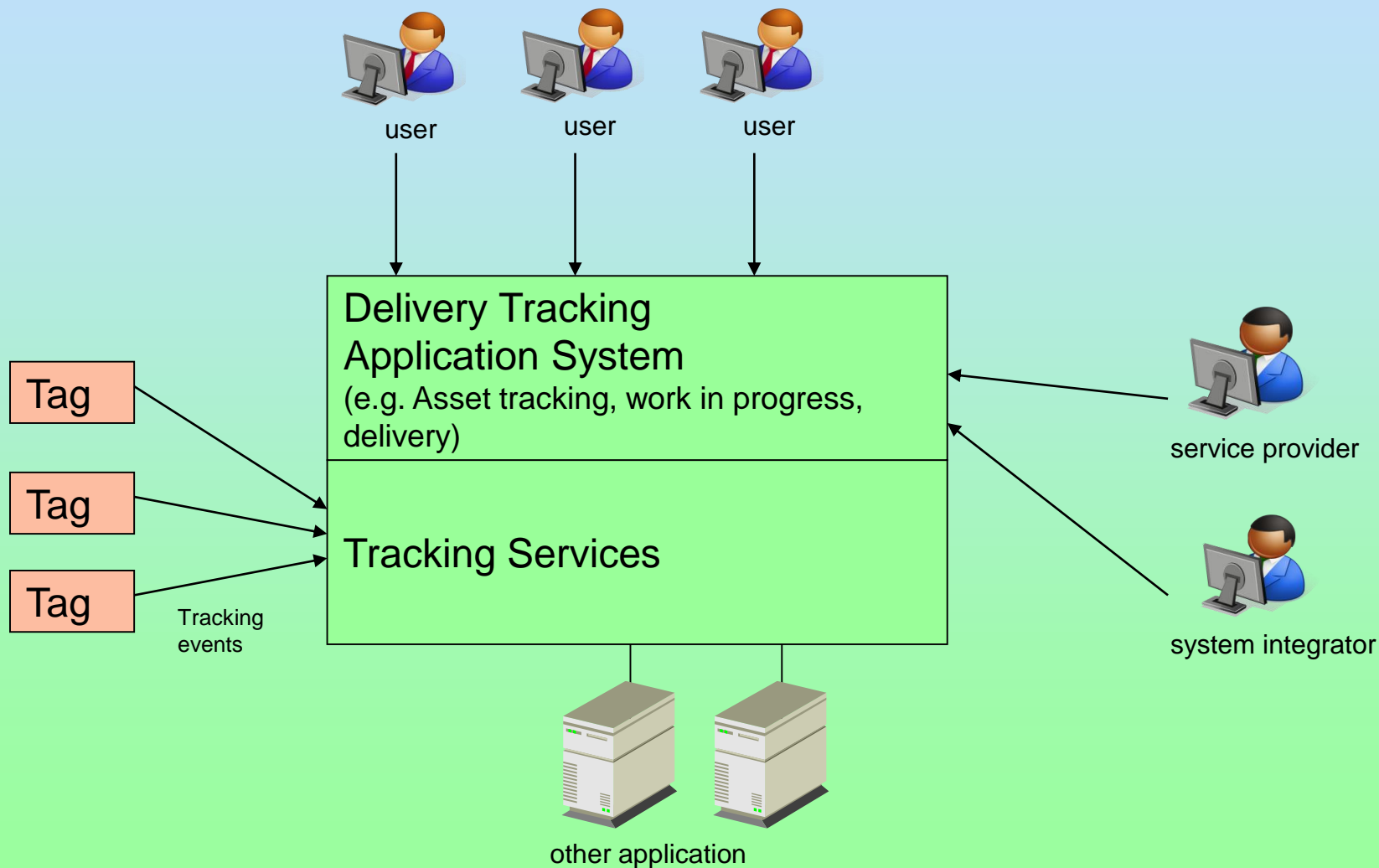


Multi-mode Cargo Tracking



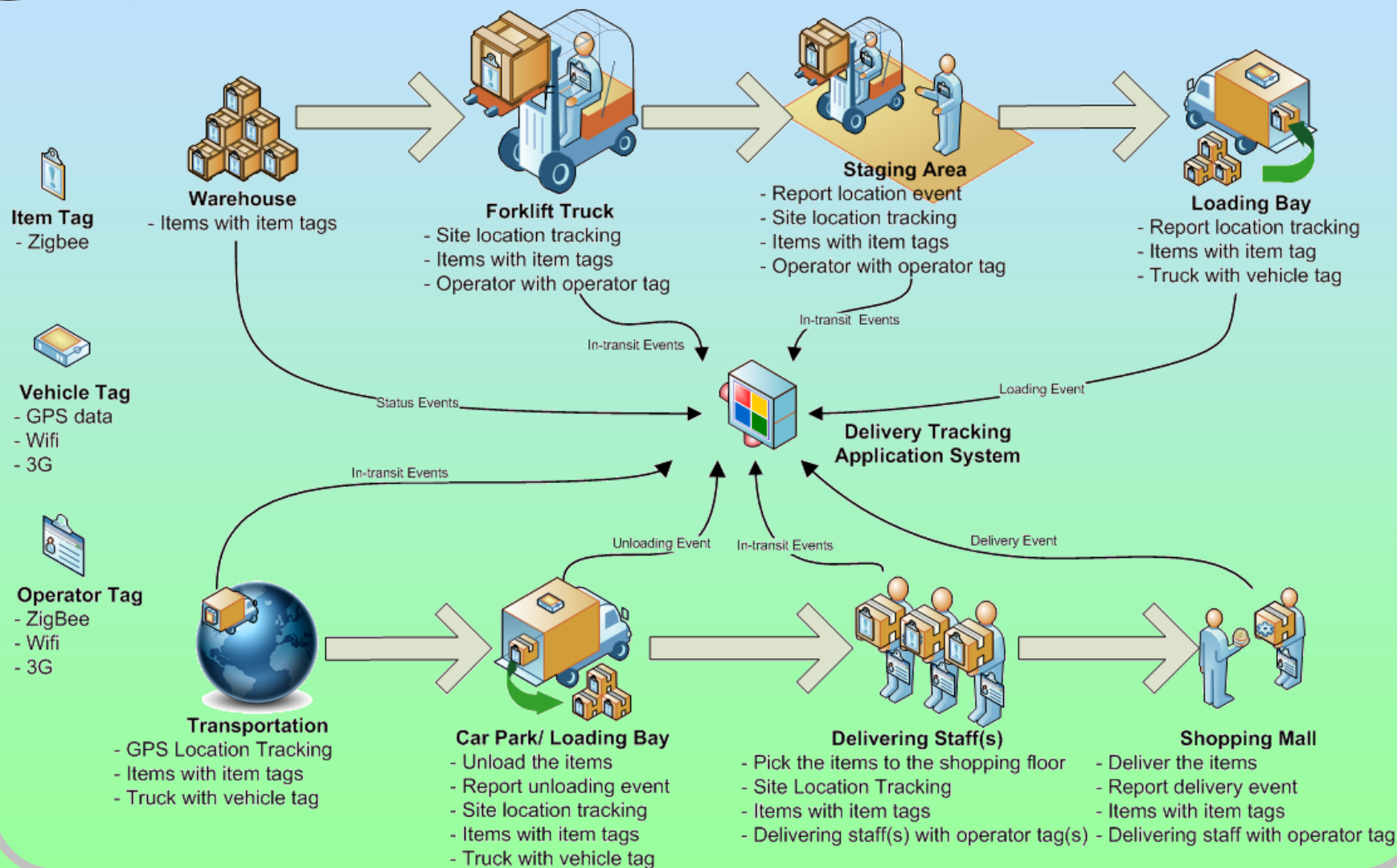


Application System





Delivery Process Flow





Tracking History



Delivery Tracking Application System



Live Monitoring Delivery Note Tracking History System Function

User Id: daniel@lscm.hk

Tracking History

☒ Date of Delivery Note: Vehicle Registration Mark:

☐ Delivery Note No:

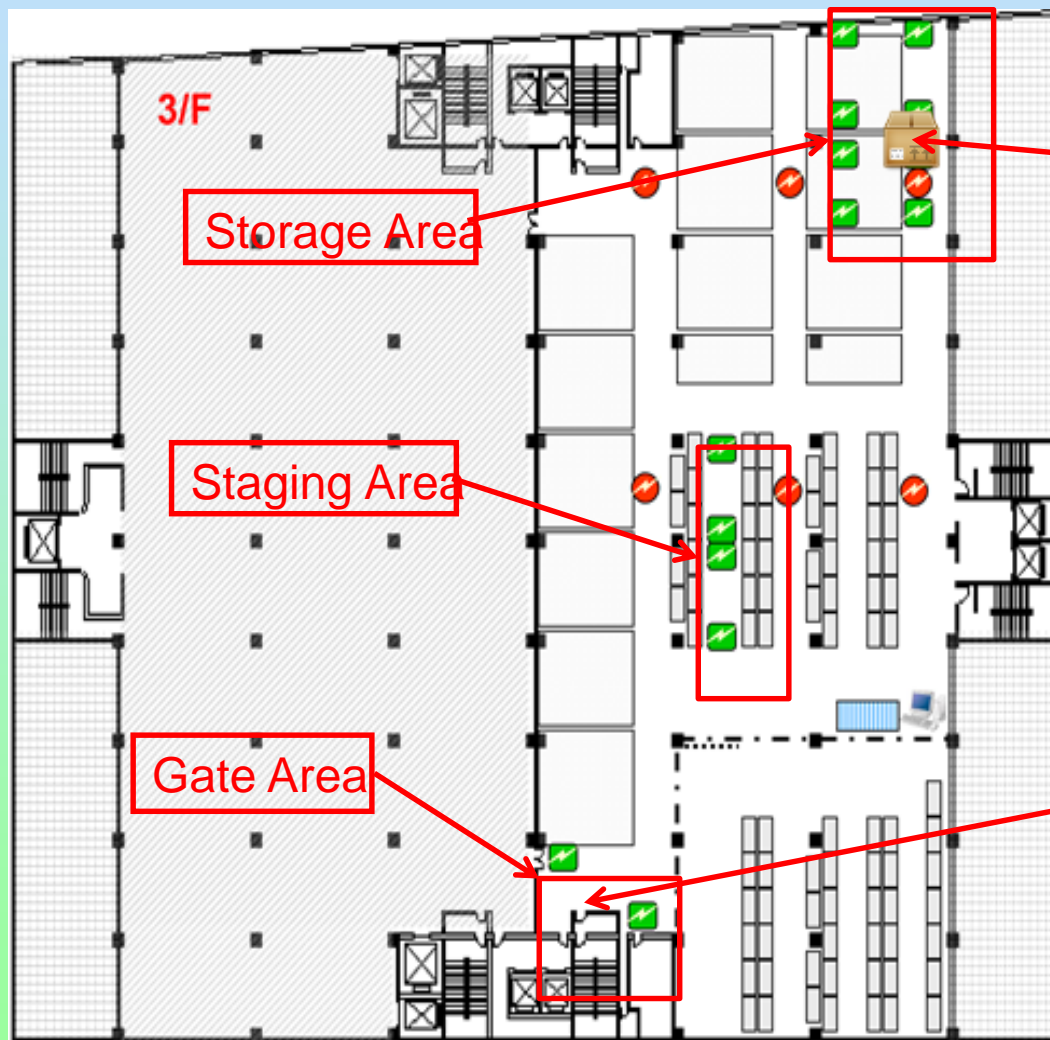
| From | To | Location | Vehicle Reg. Mark | By Staff | Delivery Status | Delivery Note |
|----------------------|----------------------|---------------------------|-------------------|----------|---------------------|---------------|
| 18 Aug 2011 14:32:32 | 18 Aug 2011 16:16:55 | Storage Area | | | In storage | |
| 18 Aug 2011 17:37:40 | 19 Aug 2011 09:40:56 | Staging Area | | | Waiting for pick-up | |
| 19 Aug 2011 09:40:59 | 19 Aug 2011 09:40:59 | Warehouse Gate | | | Picked-up | |
| 19 Aug 2011 10:15:00 | 19 Aug 2011 10:00:00 | Loading Bay | | | Loading | |
| 19 Aug 2011 10:13:10 | 19 Aug 2011 15:14:23 | Outdoor | GN819 | | In-transit | |
| 19 Aug 2011 15:14:39 | 19 Aug 2011 15:14:23 | SHOP-TimesSquare Broadway | | | Delivered | DN2011081901 |
| 19 Aug 2011 10:13:10 | 19 Aug 2011 11:49:43 | Outdoor | GN819 | | In-transit | |

Page: Go 1-7 of over 7

| Status | Delivery Note Number | | | | |
|------------|----------------------|--------------|--------------|--------------|--------------|
| In-transit | DN2011081904 | DN2011081905 | DN2011081906 | DN2011081907 | DN2011081908 |
| | DN2011081909 | DN2011081910 | DN2011081911 | DN2011081912 | |

UI of the delivery tracking application system

Warehouse Tracking



Item tag
Attached to product items



Reader
Installed in warehouse

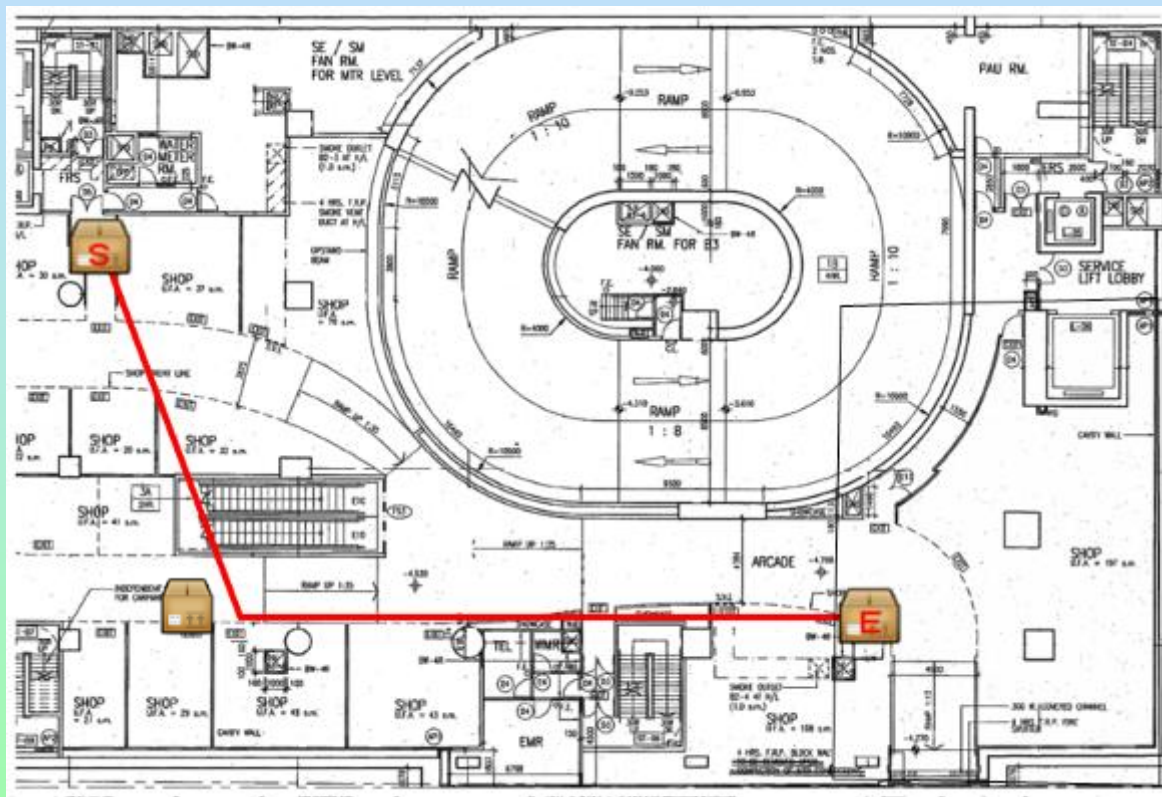
Outdoor Tracking



Vehicle tag
Installed in the truck

| Indicator | Location | Time when the vehicle is located |
|-----------|---|----------------------------------|
| | Starting location Warehouse | 5 Aug 2011 10:31:27 |
| | Delivery location Taikoo Shing Shopping Arcade | 5 Aug 2011 15:11:45 |

Shopping Mall Indoor Tracking



Operator tag
Carried by operator

| Indicator | Location | Time when the item is located at |
|-----------|---|----------------------------------|
| | Location where the item firstly appeared at the shopping mall | 5 Aug 2011 14:16:03 |
| | Location where the item was located in transit | 5 Aug 2011 14:16:31 |
| | Location where the item was delivered | 5 Aug 2011 14:23:55 |



Cost Benefit Analysis



- Pervasive cargo tracking system
 - No product in the market with similar capability
 - Existing logistics tracking systems are based on GPS or RFID, representing the two ends of tracking technologies
- TCO is acceptable for small logistics companies
 - System deployment cost: ~120K HKD
 - 200 item tags (20K HKD)
 - 4 operator tags + 4 vehicle tags (10K HKD)
 - 20 readers (80 K HKD)
 - 1 PC server (10K HKD)
 - System operation cost: ~ 2K HKD/month (mobile data services)
- Benefits
 - Enhanced logistics chain transparency and user experience
 - Total costs returned in 20 months (assume 200 cargo items per day, 1 HKD is charged for the tracking service of each item)



Pilot Projects



- Multi-mode cargo tracking
- Fleet management in city canyons



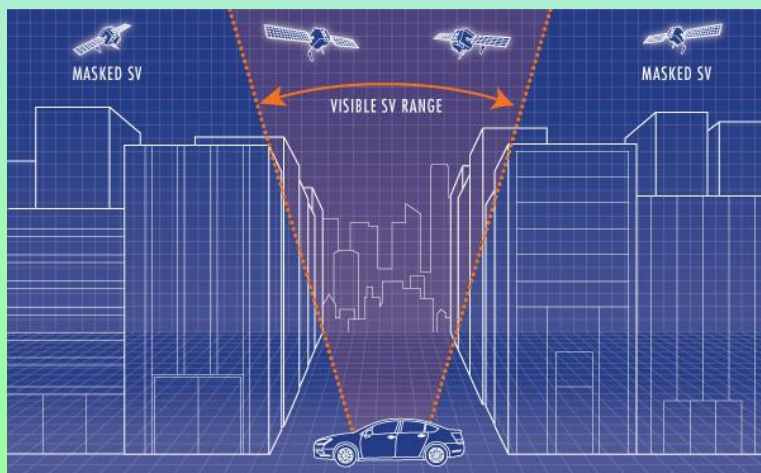
Fleet Management in City Canyons



- Project user
 - A major GIS solution provider in AP area
- Objective
 - Enhance the performance and user experience of fleet management system in city canyons
- Deliverables
 - Prototype of tracking devices used for fleet management
 - Web-based fleet management application system

City Canyon Problem

- Satellite signal blockage in city canyons
 - High buildings, tunnels
 - Indoor environments, such as warehouse, parking lots
- Degraded GPS performance
 - Low accuracy
 - GPS unlock



City canyon problem (source <http://autoelectronics.com>)



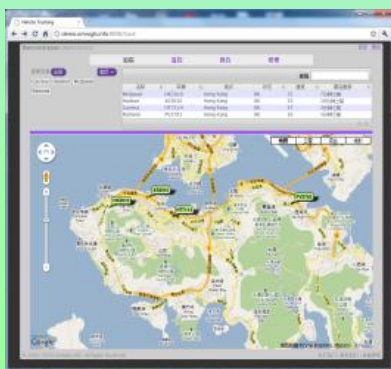
Degraded GPS performance in city canyons



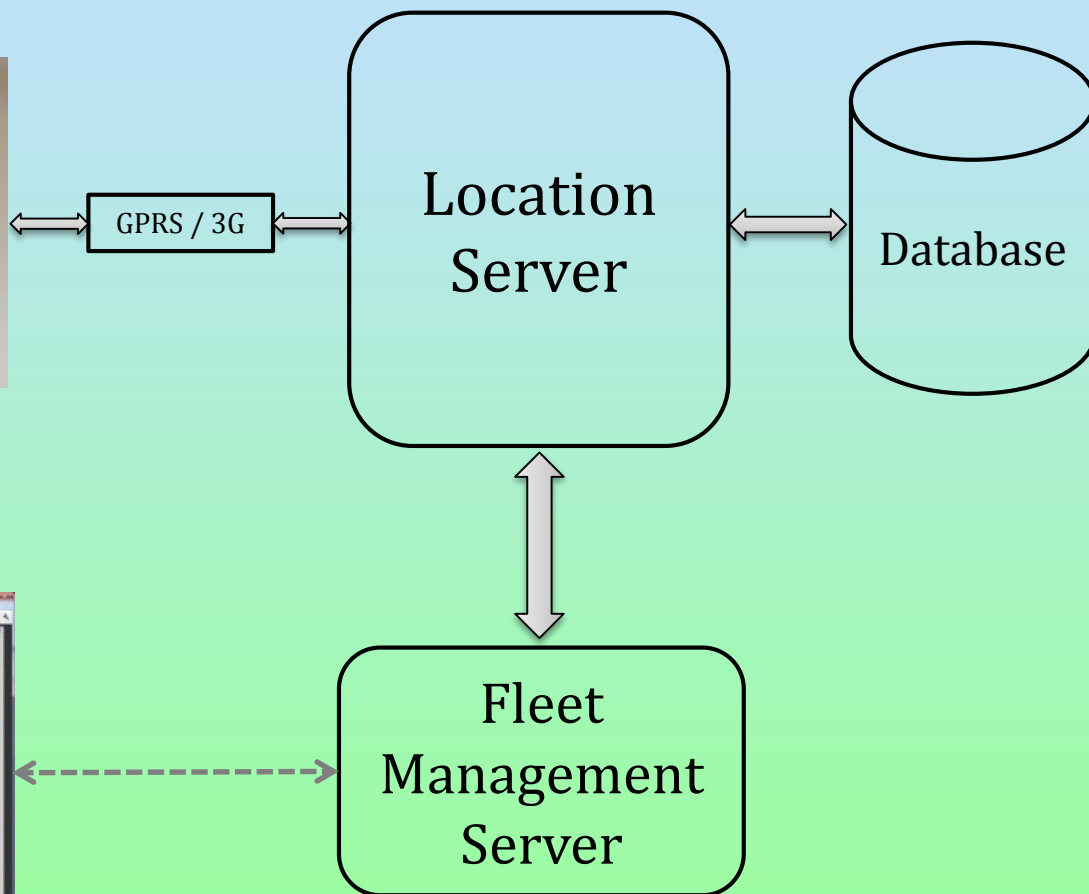
System Architecture of Fleet Management System



XPS Tracker
(WiFi + GPS + GPRS)



Browser

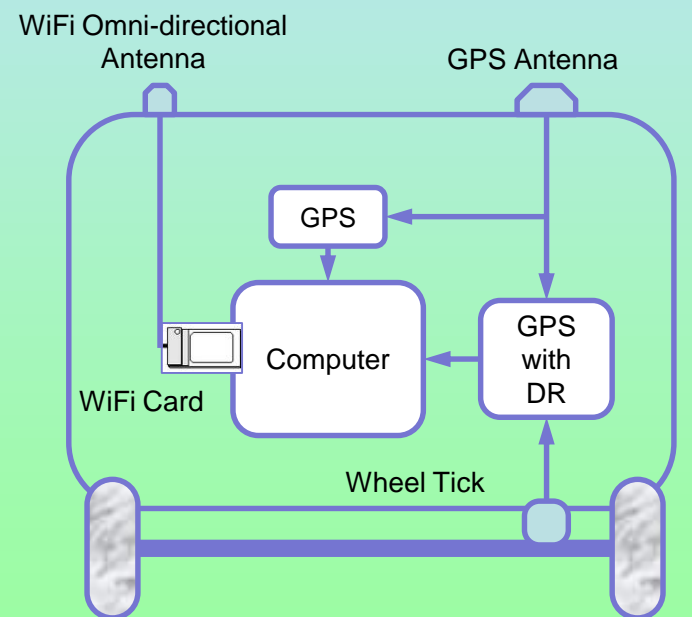


WiFi Signature Collection

- In Sai Wan (Hong Kong) district, $\sim 2 \text{ Km}^2$
 - High-density urban area
 - Total path length 2620 m
 - 280 survey points



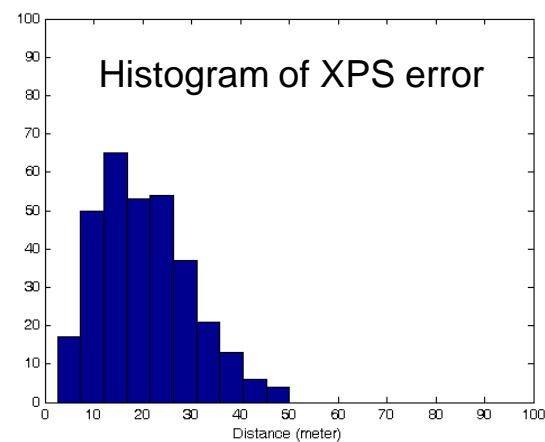
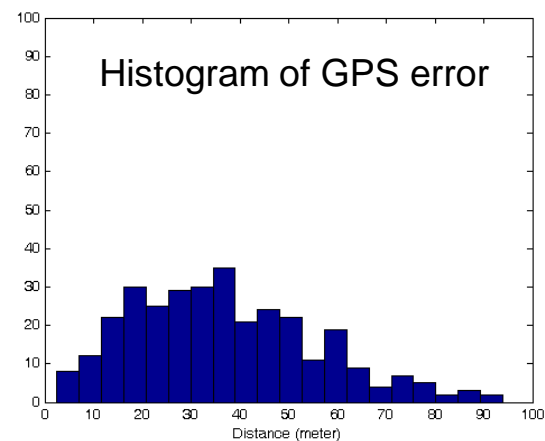
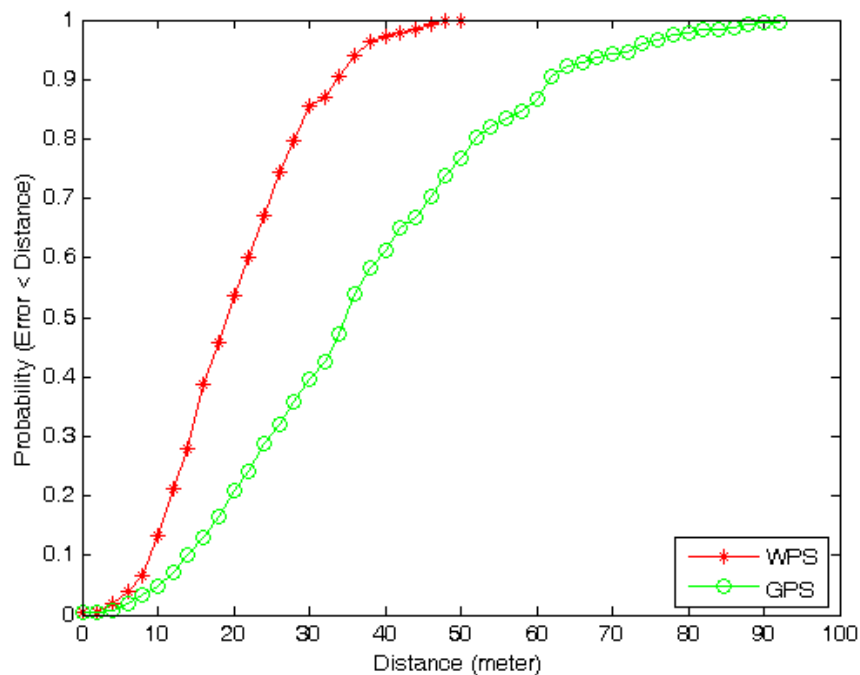
Satellite view of trial area



WiFi signature collection configuration



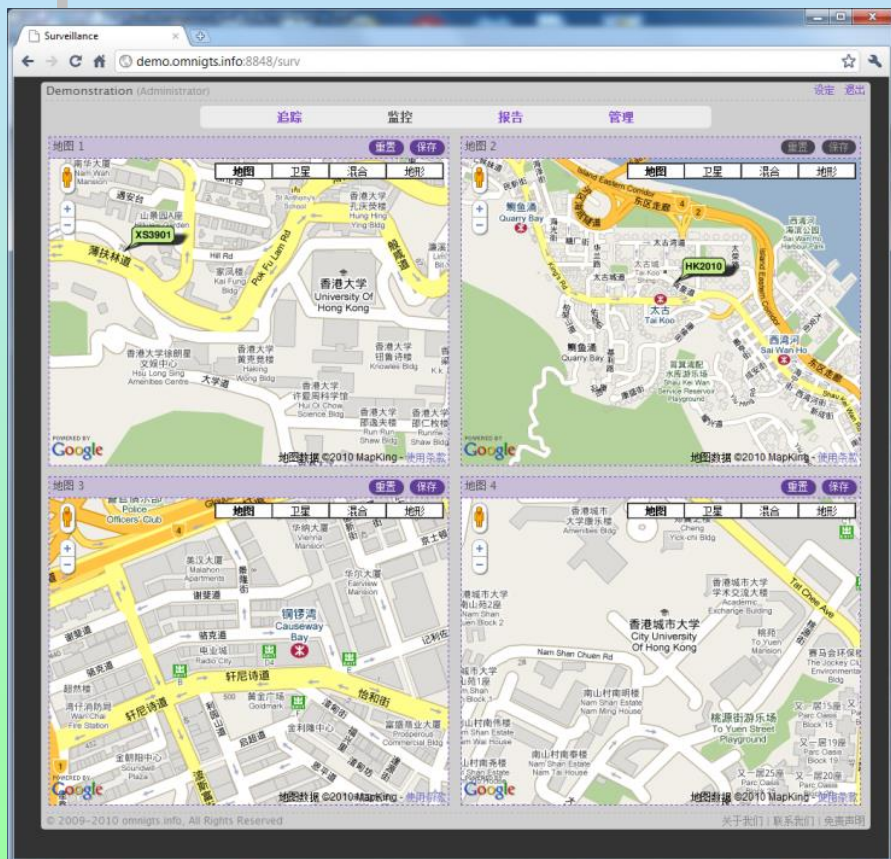
GPS vs. XPS



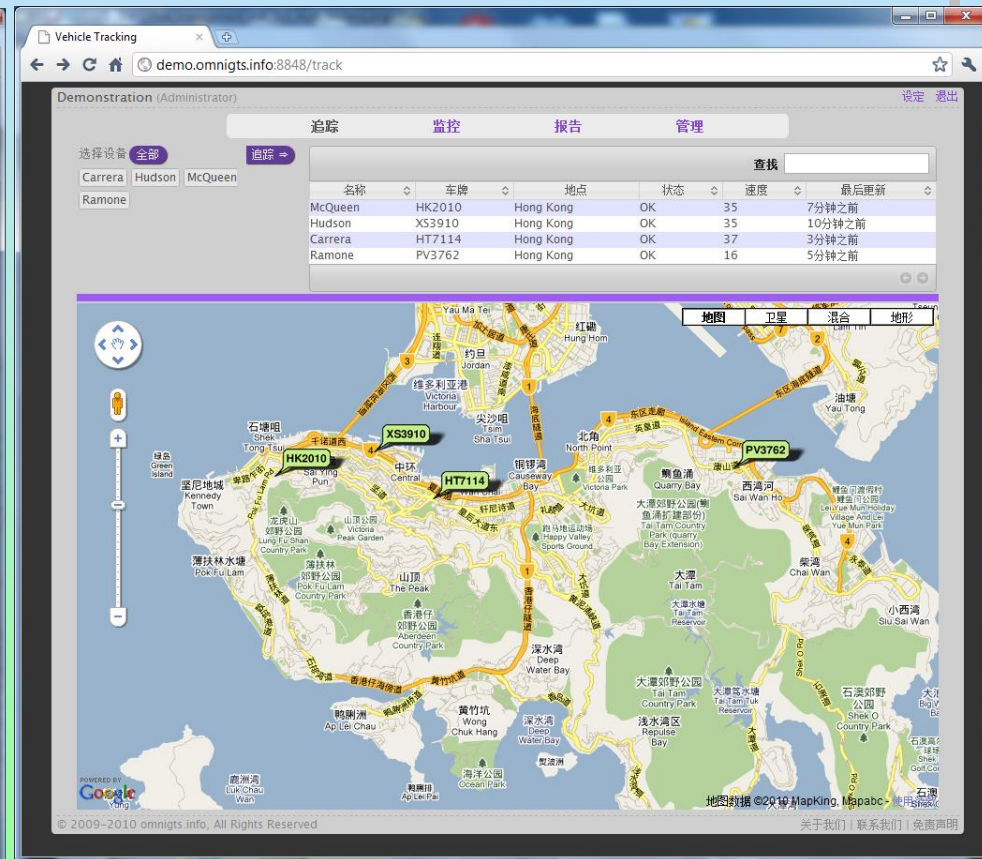
| Error | GPS | XPS |
|-------|---------|---------|
| 50% | 35.72 m | 18.37 m |
| Mean | 37.69 m | 19.93 m |
| 95% | 73.18 m | 35.47 m |
| Max | 92.91 m | 50.06 m |



Fleet Management System



Tracking of multiple sites



Tracking of multiple vehicles



Fleet Management System



Three overlapping screenshots of the Fleet Management System web interface, demonstrating the Settings section.

Screenshot 1: Settings / Zone
URL: demo.intsense.com/admin/zone
Left sidebar: Device, GeoZone, Accounts, Vehicles
Main content: GeoZone list with entries 'jbxu' and 'hku', and an '+ Add new' button.

Screenshot 2: Settings / Account
URL: demo.intsense.com/admin/account
Left sidebar: Device, GeoZone, Accounts, Vehicles
Main content: Roles and Users management. Roles include Administrator, Operator, Maintenance User, Report User, and Other. Users include ak47, admin2, and admin.

Screenshot 3: Settings / Vehicle
URL: demo.intsense.com/admin/vehicle
Left sidebar: Device, GeoZone, Accounts, Vehicles
Main content: Vehicle management. Includes a 'Teams' list (default, + Add new) and a 'Vehicles' list (Ramone, Carrera, Hudson, McQueen, + Add new). The 'Description' form shows fields for ID (3), Name (Carrera), Team (default), Model (HT7114), Type, and Driver.

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Cost Comparison



- Fleet Management System
 - Existing fleet management system is based on GPS
 - New system provides better service availability and enhanced user experience with minor increased TCO
 - GPS-based commercial product in the market
 - BOM cost: 400 HKD
 - Operation cost: 2000-3000 HKD/year
 - Hybrid tracking devices developed in this project
 - BOM cost: 550 HKD
 - Operation cost: same as GPS-based products



Cost Benefit Analysis



- Enabling technology for various location-based applications
 - Better service availability and end-user experience
 - Better security and management with higher efficiency
 - More environmentally friendly with green tracking technologies (reusable hardware, less communication and less power consumption)



Thank you!

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Tracking Device Prototype



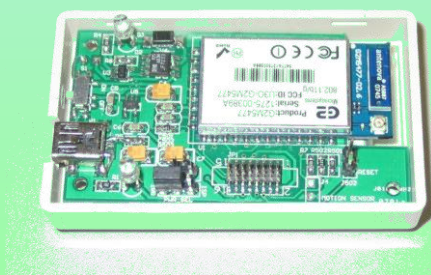
- Dummy tracking device
 - Location tracking through collaborative mechanism
 - Low cost



Dummy tracking device (2nd version)

Tracking Device Prototype

- Diverse kinds of tracking devices for different applications



WiFi tag








Vehicle tag



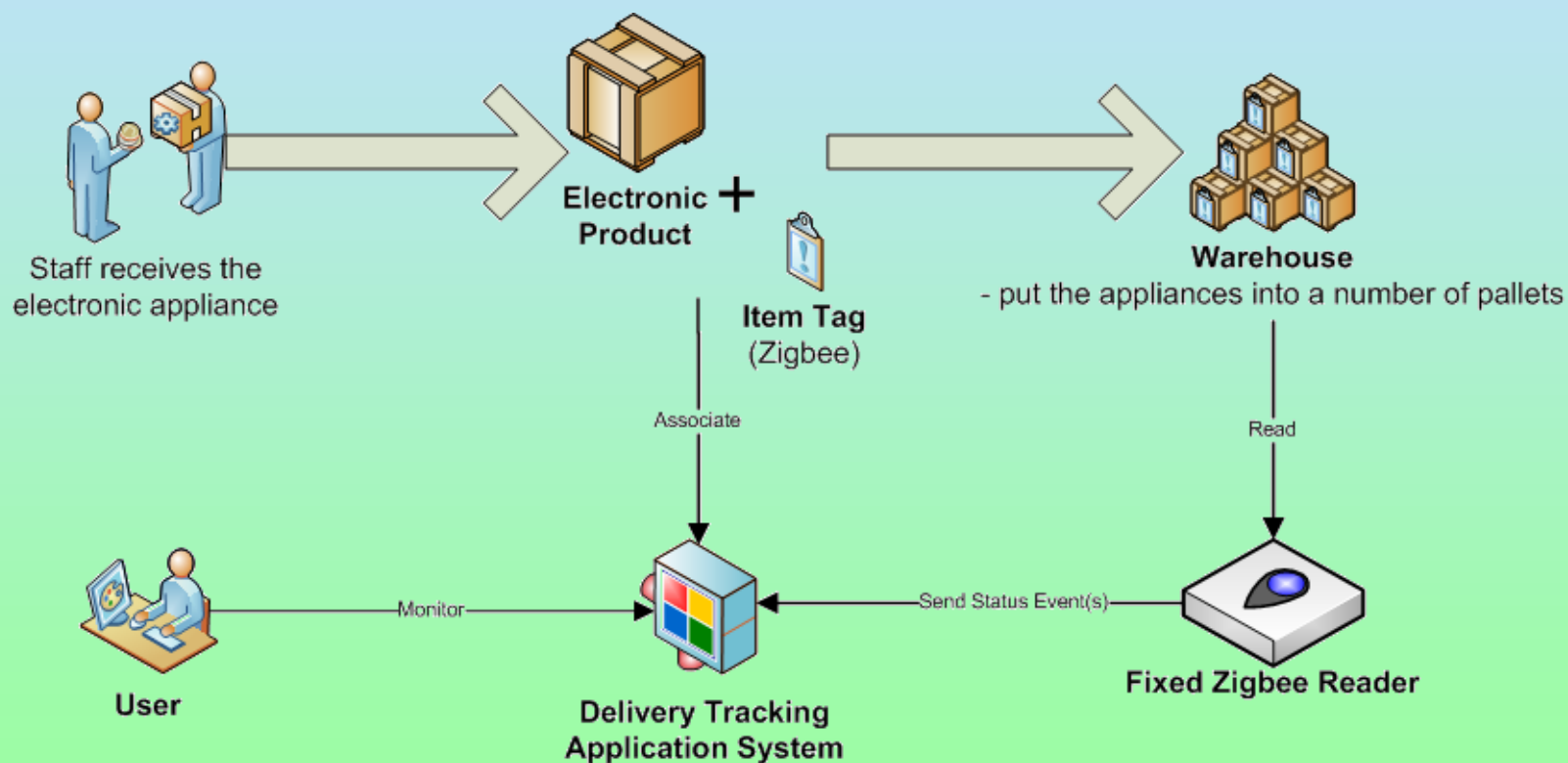
Tracking Device



| | | | |
|---|-----------------|----------------------------------|---|
|  | PDA | Barcode reader Windows CE | - To associate the item tag and the product item |
|  | Item Tag | ZigBee | - Attached to cargo items - Report delivery status |
|  | Item Tag Reader | ZigBee Ethernet (100BaseT) | - Physically installed in the warehouse - Detect and report presence of item tags (Zonal location tracking) |
|  | Operator Tag | ZigBee WiFi 3G (GPRS) | - To be carried by delivery staff (on a belt) - Report all nearby item tags - Report tag in-door location based-on WiFi positioning |
|  | Vehicle Tag | 3G (GPRS) GPS ZigBee | - Mount on cargo truck - Track truck movement using GPS - Can also be used to locate item tags |



Tag Association Process Flow





Tag Association Application



Item tag



Tag ID in 2D barcode



Associate item tag
with cargo



Cargo



Product serial No.
in barcode

Association
information



Delivery tracking
application system

Tag association application



Process Flow for Delivery



One day
before actual
delivering

- Receive delivery plan
- Pick up cargo items from storage area to staging area
- Group and sort items according to delivery notes

Actual
delivering

- Move items from staging area to loading bay
- Load truck
- Deliver items to each destination site (retail stores)
- Detached item tags from the cargo items upon delivery

Loading Bay Tracking



Floor plan of the loading bay

Products can be tracked in the loading bay