Toward Enabling Convenient Urban Transit through Mobile Crowdsensing

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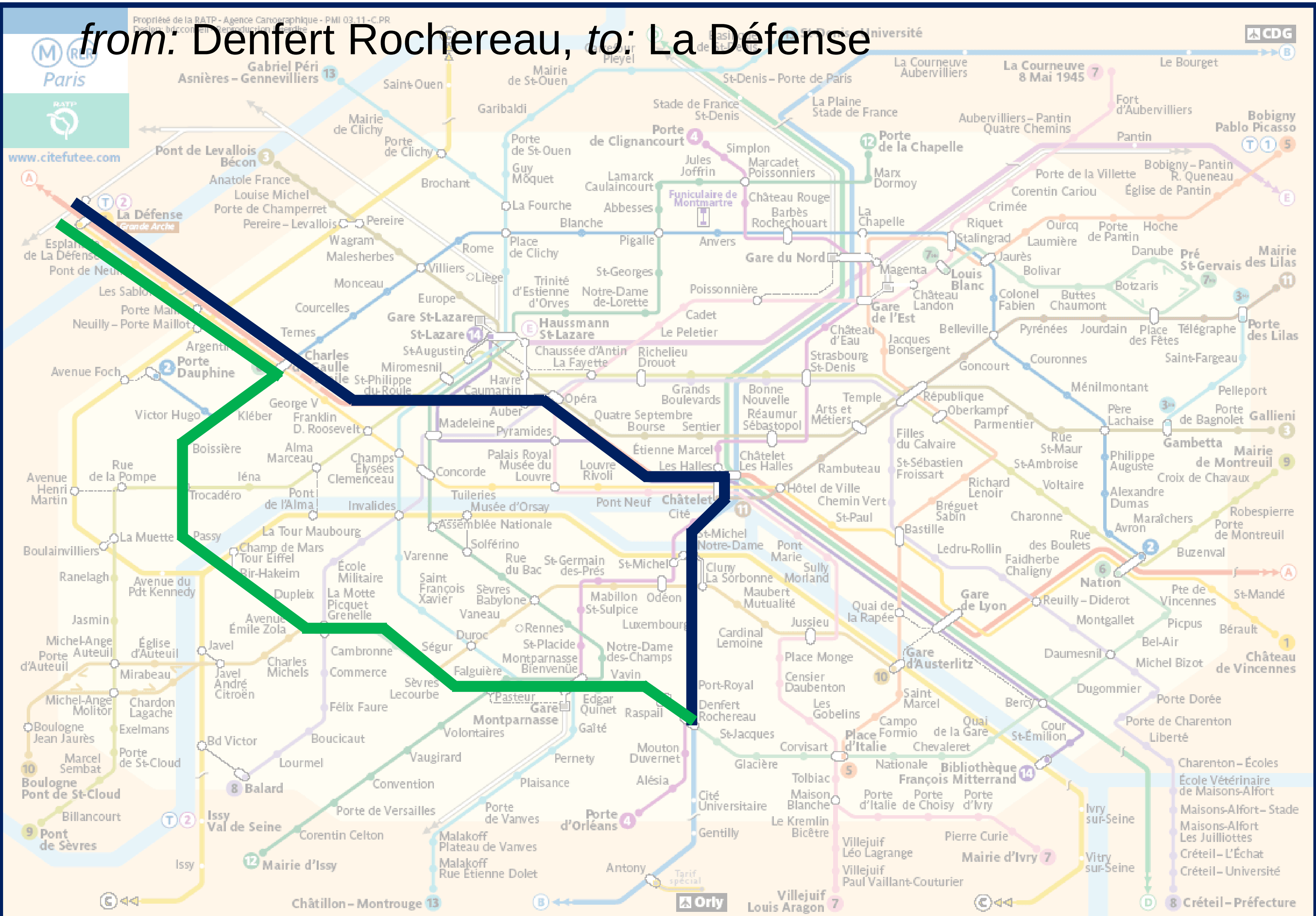
from: Denfert Rochereau, *to:* La Défense



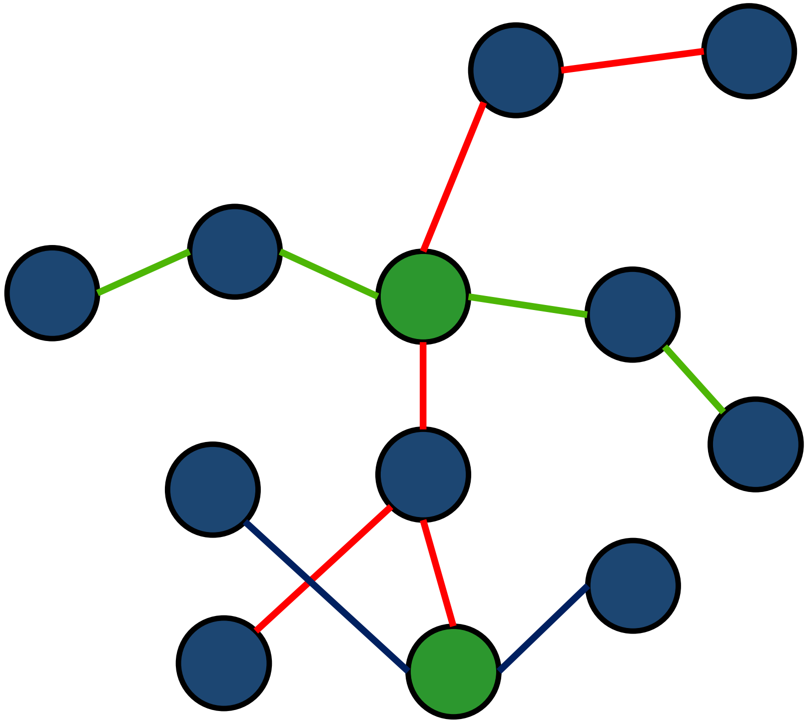
Need a convenience model for Metro transit nodes

Modeling the user's convenience

- *A function of:*

+

Representing the Metro network



- Stations as vertices of graph
- Connecting lines as edges
- Edges may belong to different lines
- Lines may be connected at junction stations

- Path $P_{(o,d)} = \{L_1, L_2, \ldots L_n\}$ where each leg is the sequence of vertices lying on the same line

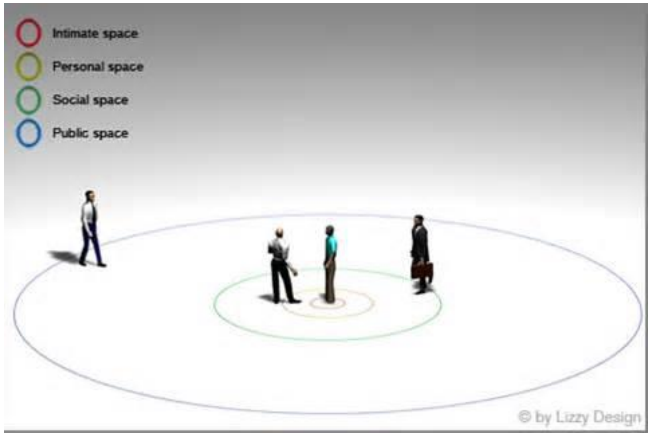
Time Inconvenience

$$E_t = \sum_{e \in P} t_e^t + \sum_{v \in N - \{o,d\}} t_v^s + \sum_{j \in J} t_j^{sw}$$

$$I_t = (A_o - E_o) + \sum_{e \in P} (A_e^t - t_e^t) + \sum_{v \in N} (A_v^s - t_v^s) + \sum_{v' \in J} (A_{v'}^{sw} - E_{v'}^{sw})$$

Congestion & Seating Inconvenience

- Congestion:
  - personal reaction bubble[1]



$$I_c = \sum_{l \in L} \int_{T_l}^{T_l^s} (A_c - N_c) dt$$

- Seating (I_s):
  - (if any) must be reported directly by the users
- Overall inconvenience (I):

$$\boxed{I = aI_t + bI_c + cI_s + \eta}$$

1 [Edward Hall, 1966]

Middleware for Mobile Crowdsensing into the Metro

- A middleware for:
  1. collect ground truth data required for identifying the constants *a,b,c* and η of the convenience model
  2. *p*rovide a list of public transit modes that best meet the user specifications
  3. collect and provide information through mobile applications
- Efficient interaction by considering three basic constraints:
  - Connectivity
  - Energy efficiency
  - Timeliness (Freshness) of data

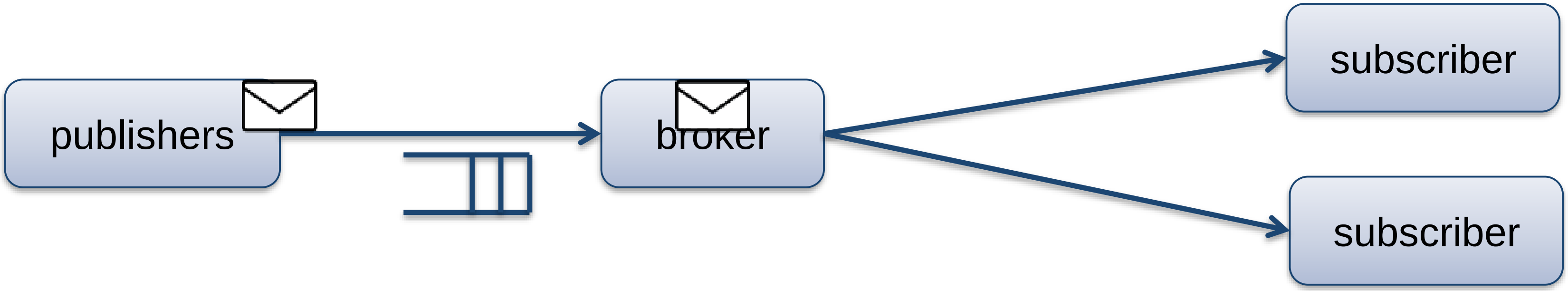
Basic Interaction Paradigms

Client-Server - *CS* (e.g., REST)

CS

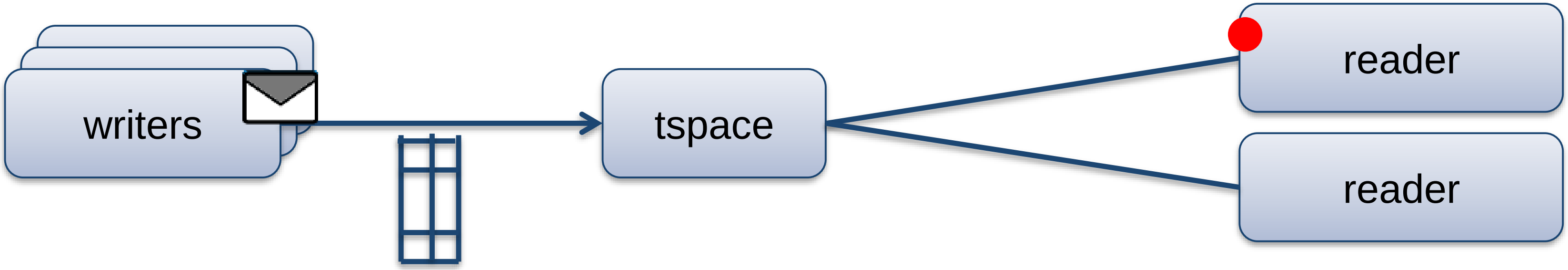
Publish/Subscribe - *PS* (e.g., MQTT)

PS

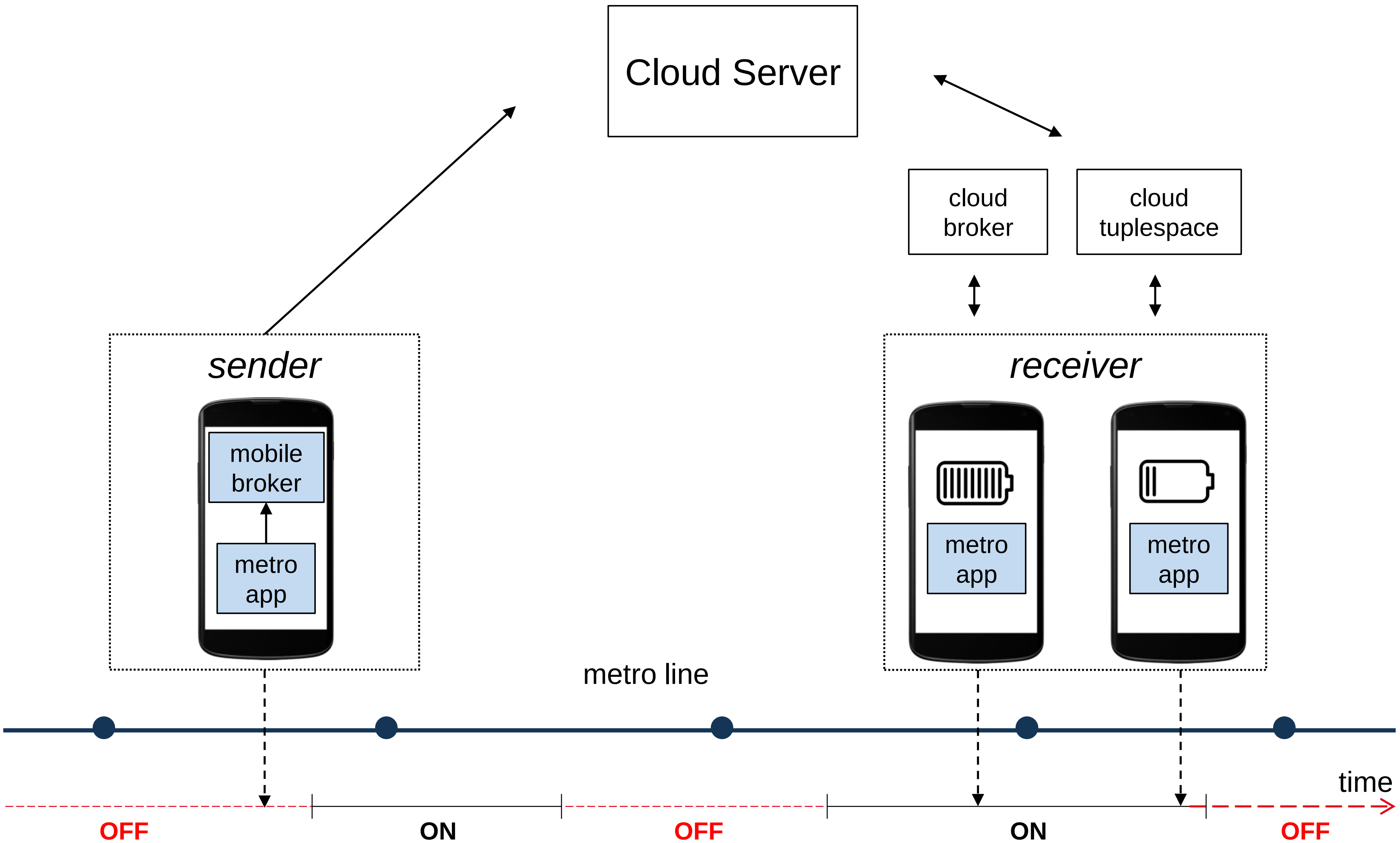


Tuplespace - *TS* (e.g., LightTS)

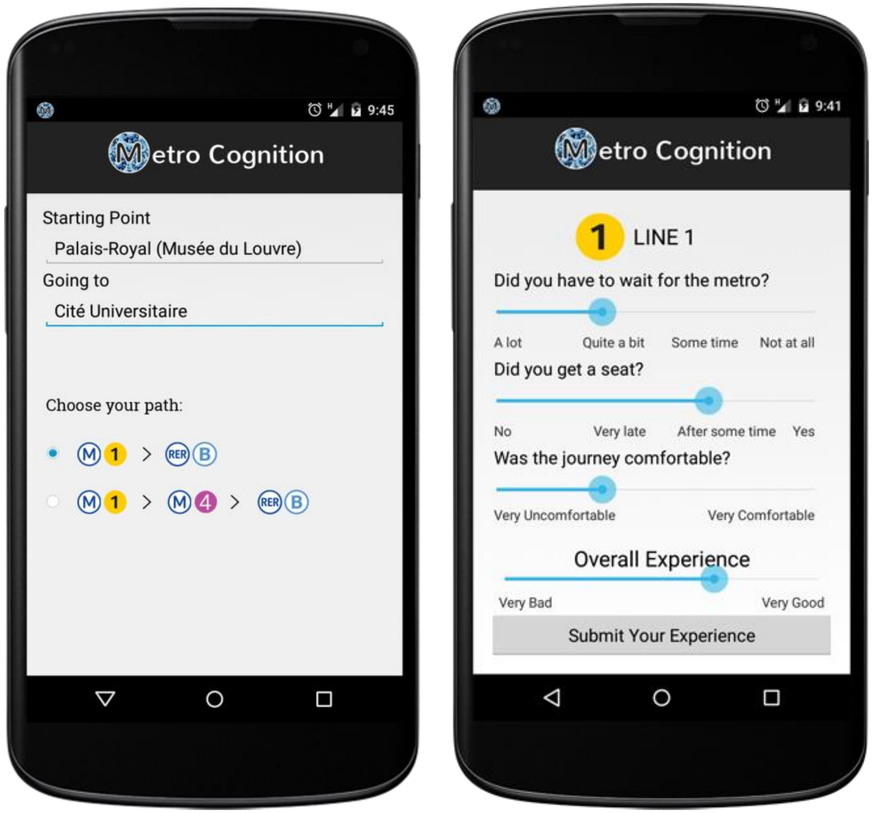
TS



Mobile System Architecture



Android Application - Metro Cognition[1]



- currently acts as a sender
- collects values for constants *a*,*b*,*c* and η of the convenience model
- collects connectivity tuples every 30 seconds using a background service
- the *GoFlow*[2] pub/sub middleware is used for the submission of data

[1] https://play.google.com/apps/testing/edu.sarathi.metroCognition
[2] https://goflow.ambientic.mobi/

Early Experiments – Convenience Analysis (1)

- Similar experiments into the Metro of Paris and Delhi
    - 24 users participated (12 from each city)
- Two goals:
    - ✓ Identifying parameter values (a,b,c and η) for a city-wide convenience model
    - ✓ Identifying technique with best accuracy over the collected dataset
- Dataset was heterogeneous – one legged, two legged, and three legged journeys:
    - ❑ Preprocessing to separate out similar paths

	One Leg	Two Legs	Three Legs	Total
Paris	52	37	15	104
Delhi	7	38	53	98

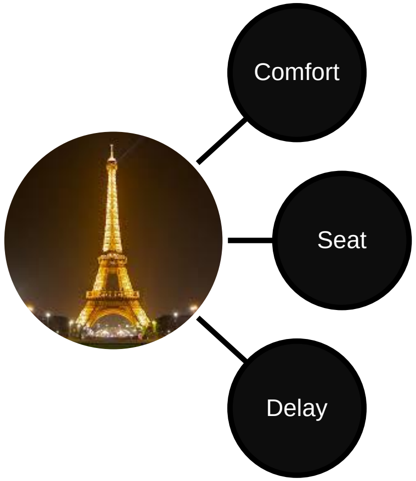
Early Experiments – Convenience Analysis (2)

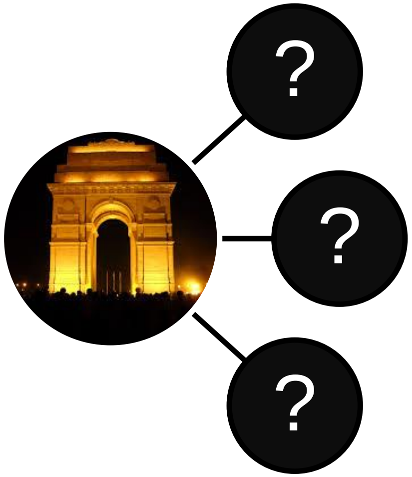
Techniques used:

- Decision trees (DT)
- Multiclass Linear Regression
- Support Vector Machines (SVM)
- Neural Networks (NN)

Results:

Method	Average Accuracy
Decision Trees	<75%
Multiclass Linear Regression	~75-80%
SVM	Overfitted accuracies reported
Neural Networks	~79-98%



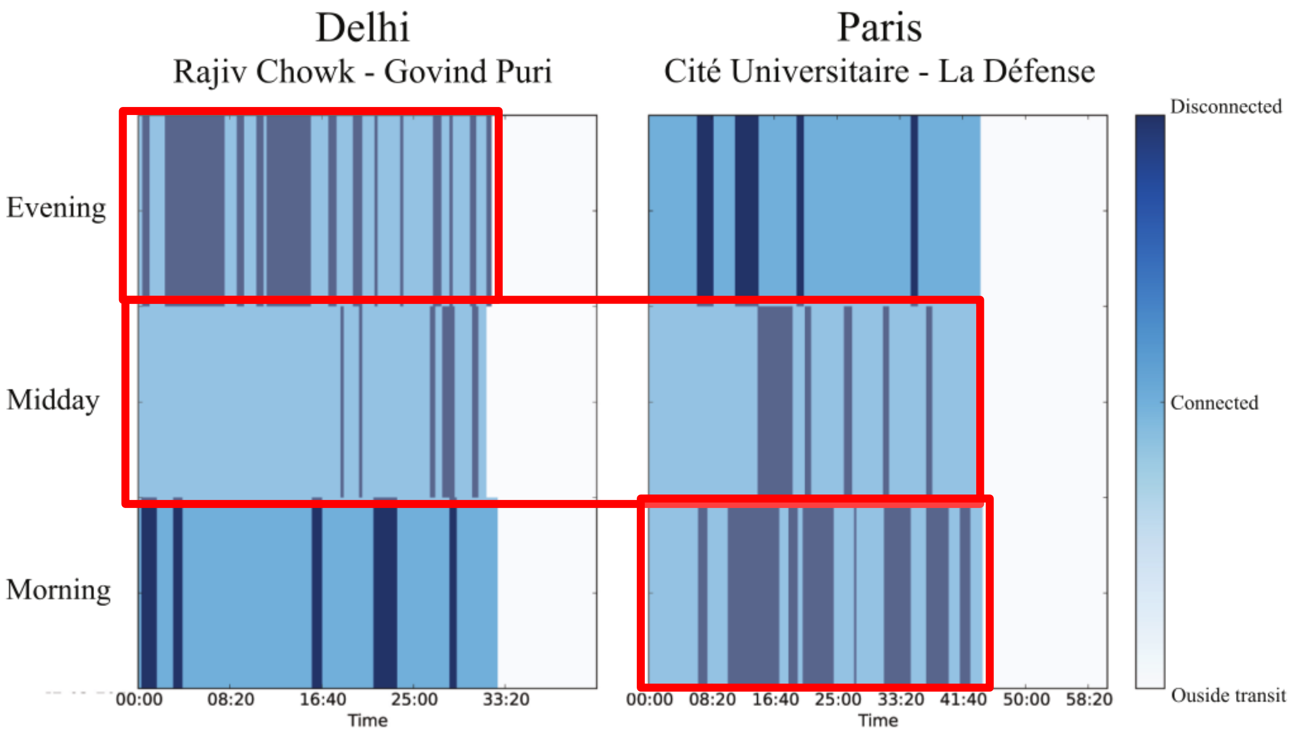


Early Experiments – Connectivity Analysis (1)

- Experimental setup:
  - analyzing the user’s connectivity pattern (internet connection)
  - each connectivity pattern consists of many tuples for a specific path
  - 2 business districts: La Défense (Paris) and Rajiv Chowk (Delhi)
  - 2 residential districts: Cité Universitaire (Paris) and Govin-dpuri (Delhi)
  - route in Paris: Cité Universitaire → La Défense, and back
  - route in Delhi: Govindpuri → Rajiv Chowk, and back
  - routes are classified to 3 categories: *Morning, Mid-day, Evening*

Early Experiments – Connectivity Analysis (2)

Results



	Morning	Midday	Evening
Cité Universitaire - La Défense	51%	81%	83.5%
Govind Puri - Rajiv Chowk	59%	88%	76%
La Défense - Cité Universitaire	78%	81%	44%
Rajiv Chowk - Govind Puri	82%	79%	51%

Conclusion and future perspective

- Enabling convenient urban transit through Mobile Crowdsensing
  - Introduce our inconvenient model and middleware platform
- We develop convenience models for Delhi and Paris using machine learning techniques
- We identify the ideal interaction paradigm regarding the constraints into the Metro

➢ Next step

  - use the developed convenience models to provide personalized mobility services
  - utilizing connectivity patterns as a realistic input-parameter to our queueing network

Thank you

Further information:

Inria MiMove: https://mimove.inria.fr

SARATHI: https://mimove.inria.fr/sarathi

XSB: http://xsb.inria.fr