RUTGERS

Enabling Internet-of-Things (IoT) Services in MobilityFirst FIA

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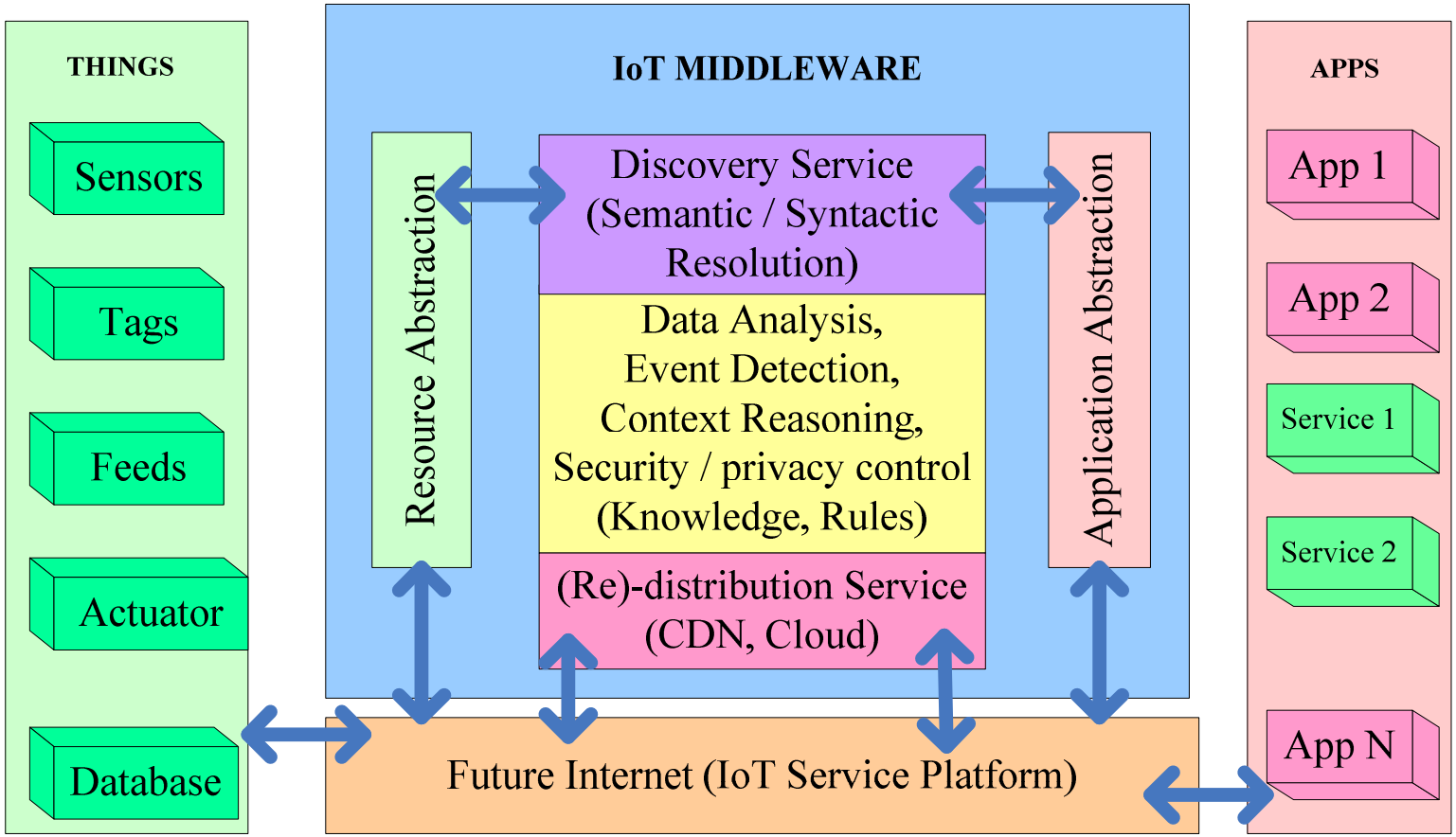
A Big Question

- Does Internet of Things (IoT) need a new FIA design?
  - No, IoT is just another name of
    - Applications: M2M, Web of Things, Cyber physical system
    - Overlay services: enabled by CDN, Cloud computing
  - Yes, IoT is ALSO a platform for
    - Pervasive / ubiquitous computing
    - Converging isolated vertical M2M applications into a flat, resource sharing framework
- MobilityFirst – an ideal platform of pervasive computing
  - In-network supports of (Data & service) identity, security, storage, computing and multicasting transport

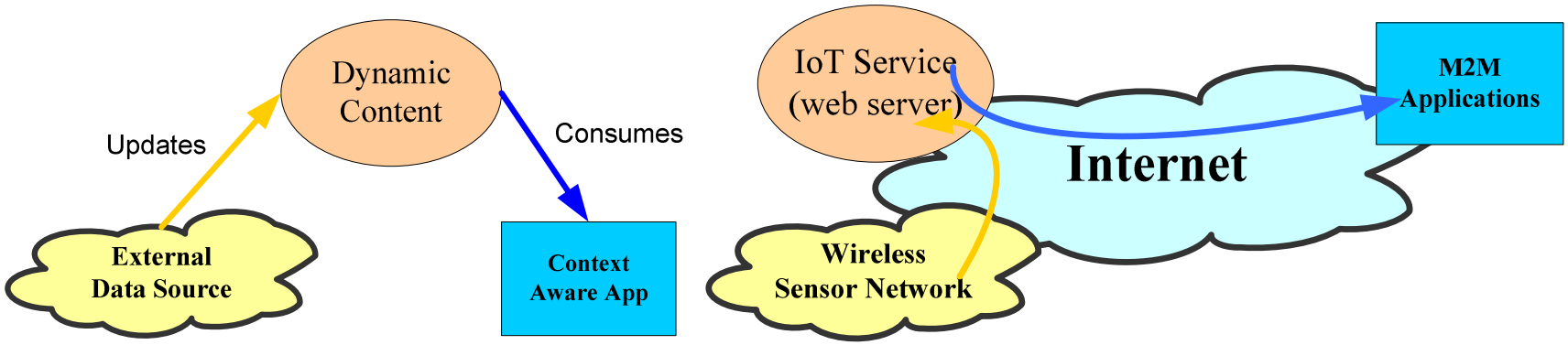
Internet-of-Things Services

- IoT Service = Sensor Data + Middleware



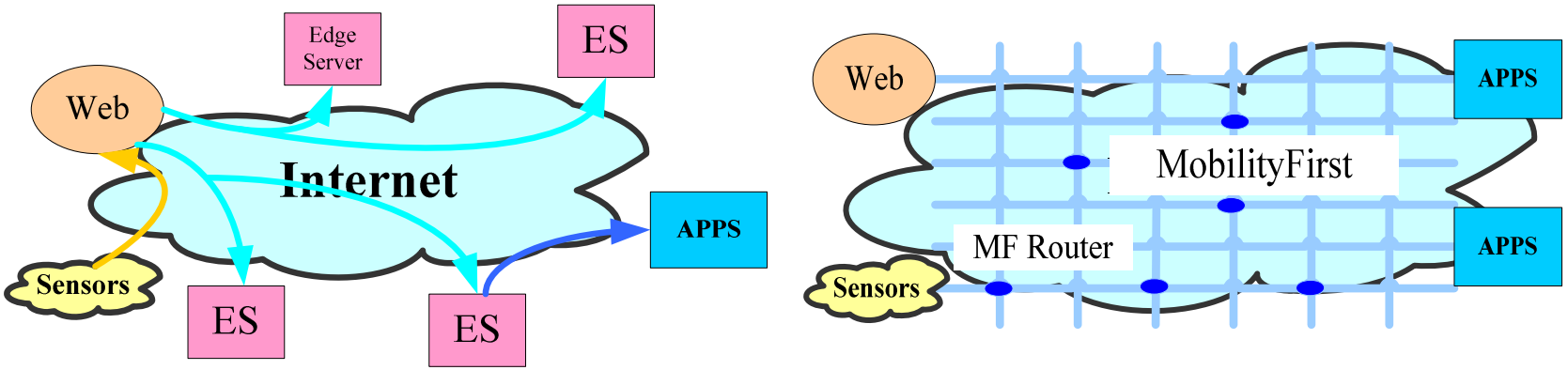
IoT Services as Dynamic Content

- Dynamic content: resource that provides time-varying and context aware data, eg. web2.0 blog
- Challenges:
  - Isolated information islands – no unified platform
  - High latency and traffic load over Internet



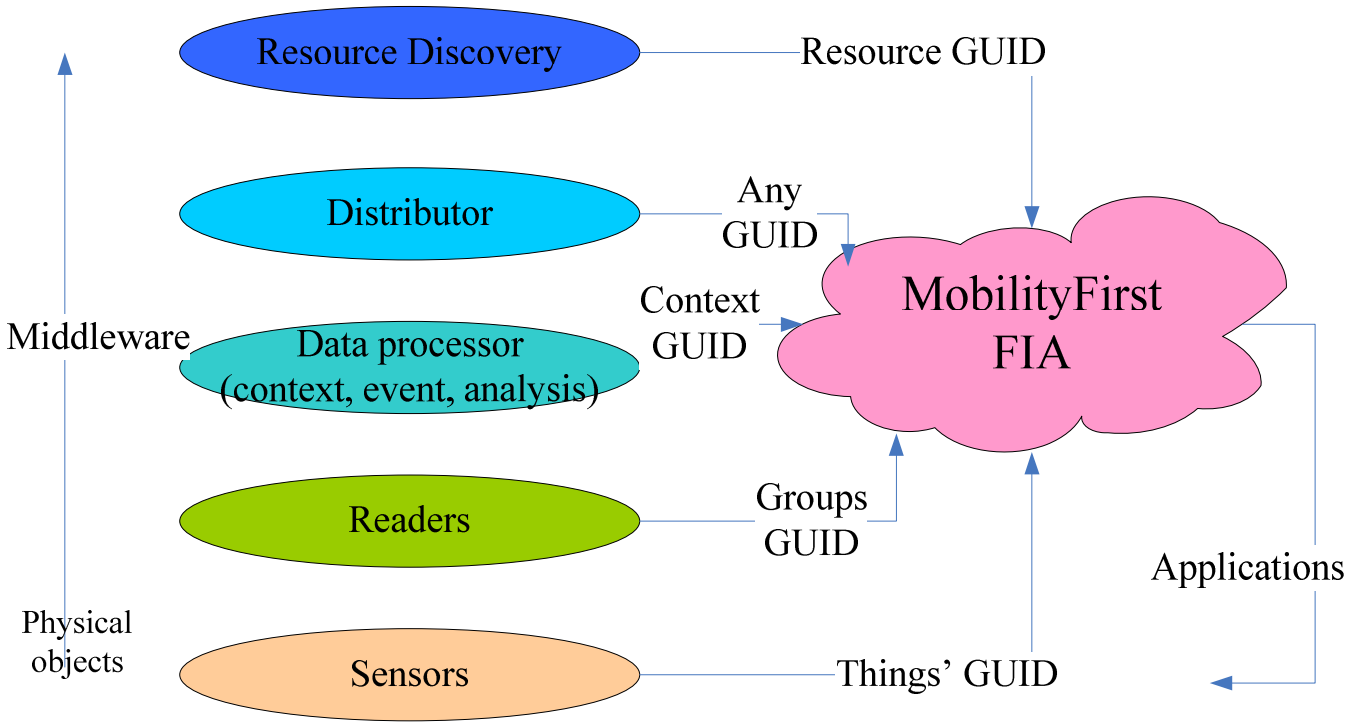
MobilityFirst as a CDN

- Current solution – Content Distribution Network (CDN)
  - Overlay network with edge servers (ES) to reduce latency and traffic load
- MobilityFirst – an in-network CDN
  - GUID as identity for data and services at core network
  - A computing grid with storage and computing plane at each node
- Challenges: consistency of dynamic content across ES / MF nodes



GUID – a Universal Identity

- IoT/M2M from vertical to flat, close to open

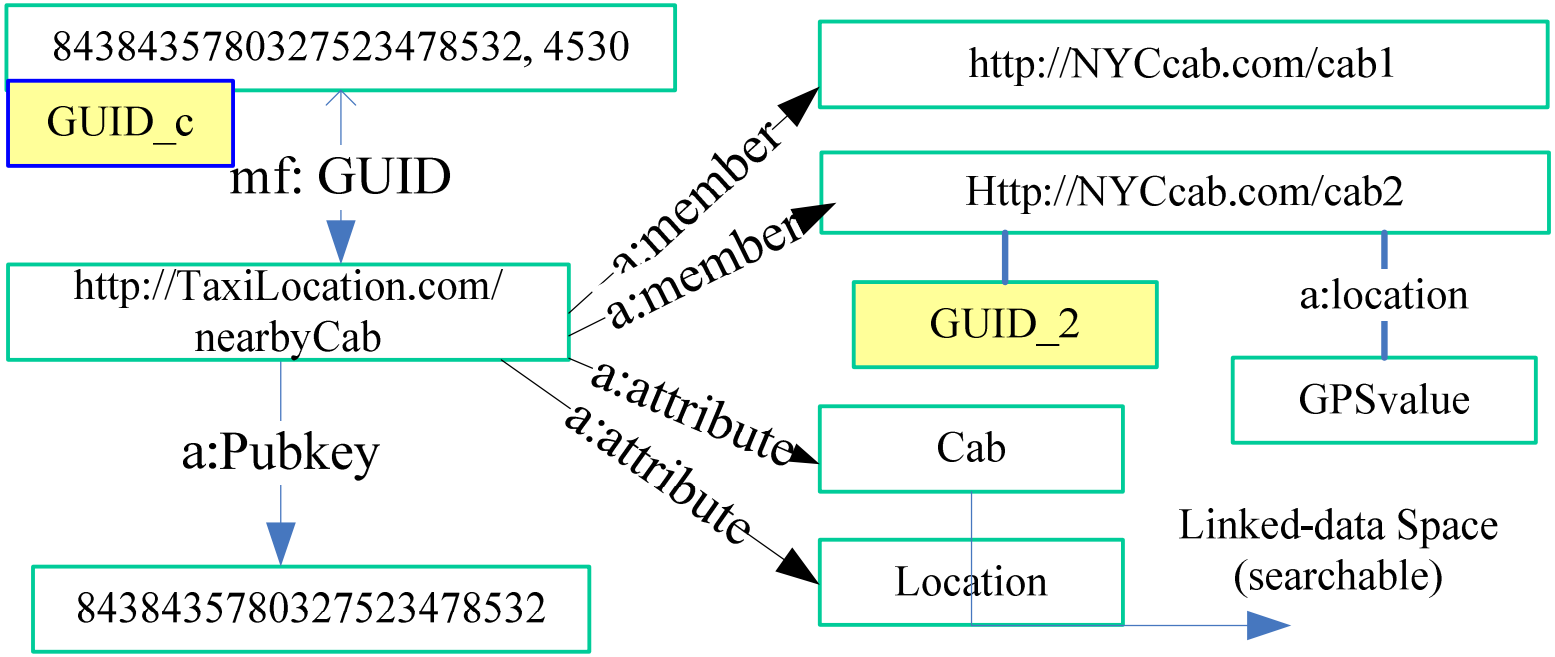


Example: Context-aware IoT Service

- UbiCab
  - "*James walks on NYC streets and makes a call to a CONTEXT "Nearby Cab"* – A phone call from James is automatically routed to a nearby taxi driver.
- IoT service – a dynamic content provided by Taxilocation.com on a web server
- Sensor data – GPS on drivers' mobile phones, updating the IoT service
- Context-aware app – voice app on James' phone, call to IoT service, providing his own location

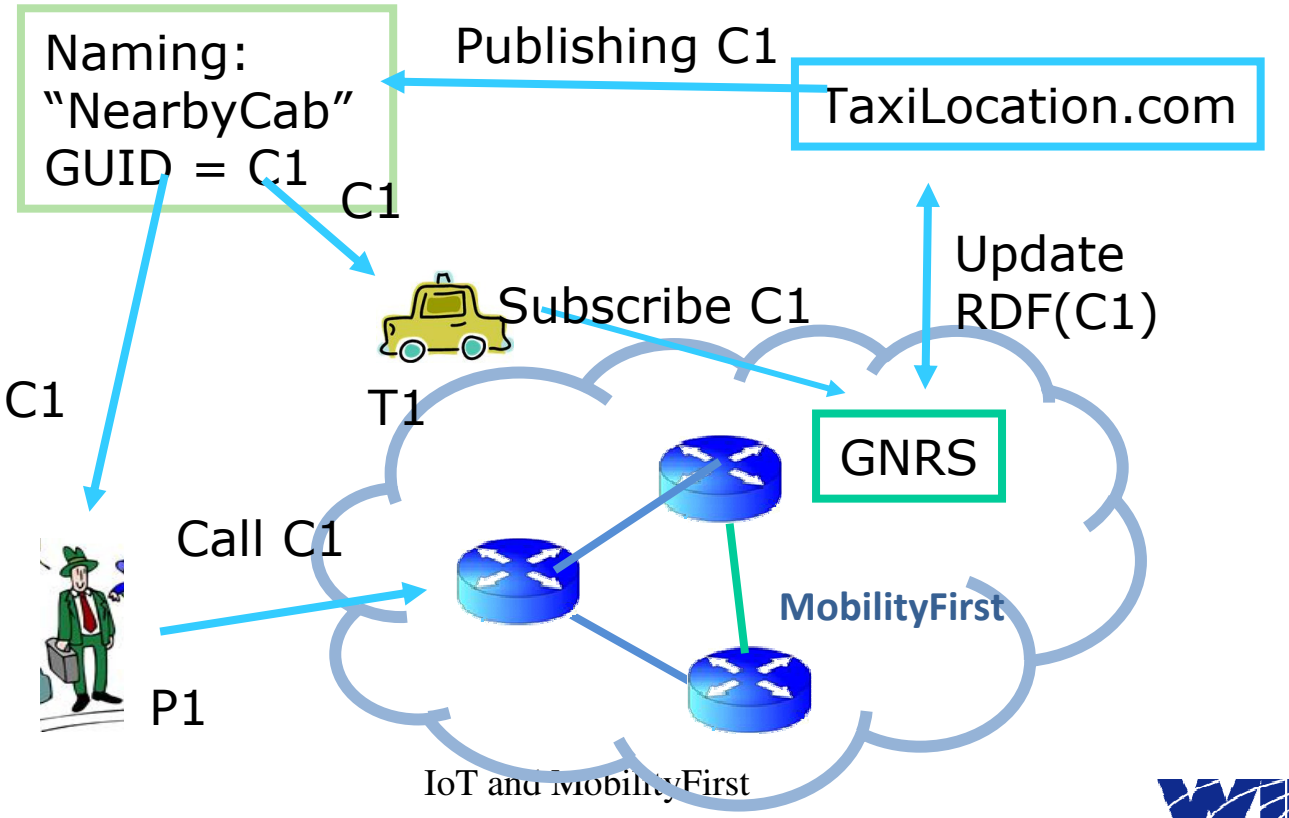
RDF Graph – a Universal IoT Service Description

- A standard service description using semantic web language describing an IoT service in RDF graph, representing a dynamic content at TaxiLocation.com/nearbyCab.



Solution: GNRS Overloading

- GNRS resolves context through C1's RDF
- Taxi drivers subscribe C1 at GNRS server (MF router for C1)
- Calls to C1 is redirected to members of C1 according to the RDF

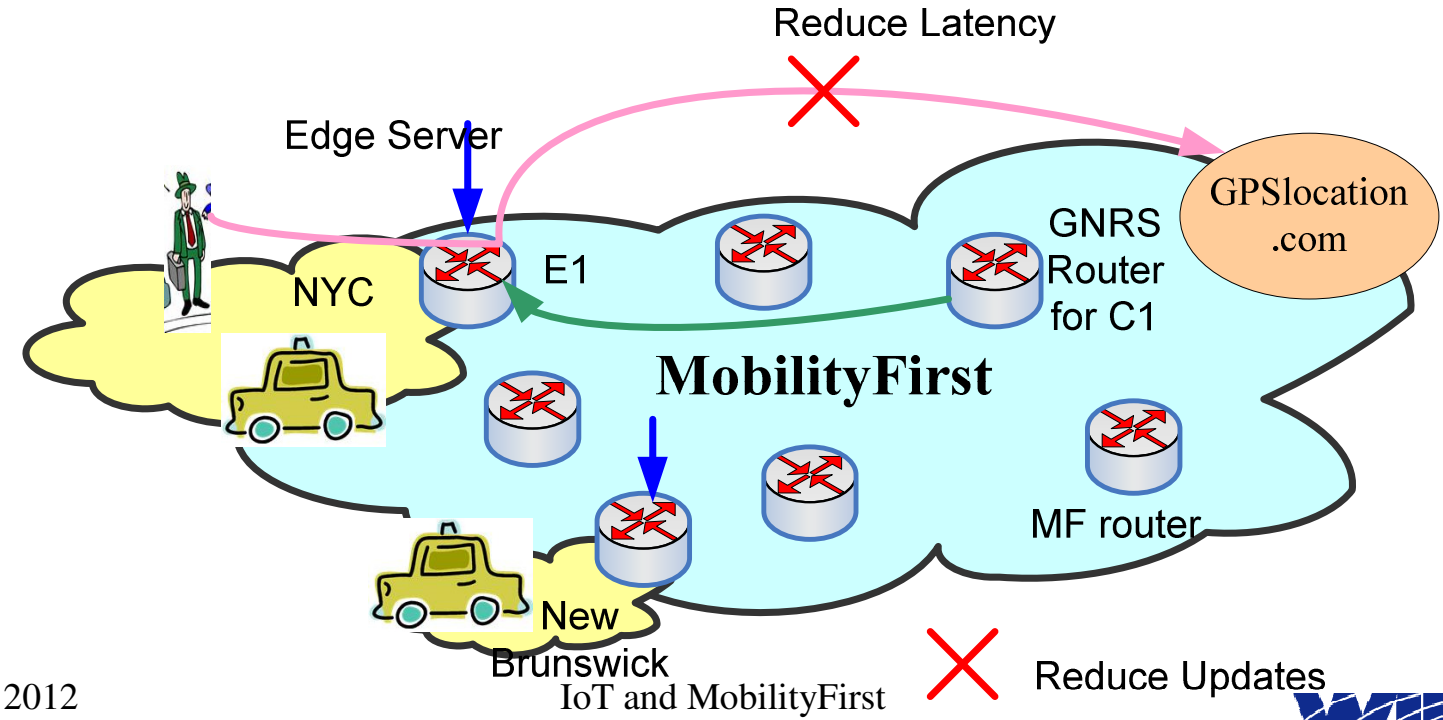


Technical Challenges

- Random locations of *GNRS* servers for a GUID
  - *k* hash to assign more *GNRS* routers
  - Hierarchical *GNRS*, local + global
- Consistency of dynamic data on *GNRS* servers
  - Full duplication? Partially distributed?
  - Aggregation of data on local *GNRS* to global *GNRS*
- Performance of service distribution
  - Latency of call response
  - Traffic load for dynamic data updates

MobilityFirst – an in-network CDN

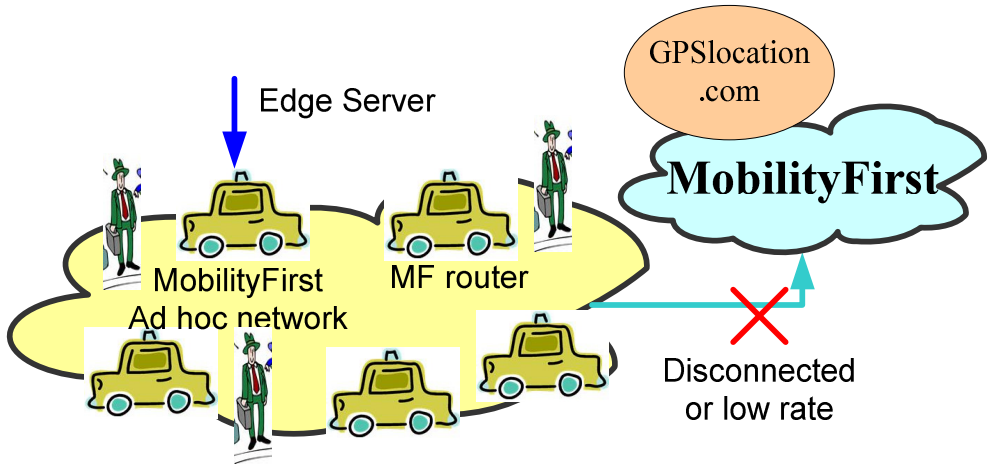
- Every MF router can be an edge server
  - Indirect reference: E1 as a member of C1 in RDF on GNRS server
- Conventional CDN techniques applicable:
  - *Caching strategies, cache replacement algorithms*



In-network Delivery: Benefits to IoT

- Features of IoT services
  - more sensitive to delay
  - more dependent on context (time, location & more)
- In-network service distribution is more beneficial to IoT
  - Fast response, traffic load balancing based on location information

- Frequently updated service
- Short-lived ad-hoc services
- Disconnected ad-hoc network
- High data local service

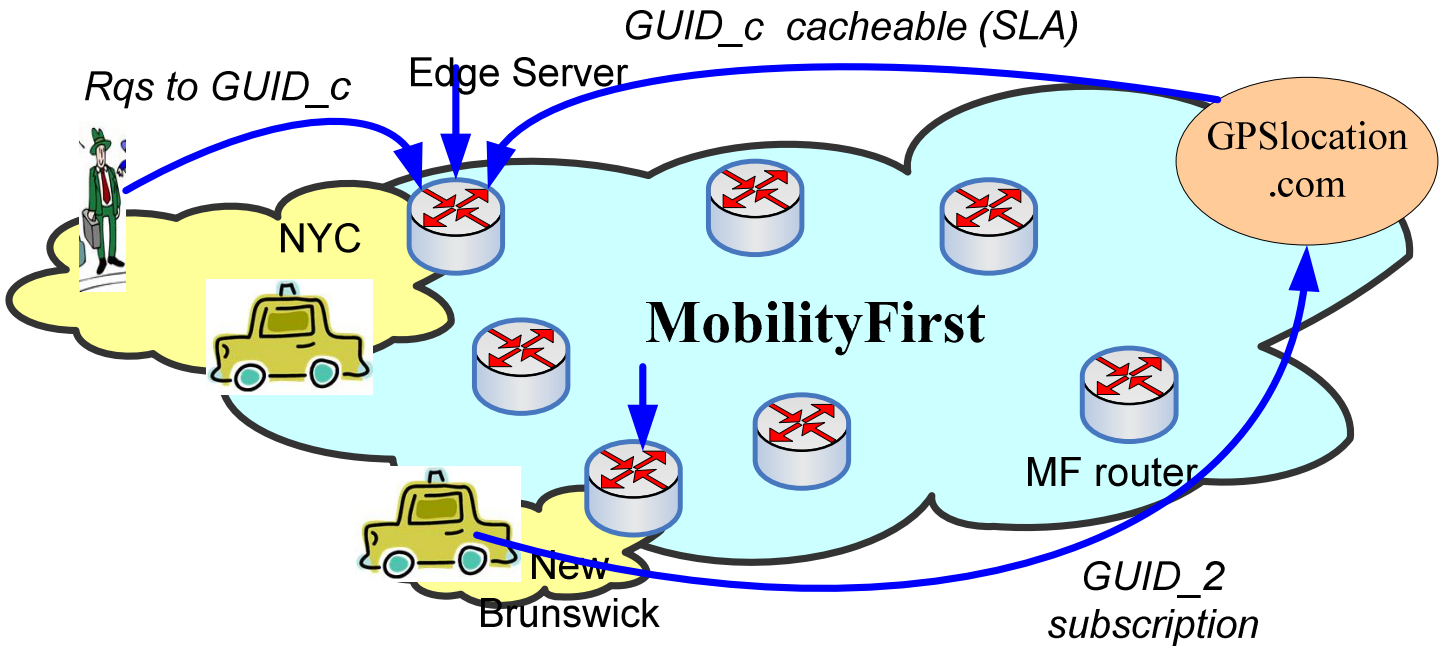


Charging in-network service: GUID based AAA

- CDN and Cloud computing
  - Authentication and Authorization via account management
  - Accounting based on access control and secure channels required
- MobilityFirst – pervasive computing
  - Authentication and authorization via GUID certificate
  - Accounting based on GUID signature verification
  - Can implement charging to access GUID (flat rate), service GUID (800#) and user GUID (pay-per-view)
  - No access control and/or secure channel are needed

Charging on GUID

- GUID_c agrees to pay for MobilityFirst in-network service caching
- GUID_2 agrees to pay service provider of GUID_c at subscription
- Requests to GUID_c are charged to service provider



Conclusions

- MobilityFirst is a pervasive computing platform that IoT / M2M applications need
- MobilityFirst routers and protocol stack enable efficient IoT service distribution
  - Universal identity (GUID) and middleware service description (RDF)
  - *GNRS* works as context resolver and MF router, as edge server
  - GUID identity based economic models between MF and IoT service (operators), IoT services and subscribers, IoT services and consumers.

Questions?