



Towards Personal Mobile Personal Assistants

myCompanion

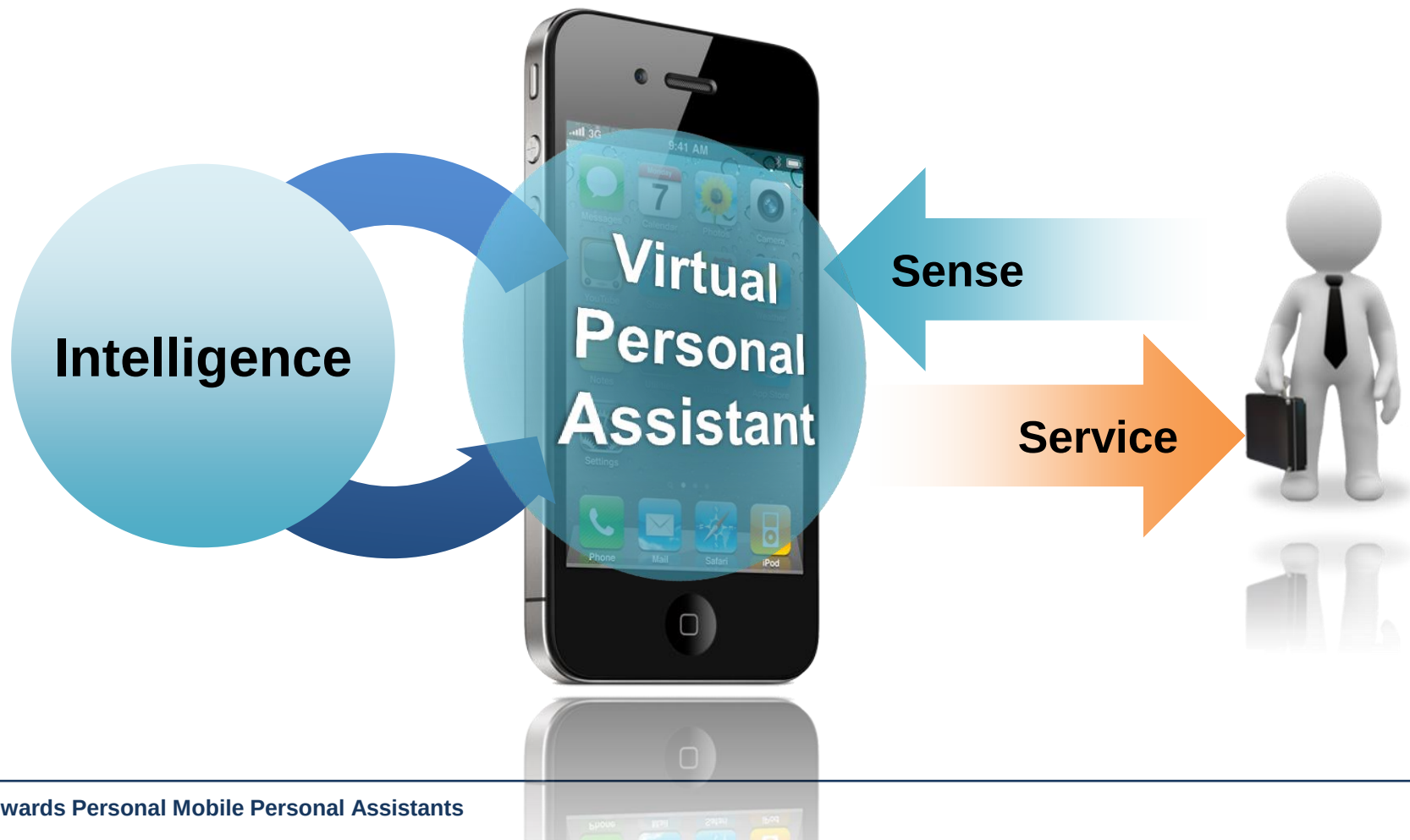
2014.10.10

Young Tack Park
School of Computing
Soongsil University



Smartphone Trends: : Virtual Personal Assistant

- Virtual Personal Assistant based on smartphone sensors and artificial intelligence



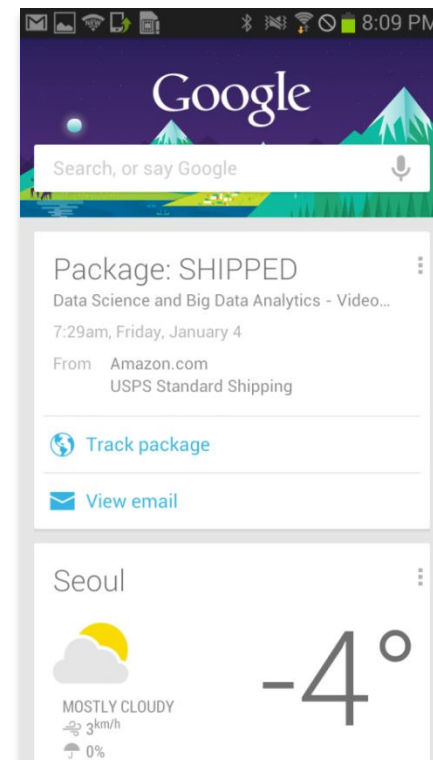
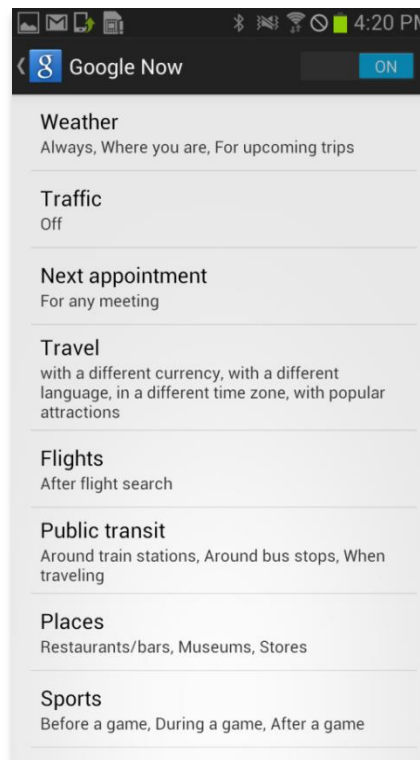
Sensors!!!

Smartphone Sensor	Sensing Value	Mobile Contexts
	GPS 위도, 경도	Point of Interests, Routes
Accelerometer	가속기 X,Y,Z 값	이동 수단, Stable, Shaking,
	근접	MIC Distance from phone
Proximity		Brightness of environment
	방향	Bluetooth Stable or Vibrating
Light	axis	Stable, Vibrating or Front/Back
	반사 강도	Wi-Fi In Wi-fi zone or disconnect
Magnetic	블루투스 ID/신호강도	Being alone / with someone / communicating with others /
	Sound 수준	Environmental noise(Crowded or calm), Monologue, Dialogue etc.



Predictive Service of Google NOW

- Google's VPA
- Just the right information at the just right time



Google's Location/Web History

- Location information is important for predicting users' behavior

The image displays two screenshots from a mobile device. The left screenshot shows the 'Privacy & accounts' settings page. A yellow arrow points from the 'Manage location history' option to the 'Location history' section of the right screenshot. A blue arrow points from the 'Manage Web History' option to the 'Web History' section of the right screenshot.

Location history

Map Dashboard

January 2013

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9

Show: 3 Days

January 20, 2013 to January 22, 2013

▼ Hide timestamps

January 20, 2013

▼ Hide timestamps

- 12:00 AM - 1:00 AM
- 12:01 AM - 12:47 AM
- 2:00 AM - 3:00 AM
- 2:11 AM
- 3:00 AM - 4:00 AM
- 3:25 AM
- 4:00 AM - 5:00 AM
- 4:49 AM
- 6:00 AM - 7:00 AM
- 6:13 AM
- 7:00 AM - 8:00 AM

The map shows a red line indicating movement through various locations in Seoul, including Seongnam, Yongsan, and Gangnam.

Web History

Only you can see your history

All History

- Web
- Images
- News
- Shopping
- Ads
- Videos
- Maps
- Blogs
- Books
- Visual Search
- Bookmarks

Hourly search activity

Daily search activity

Web Activity

Jan 2013

S	M	T	W	T	F	S
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2

Total Google searches: 8408

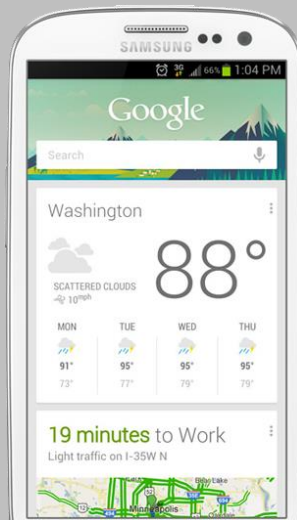
Today

- ☐ Searched for google history 11:09pm
- ☐ Google Accounts - google.com - Viewed 2 times ☆ 11:09pm
- ☐ Searched for google latitude 11:03pm
- ☐ Google Latitude - google.com - Viewed 18 times ☆ 11:03pm

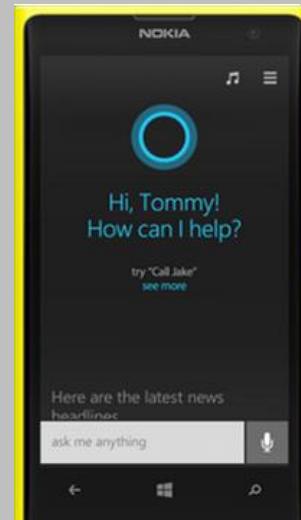
Virtual Personal Assistants



Siri



Google NOW

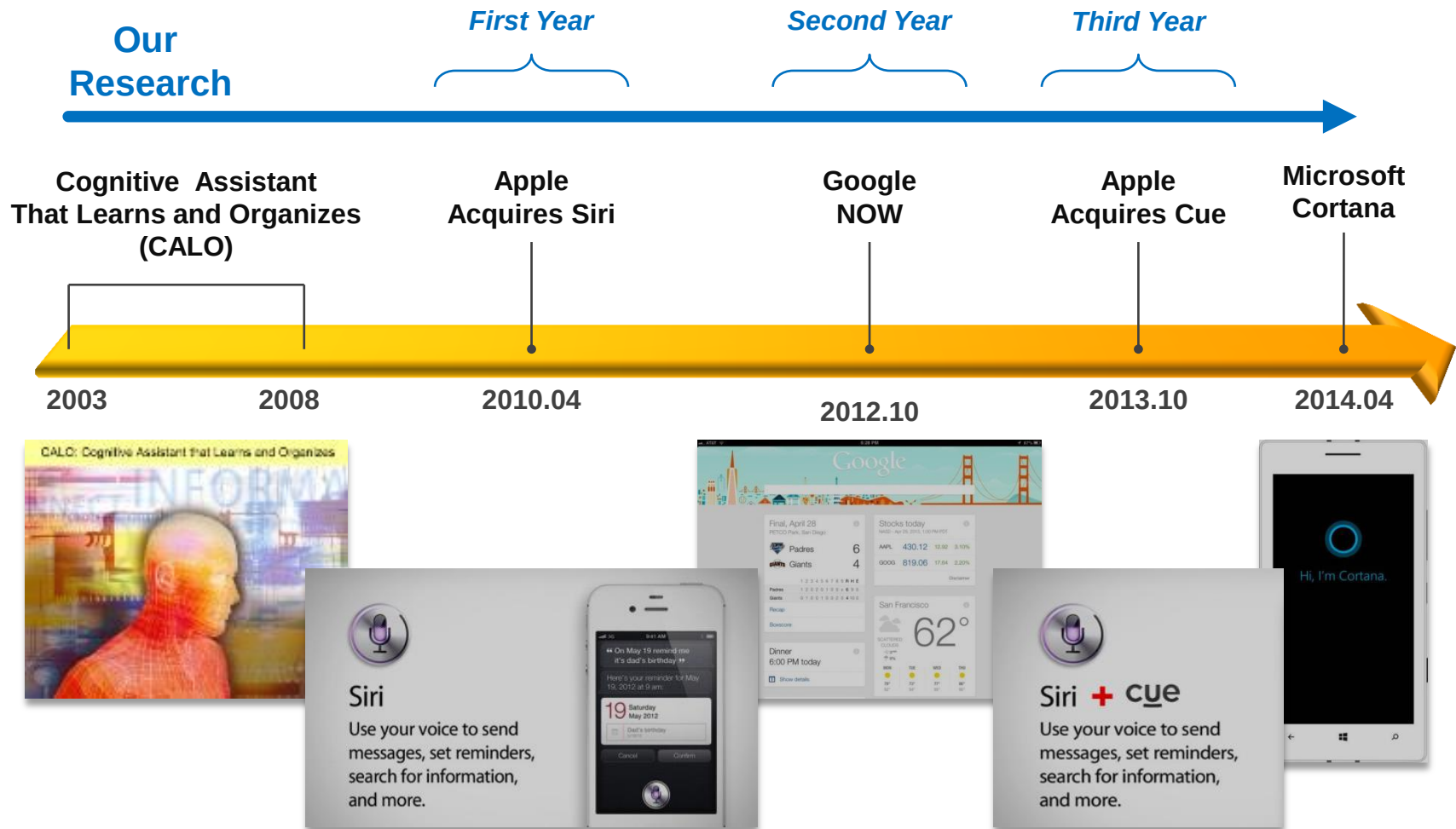


Cortana



InMind

Virtual Personal Assistant Timeline



Towards Cognitive Assistants



A Simple Scenario: Predictive Assistant

SpatioTemporal Knowledge



Context

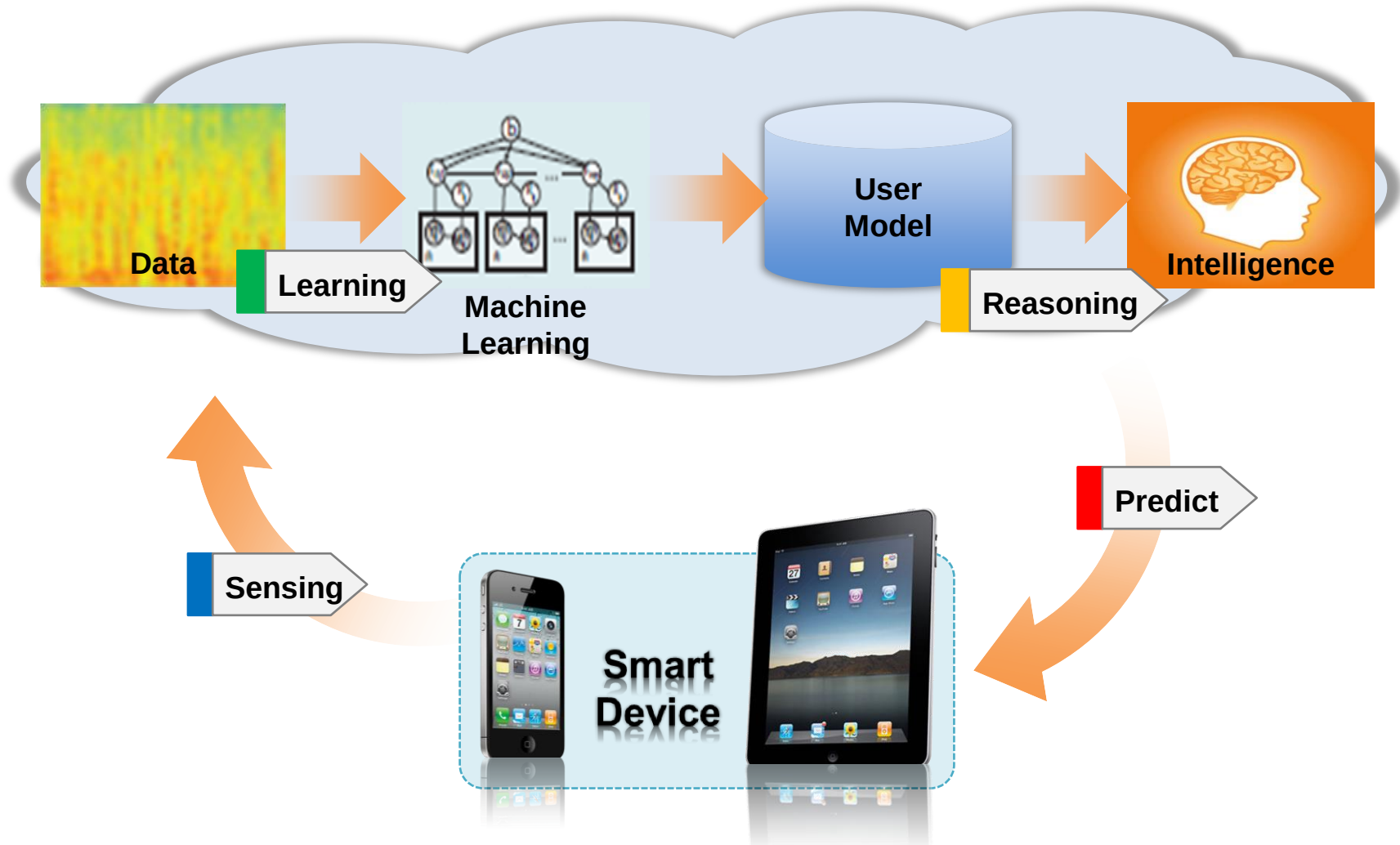
Driving to work
on Monday Morning

Prediction

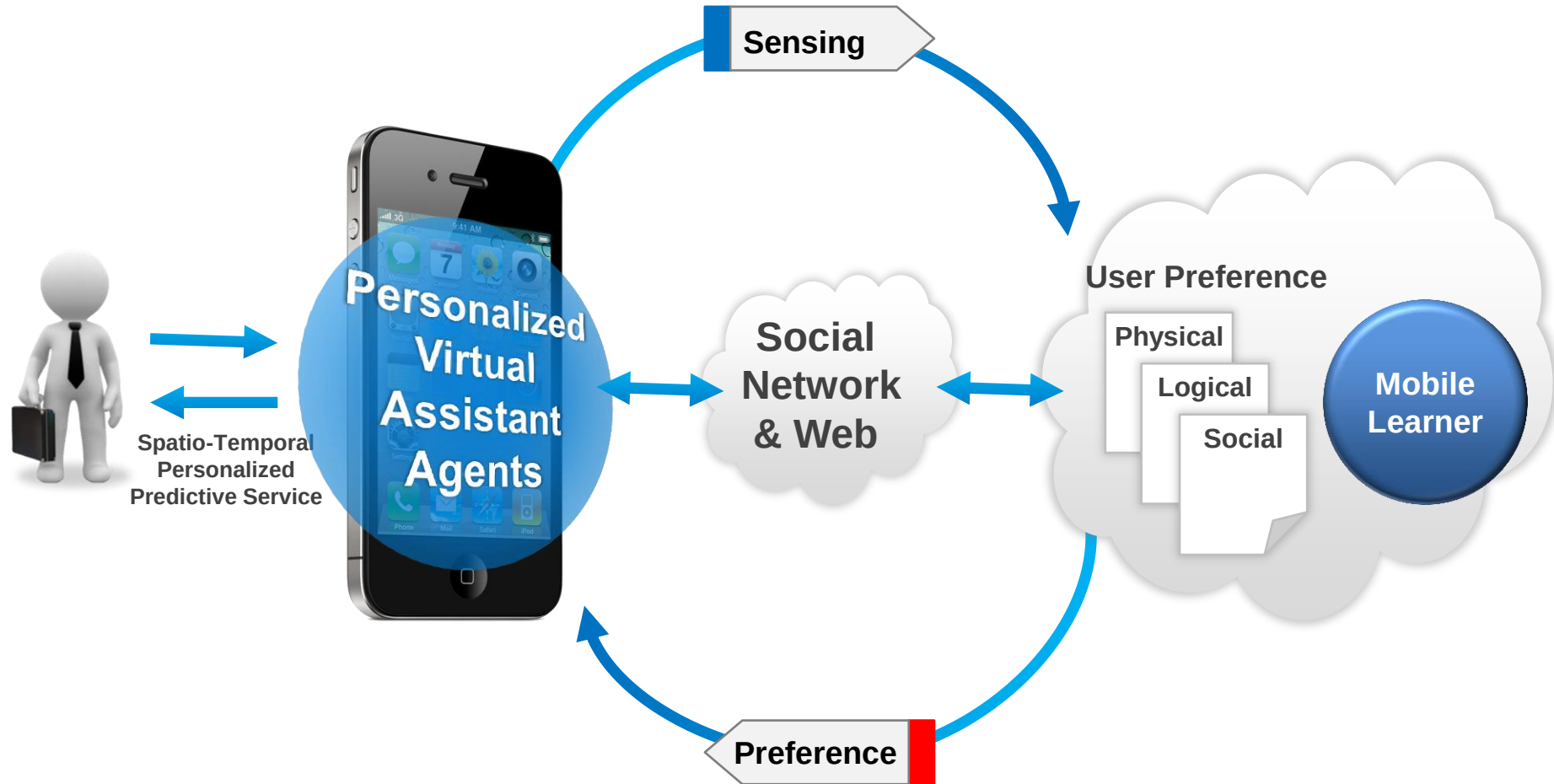
Going to SNU	80%
Turn right on next signal	90%
Classic music	80%
Sports article	90%

While Driving

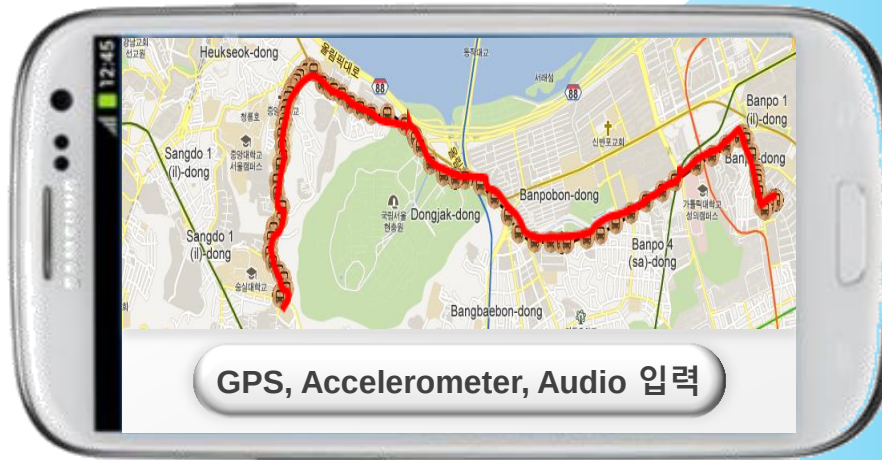
Sensing, Learning, Reasoning & Prediction



Client/Server Architecture



Where are they going? : Location Prediction

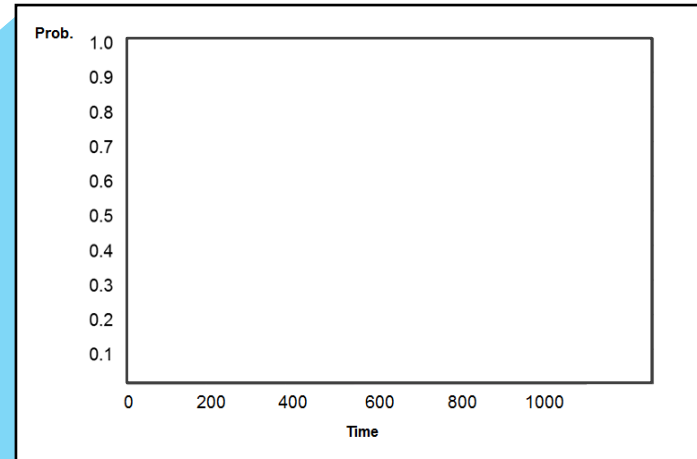


 Walking

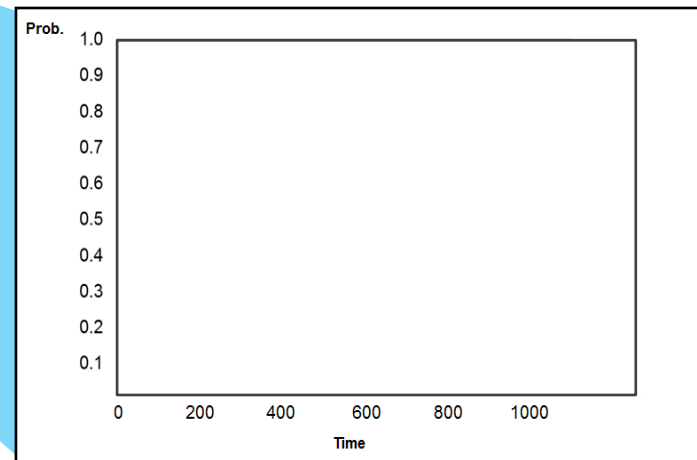
 Bus

 Jogging

 Subway



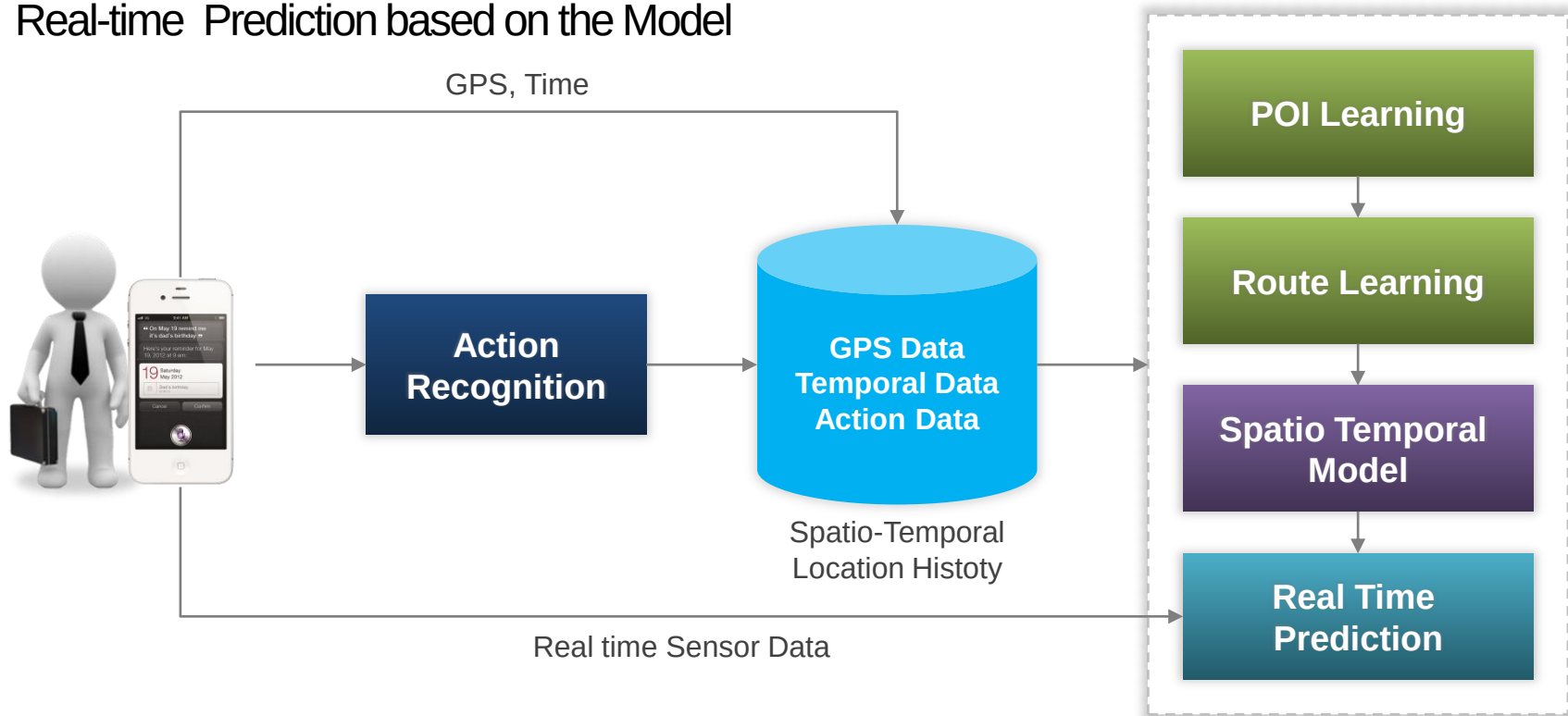
Goal Prediction Probability



Route Prediction Probability

Research Areas for Mobile Prediction

- Activity Recognition
- Spatio-Temporal User POI(Points of Interests) and Route Learning
- Spatio-Temporal Probability Model
- Real-time Prediction based on the Model



Action Logger

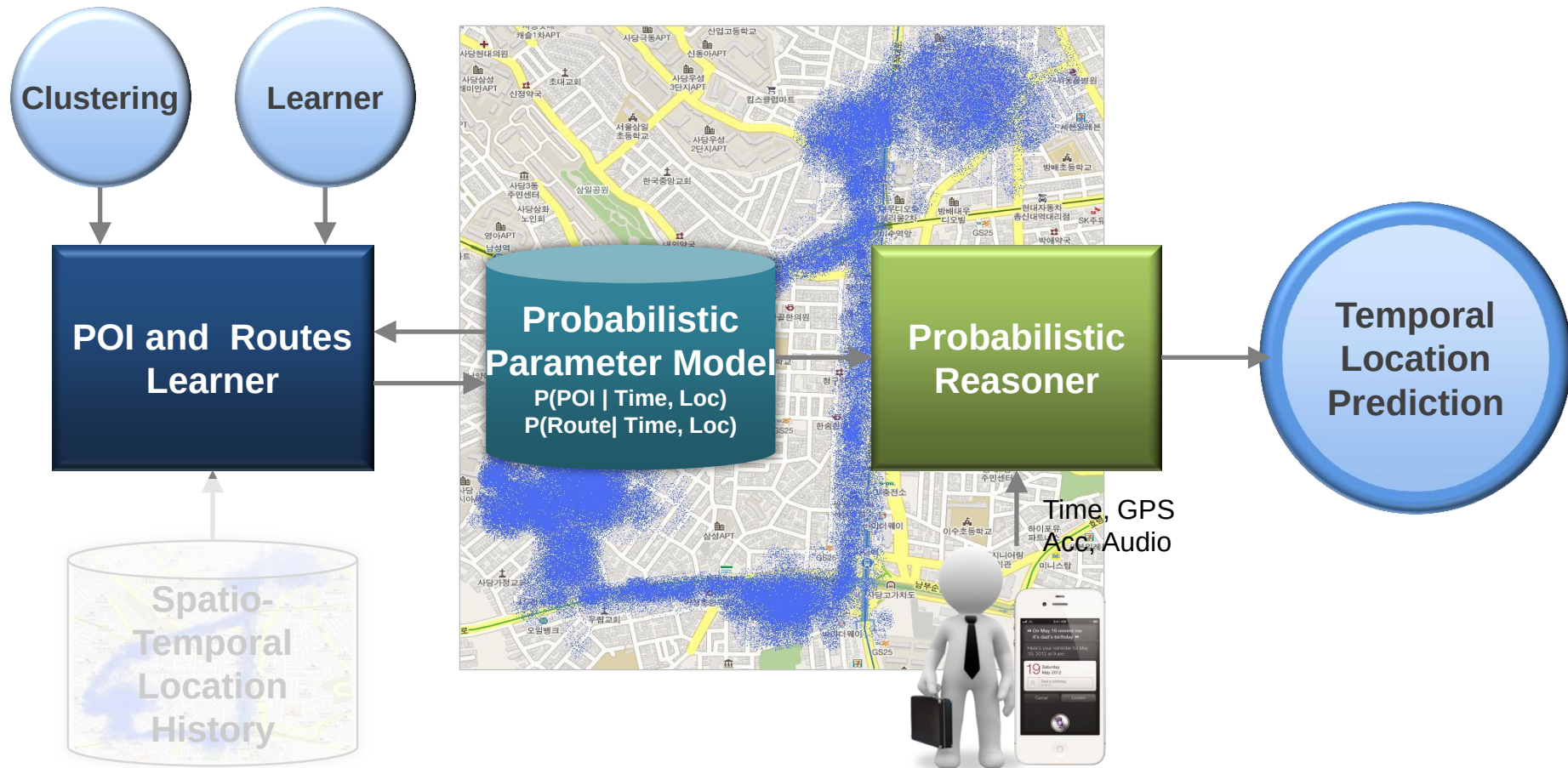


Sensor Based Action Learner

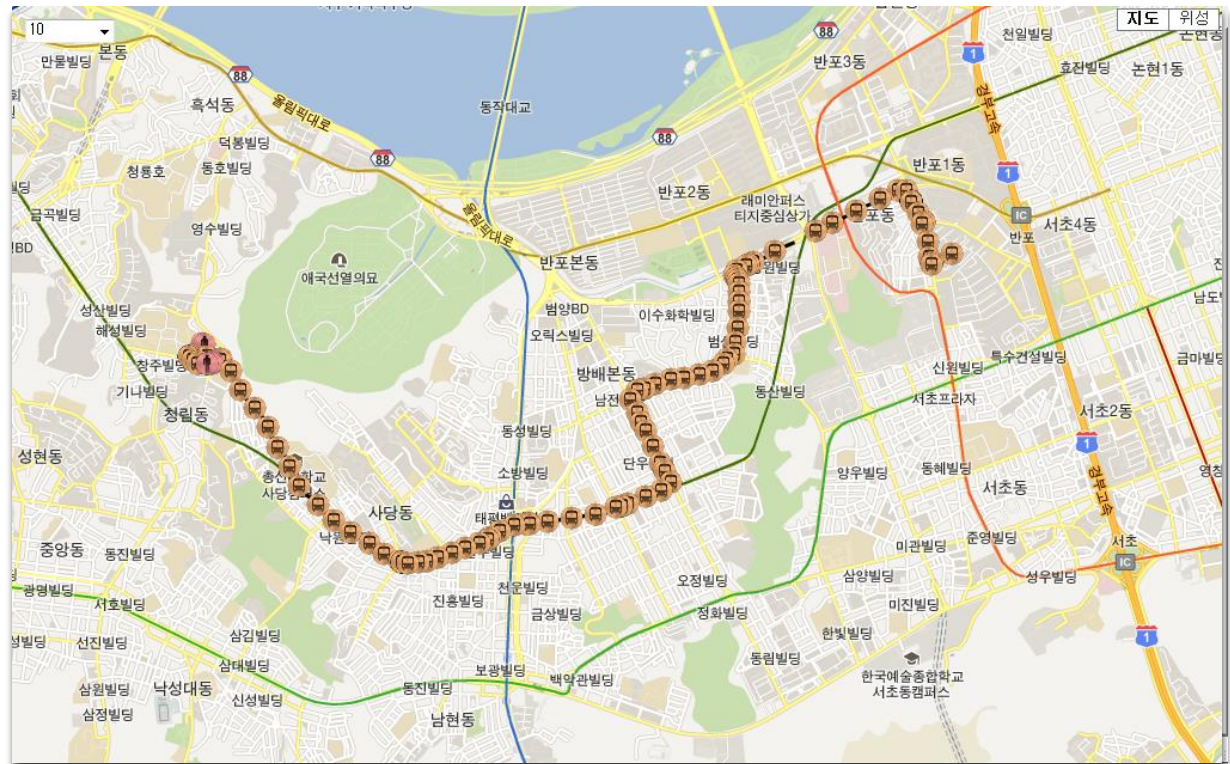


Spatio-Temporal User Model

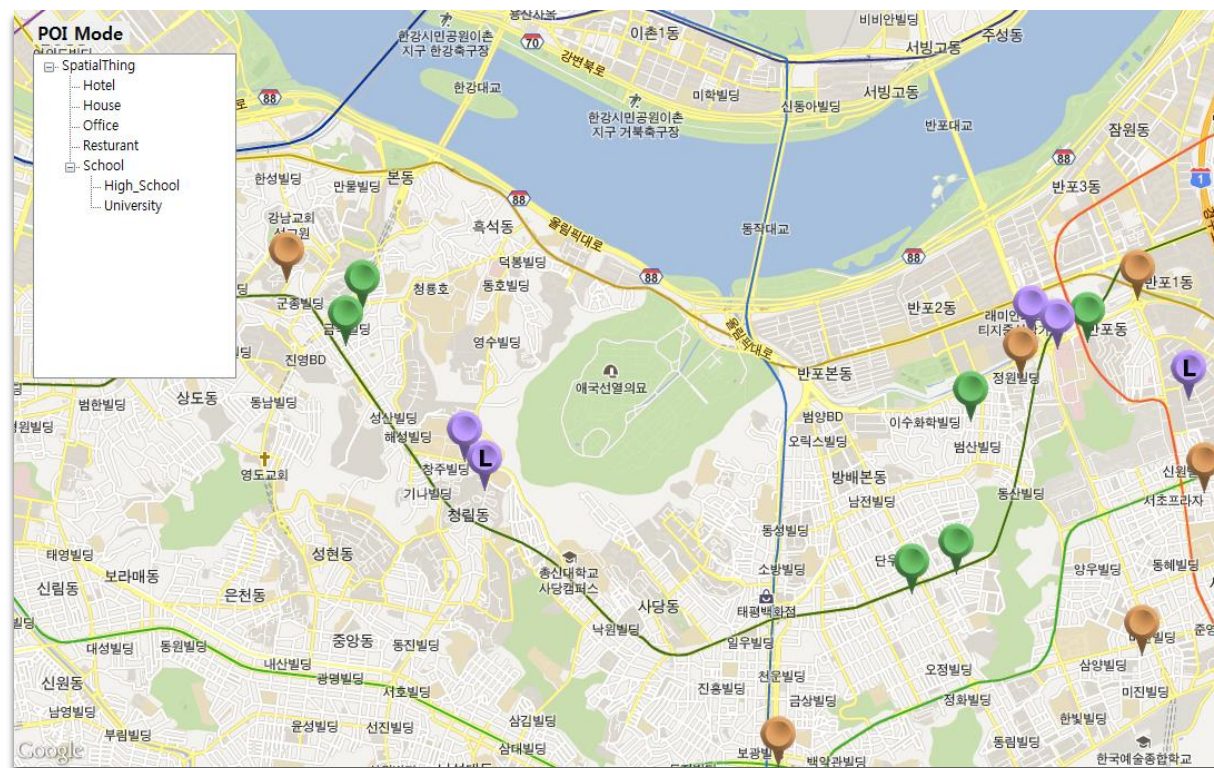
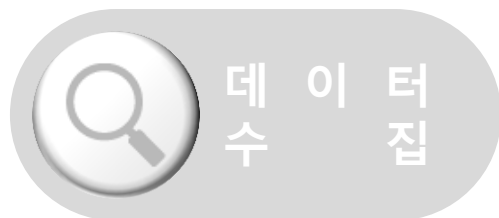
- Spatio temporal over Points of Interests
- Spatio temporal probability of taking a particular routes going to a POI



Mobile Life Logging



Points of Interests Learning



Route Learner

```
20121130112357 PRX 1
20121130112357 GPS 37.50025098 127.01233244 56.70000076293945 3.5 332.0 14.422205
20121130112357 ACTION Bus
20121130112357 MAP 37.500214/127.012129/121/702/6830/134/우면로/37.501293/127.011877/37.500106/127.0

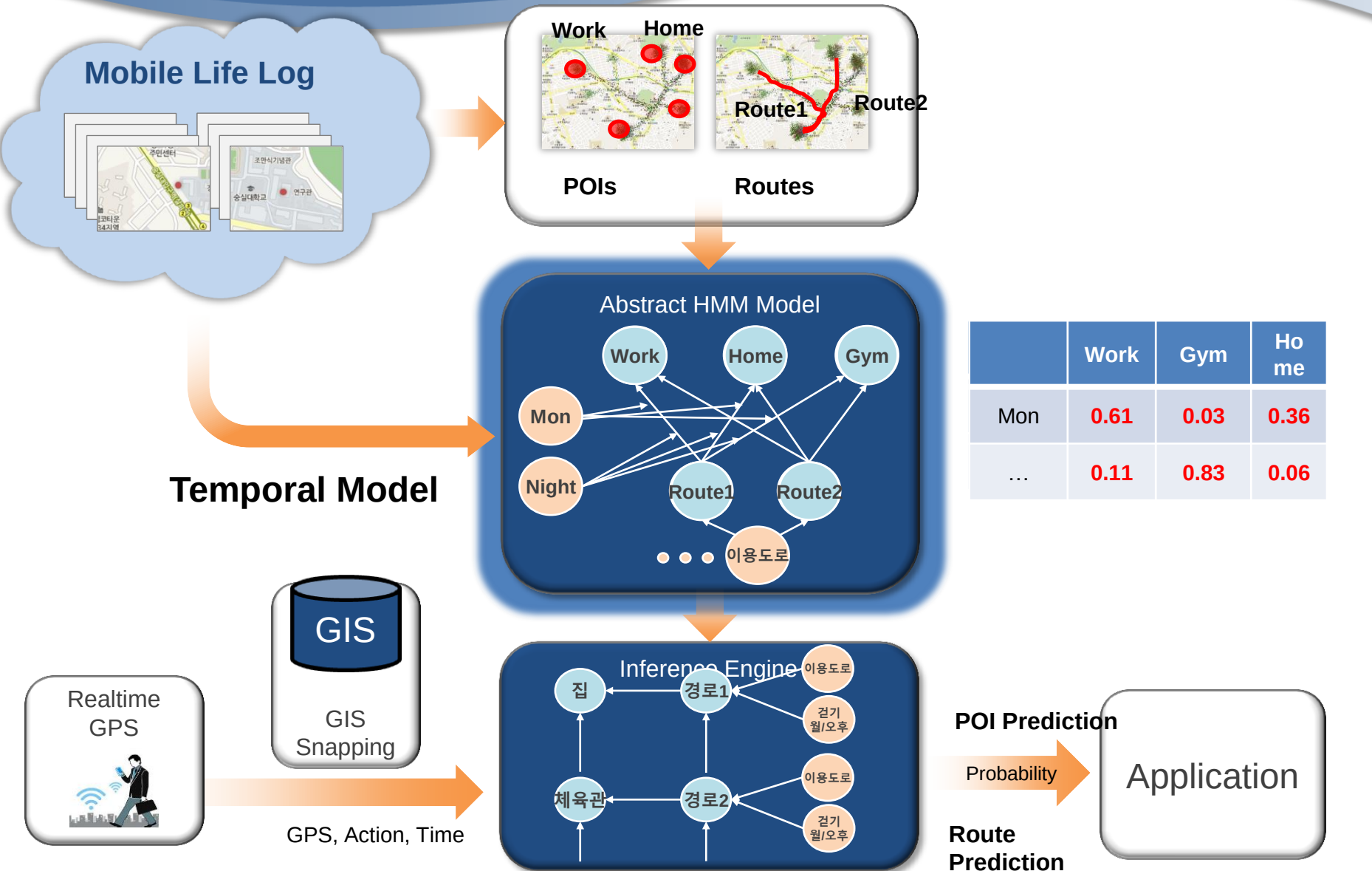
20121130112358 PRX 1
20121130112358 GPS 37.50028067 127.01230569 57.599998474121094 3.5 334.5 14.422205
20121130112358 ACTION Bus
20121130112358 MAP 37.500259/127.012117/116/702/6830/134/우면로/37.501293/127.011877/37.500106/127.0

20121130112359 PRX 1
20121130112359 GPS 37.50032574 127.01227842 58.099998474121094 5.59017 349.2 13.416408
20121130112359 ACTION Bus
20121130112359 MAP 37.500304/127.012105/111/702/6830/134/우면로/37.501293/127.011877/37.500106/127.0

20121130112400 PRX 1
20121130112400 GPS 37.50037654 127.01225488 58.79999923706055 5.5226803 348.6 13.416408
20121130112400 ACTION Bus
20121130112400 MAP 37.500349/127.012104/106/702/6830/134/우면로/37.501293/127.011877/37.500106/127.0

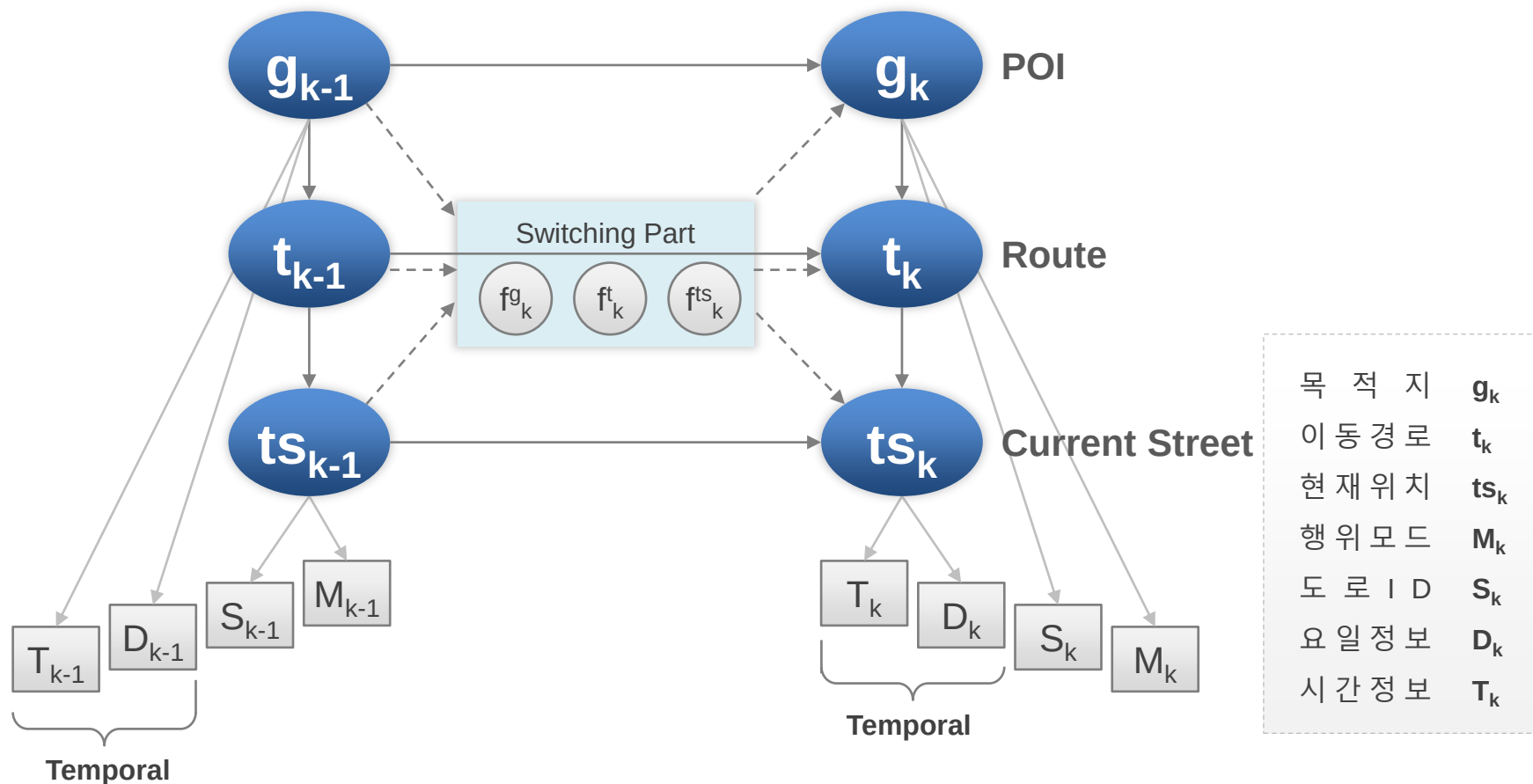
20121130112401 PRX 1
20121130112401 GPS 37.5004295 127.01223218 58.79999923706055 5.5 345.8 13.416408
20121130112401 ACTION Bus
20121130112401 MAP 37.500403/127.012081/99/702/6830/134/우면로/37.501293/127.011877/37.500106/127.0
```

Overview of Prediction Model

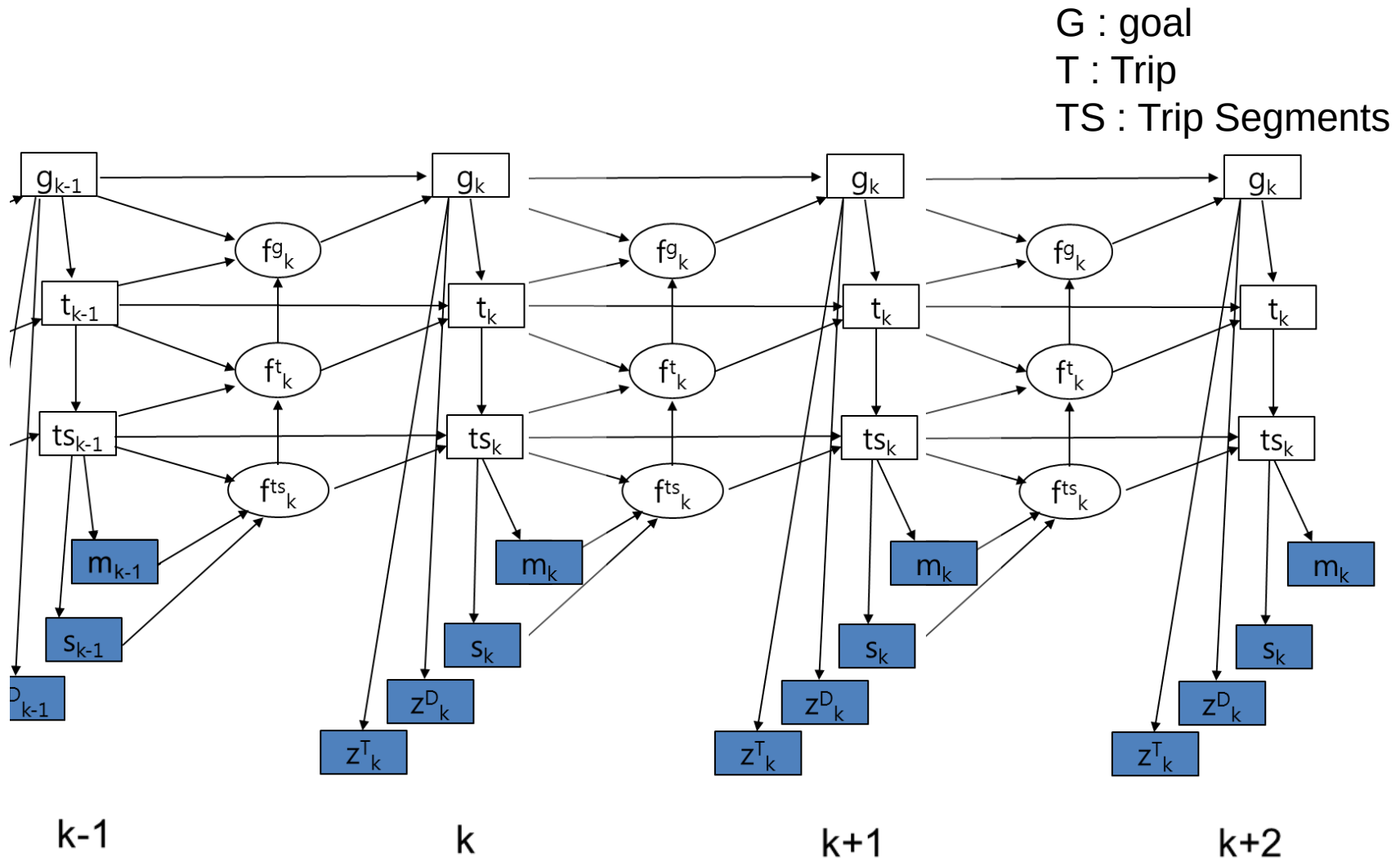


Spatio Temporal User Model

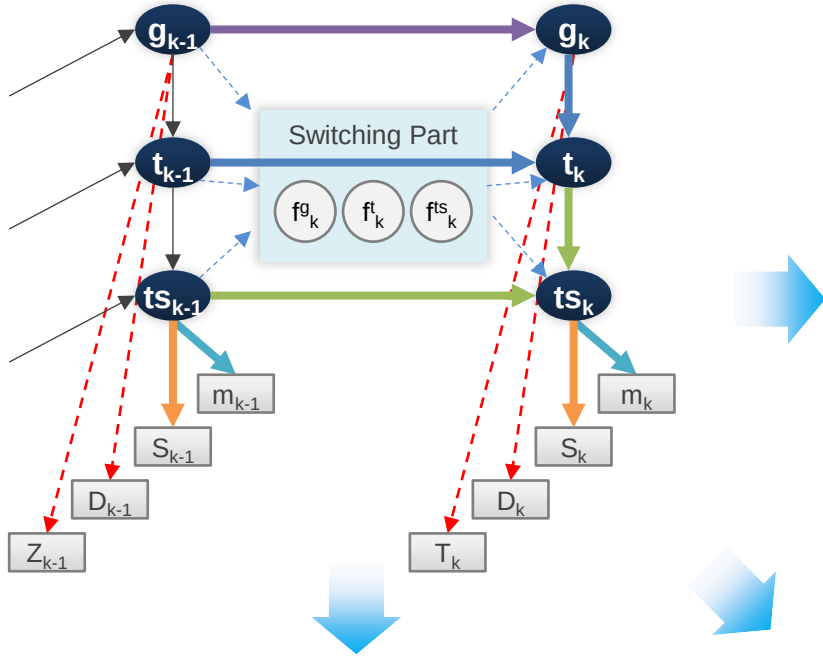
- Spatio Temporal User Model
- Dynamic Bayesian Network



Dynamic Bayesian Network Representation



Abstract HMM Model 확률 파라미터



Transition CPDs

Goal-to-Goal

$$\begin{cases} P(g_k | g_{k-1}, f_k^t = \text{off}) = 1, & g_k = g_{k-1} \\ P(g_k | g_{k-1}, f_k^t = \text{on}) = \frac{\sum I(g_{k-1} \rightarrow g_k) + \alpha}{\sum_{\text{swt_on}} I(g_{k-1}) + \alpha'} \end{cases}$$

Trip-to-Trip

$$\begin{cases} P(t_k | t_{k-1}, g_{k-1}, f_k^t = \text{off}) = 1, & t_k = t_{k-1} \\ P(t_k | t_{k-1}, g_{k-1}, f_k^t = \text{on}) = \frac{\sum I(t_{k-1} \rightarrow t_k, g_{k-1}) + \beta}{\sum_{\text{swt_on}} I(t_{k-1}, g_{k-1}) + \beta'} \end{cases}$$

Street-to-Street

$$\begin{cases} P(ts_k | ts_{k-1}, t_k, f_k^{ts} = \text{off}) = 1, & ts_k = ts_{k-1} \\ P(ts_k | ts_{k-1}, t_k, f_k^t = \text{on}) = \begin{cases} \begin{cases} 0.2, \text{prev}(ts_{k-1}, t_k) \\ 0.4, ts_{k-1} \end{cases}, & ts_{k-1} \text{ in } t_k \\ \begin{cases} 0.4, \text{next}(ts_{k-1}, t_k) \\ \frac{\sum I(ts_{k-1} \rightarrow ts_k)}{\sum I(ts_{k-1})}, ts_{k-1} \text{ not in } t_k \end{cases} \end{cases} \end{cases}$$

Emission CPDs

Trip-to-Ob. action

$$P(m_k | t_k) = \begin{cases} w_1, & m_k = \text{action}(t_k) \\ w_2, & m_k \neq \text{action}(t_k) \end{cases}$$

True street-to-Ob. street

$$P(s_k | ts_k) = \frac{1}{\min_dist(s_k, ts_k) + \gamma}$$

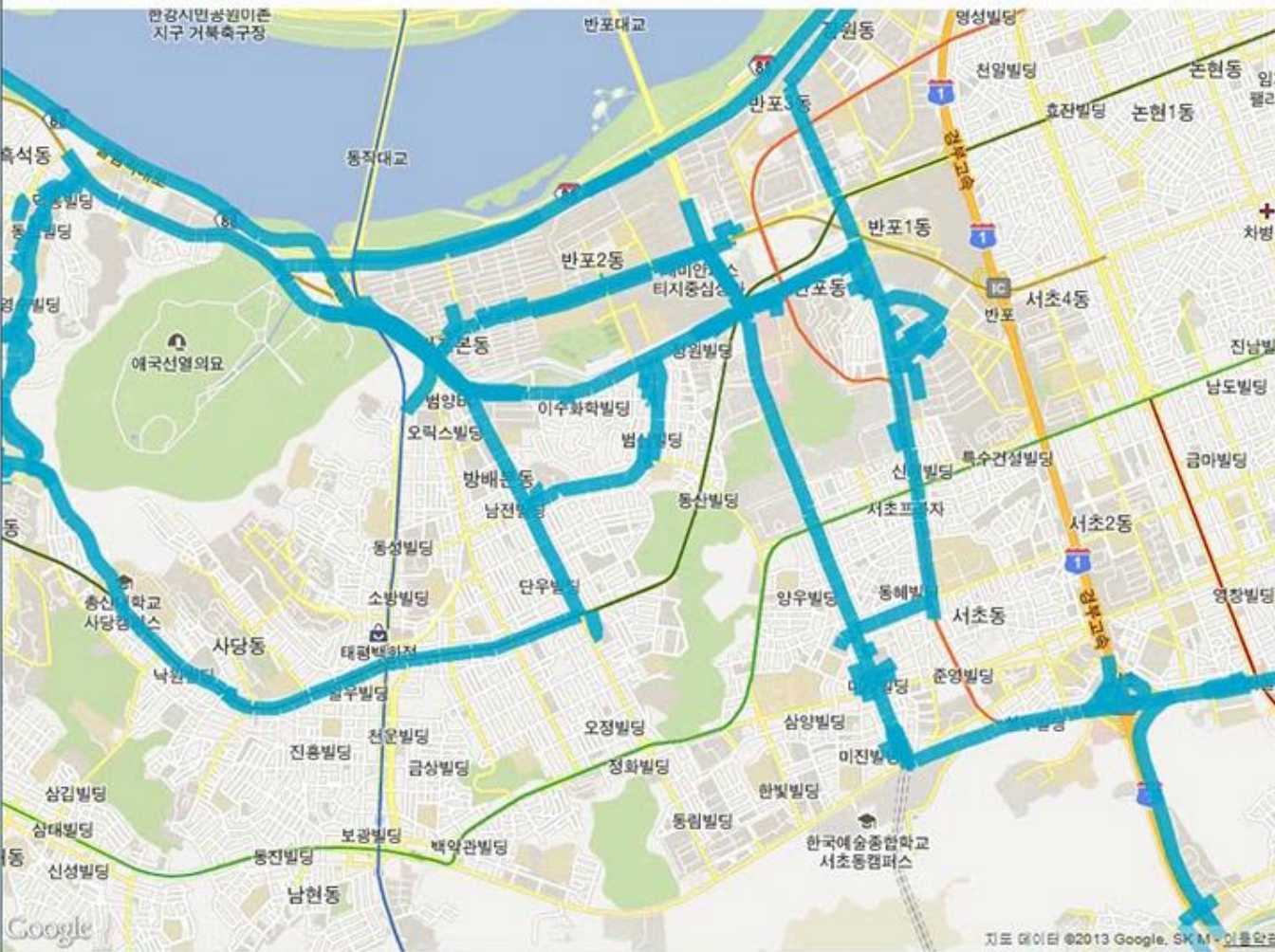
Temporal CPDs

Goal-to-Weekday

$$P(Z_k^D | g_k) = \frac{\sum I(Z_k^D, g_k) + \varepsilon}{\sum I(g_k) + \varepsilon'}$$

Goal-to-Timeband

$$P(Z_k^T | g_k) = \frac{\sum I(Z_k^T, g_k) + \sigma}{\sum I(g_k) + \sigma'}$$



CPT Validation Table

Month		Day	
Month	Probability	Day	Probability
Action		Goal	
action	Probability	Goal	Probability
Trip		Plan	
Trip	Probability	Plan	Probability

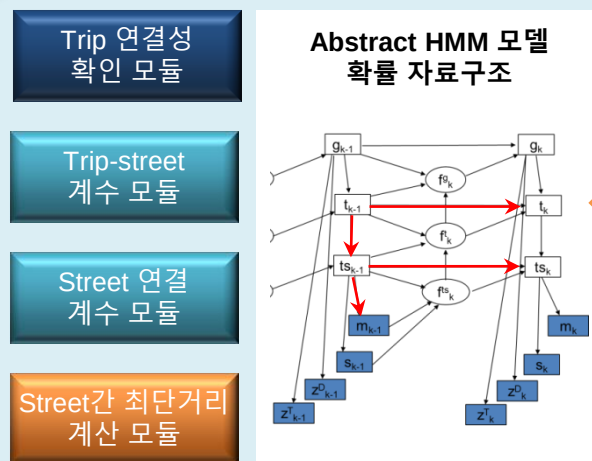


Prediction Engine

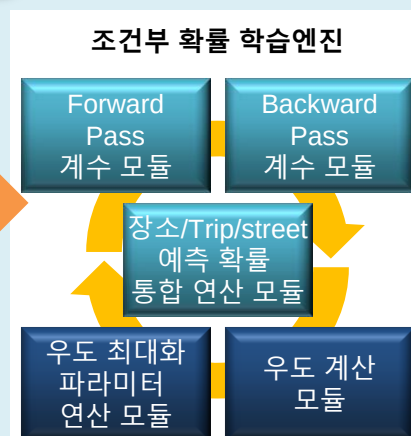
1 POI, Route Learner



2 Probabilistic Graph Model

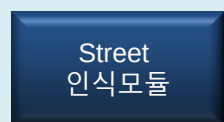


3 CPD Learner



Realtime Data

GPS Data
Action Data



4

Real time Prediction

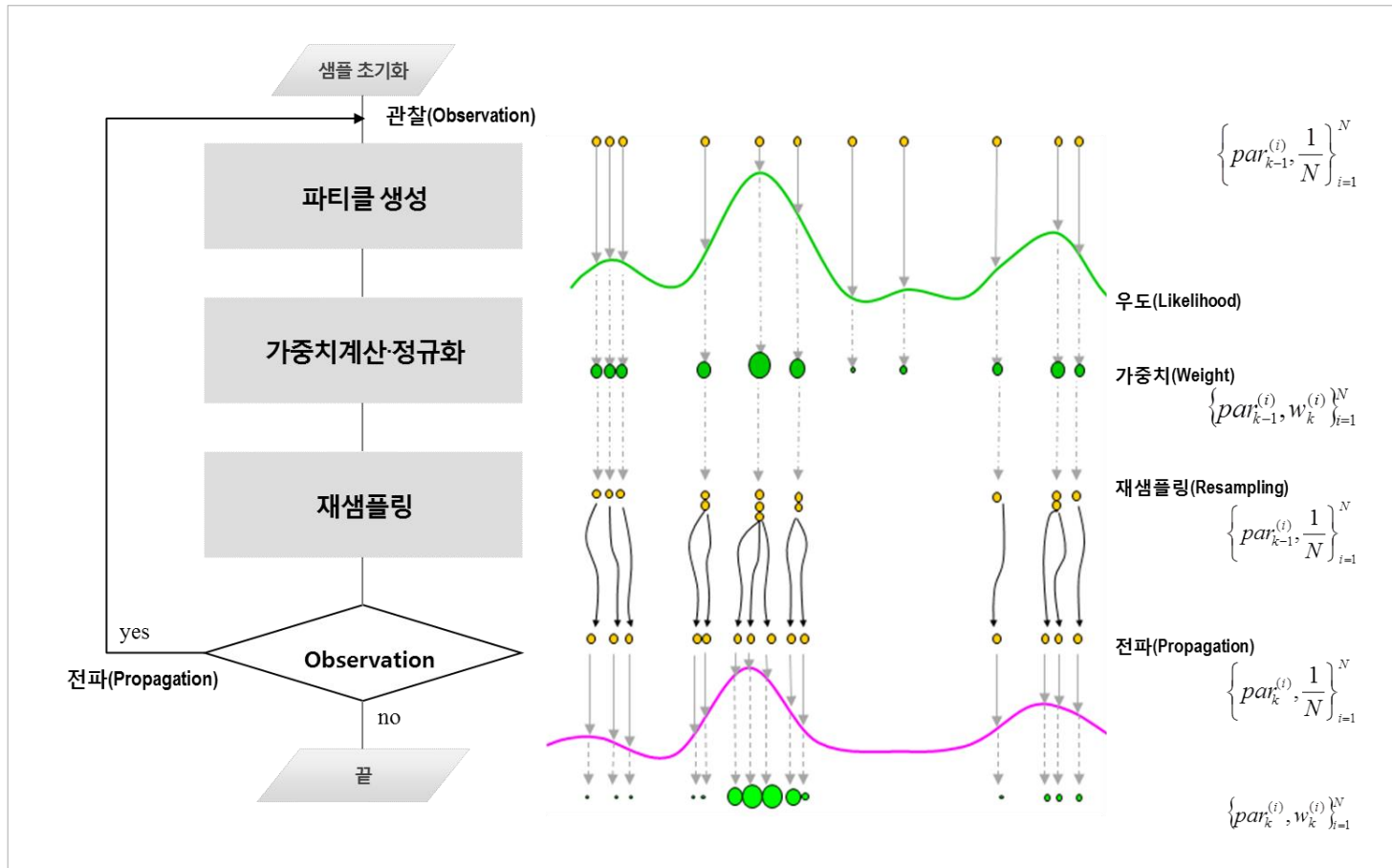


Goal
Prediction

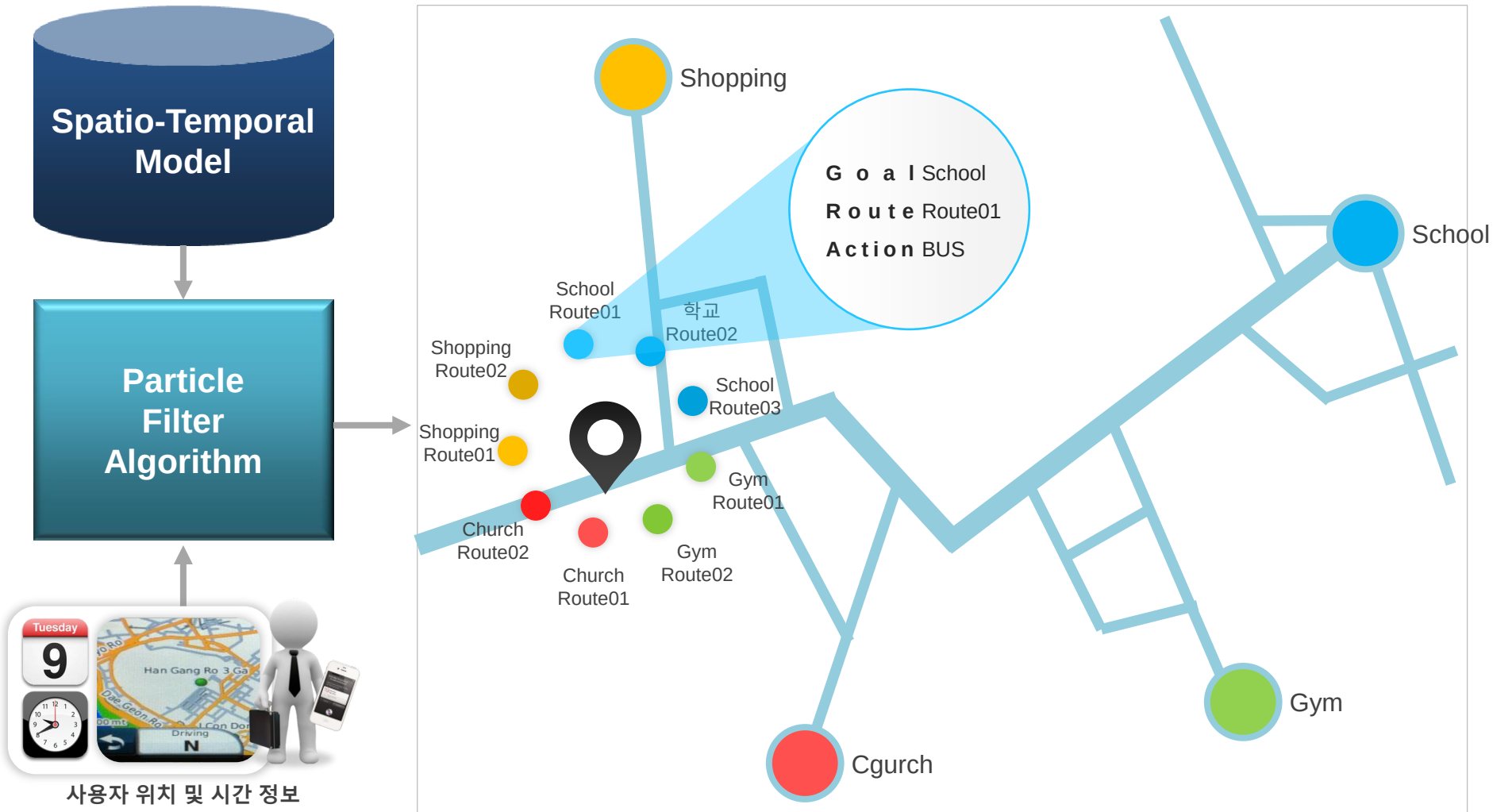
Route
Prediction

Real time Route Prediction

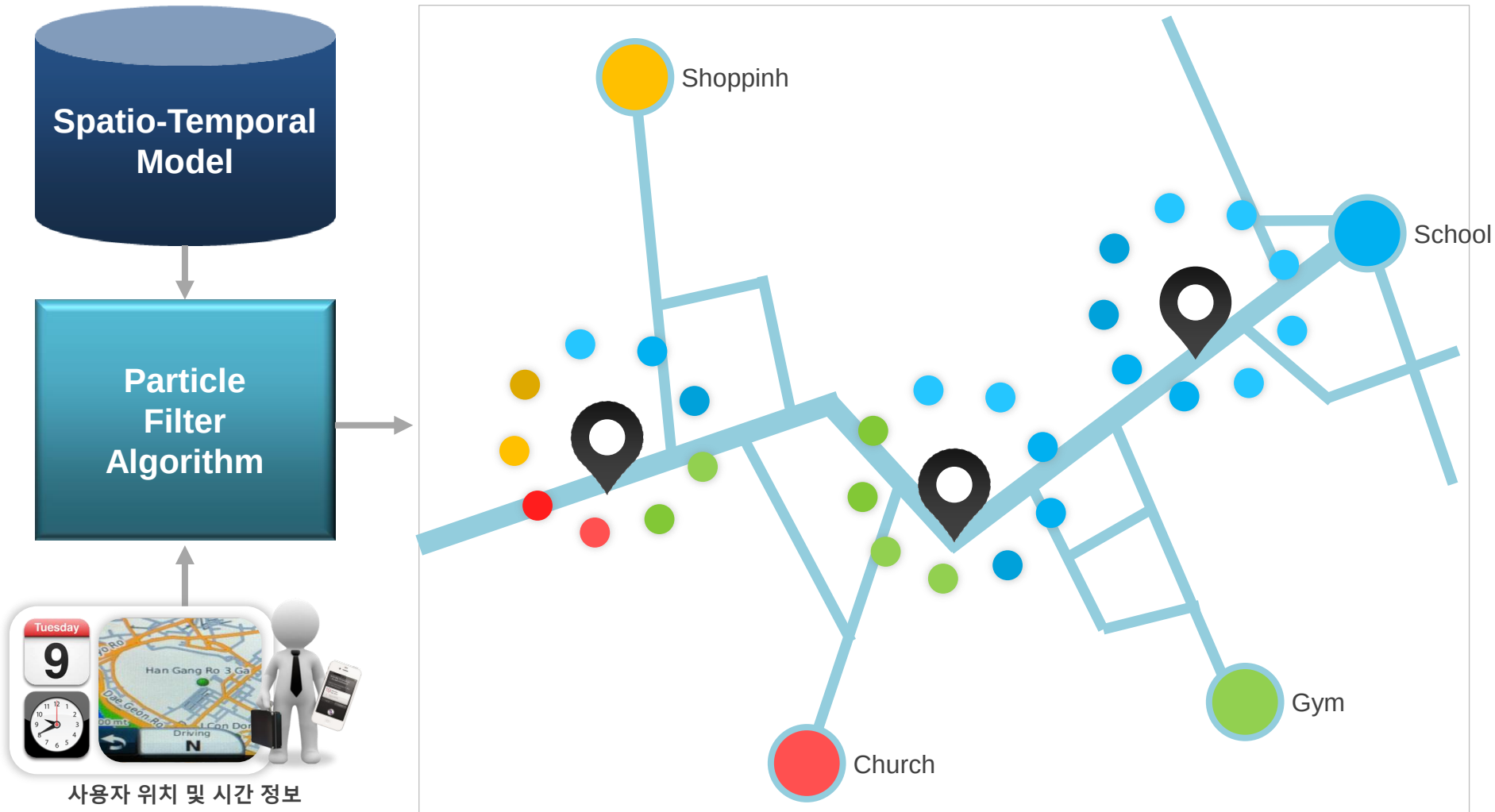
- Given : Current Context (GPS, Action, Time), Learned Personal Spatio-Temporal Model
- Identify plausible goal and route based on real time data
- Use an approximate reasoning such as a particle filtering algorithm



Prediction using Approximate Reasoner



Prediction using Approximate Reasoner



확률 그래프 학습 모델 기반

주요 거점 및 이동궤적 Browser

☐ MiniMap☒ Show Trip

Map data ©2013 SK M&C - Terms of Use

Go

1

Subway

Bus



Jogging



Walking

Stay

Goal and Route Prediction

Abstract HMM

Trip 8 / **Goal-1**



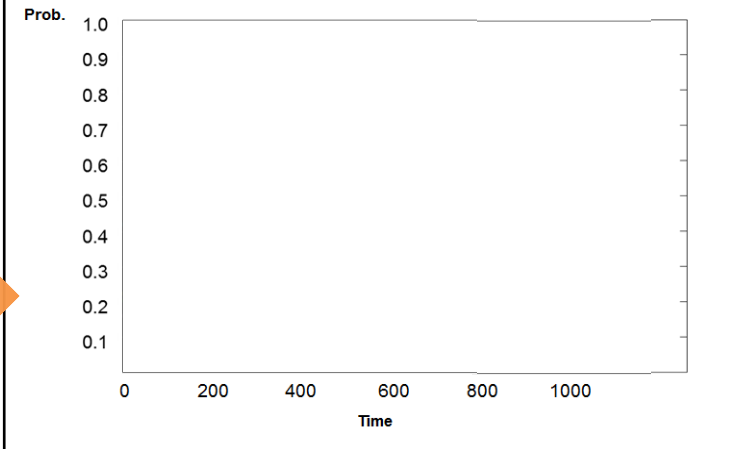
Trip 12 / **Goal-2**



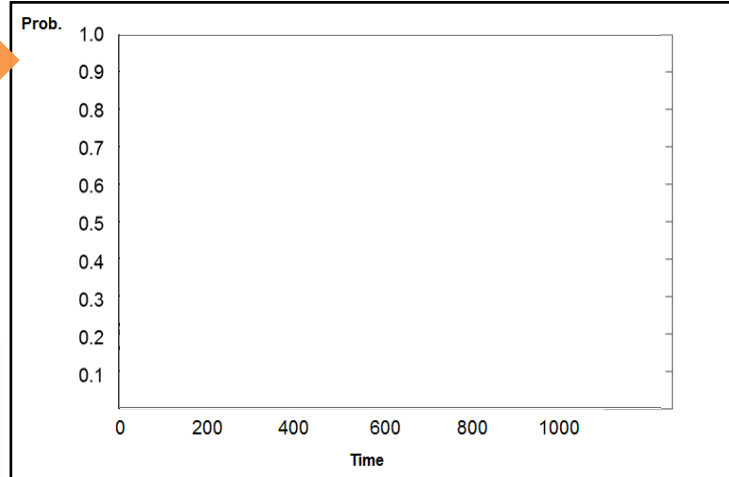
Trip 18 / **Goal-3**



Particle
Filter
Real Time
Prediction
Engine

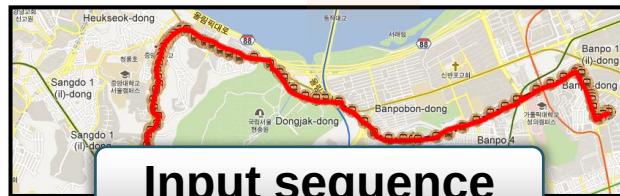


Goal Prediction Probability

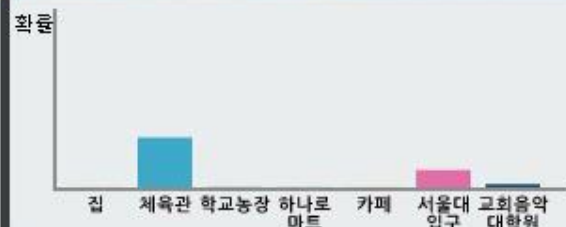


Route Prediction Probability

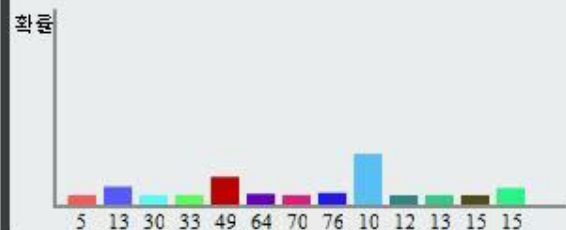
Input sequence



Goal Prediction Graph



Trip Prediction Graph



Goal	Probability		Trip	Probability
집	6	▲	5	1
학교	0		13	9
체육관	34		17	0
goal4	0		30	3
goal5	0	▼	31	0



Subway

Bus



Jogging

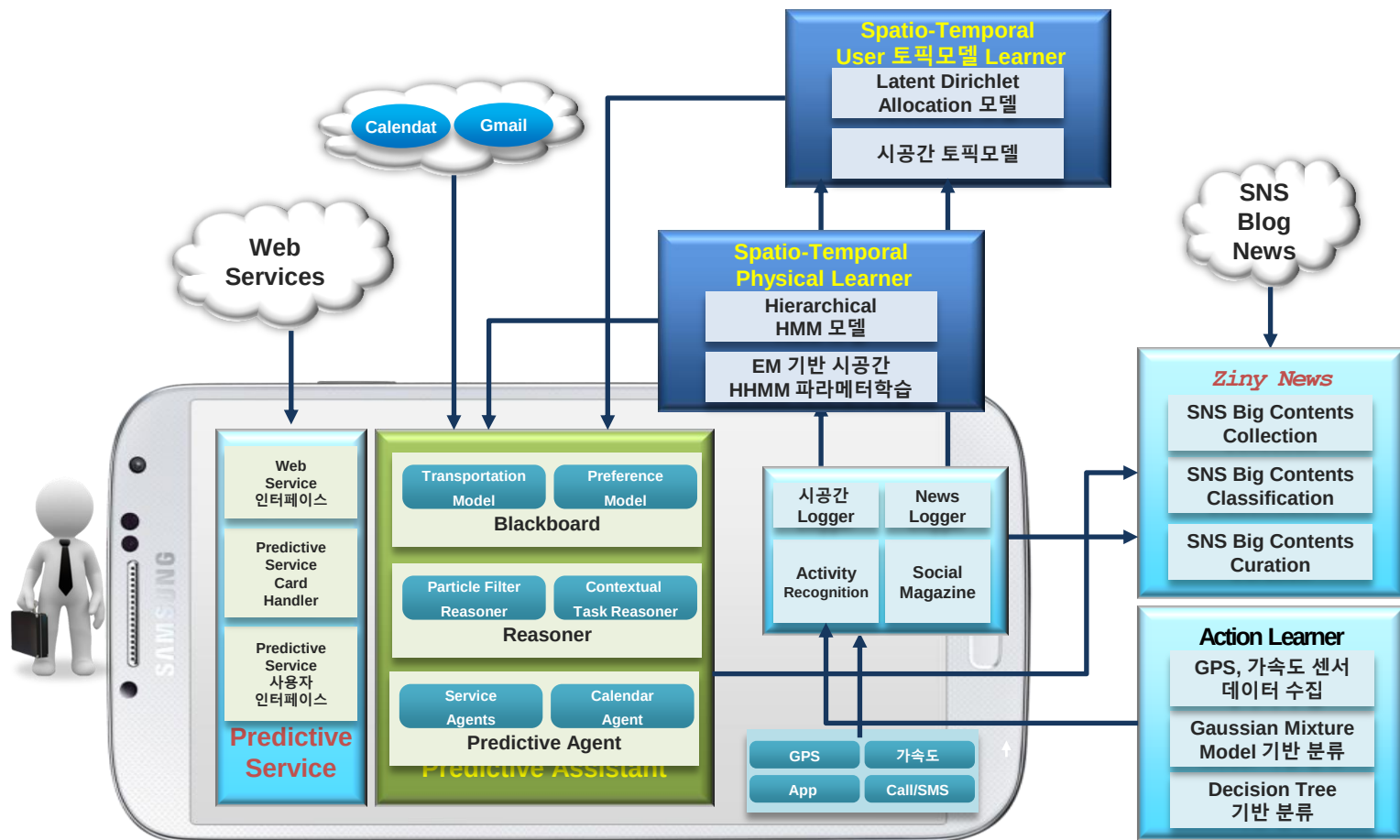


Walking

Stay

Predictive Assistant

- Robust probabilistic model to cope with uncertainties
- Approximate reasoning for realtime prediction



Predictive Assistant vs Google NOW

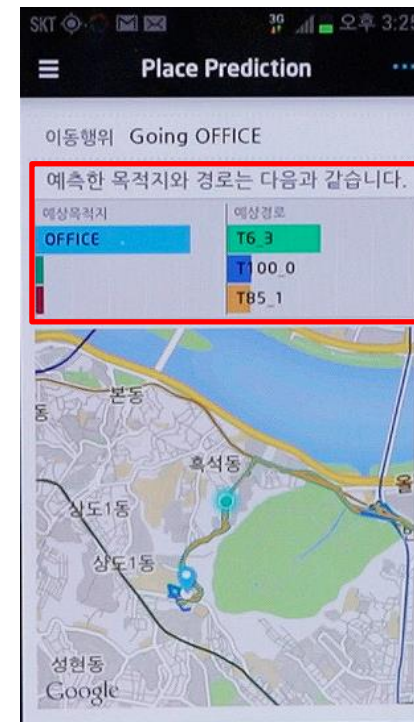
Prediction

Location History

Google NOW



myCompanion





Thank you!!

클러스터링 기반 주요 장소 학습

Action
Reasoner

장소 및
경로 추론

확률모델
학습

실시간
추론

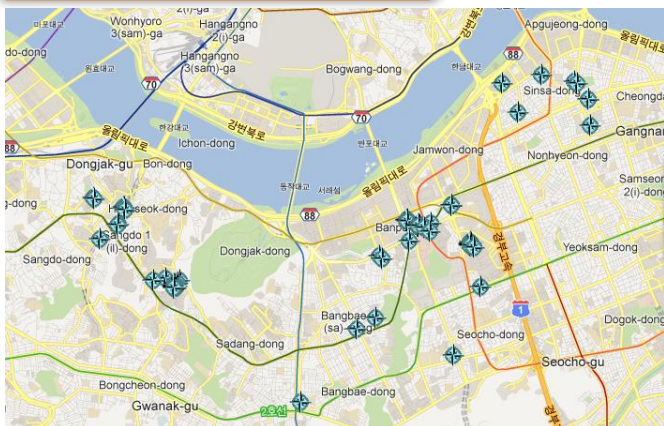
● 적용방법

- 사용자 GPS 이력을 기반으로 함
- 일정시간 같은 지점에 stay action이 인지된 좌표를 POI Candidates로 설정
- DBSCAN을 적용하여 밀집된 Candidates를 하나의 POI로 인지

● DBSCAN(density-based spatial clustering of applications with noise)

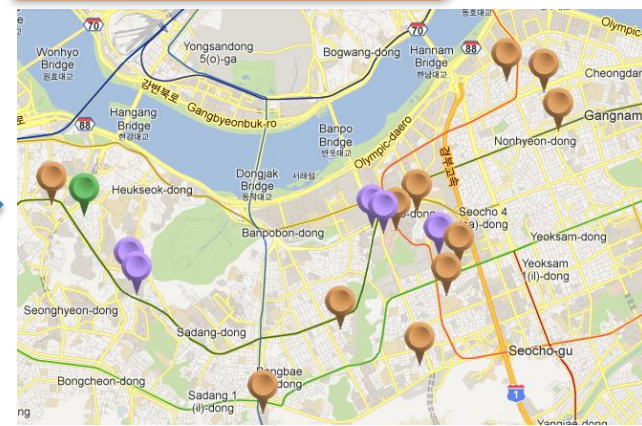
- 공간상에 분포한 대량의 데이터들에 대하여 다양한 크기와 모양의 클러스터를 탐지하는 기법

주요 장소 후보군



DBSCAN
수행

주요 장소 인지



이동 경로 학습

Action
Reasoner

장소 및
경로 추론

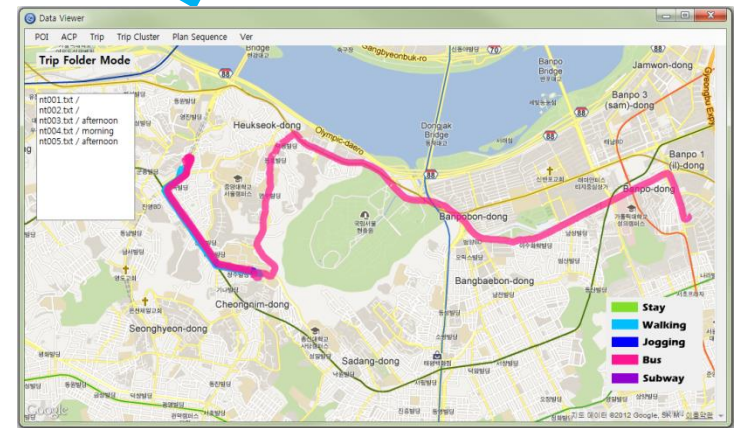
확률모델
학습

실시간
추론

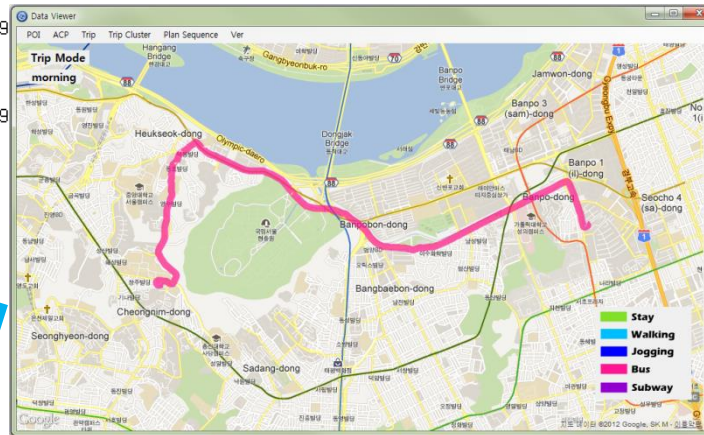
시간, 장소, Action 로그

20120518091517	PRX	1						
20120518091517	GPS		37.5004601	127.01285472	55.7000007629	5.75	231.2	13.416408
20120518091517	ACTION	Bus						
20120518091518	PRX	1						
20120518091518	GPS		37.50041124	127.01281422	55.2000007629	5.25	229.5	10.0
20120518091518	ACTION	Bus						
20120518091519	PRX	1						
20120518091519	GPS		37.50036846	127.01277195	55.2999992371	5.25	233.6	10.0
20120518091519	ACTION	Bus						
20120518091520	PRX	1						
20120518091520	GPS		37.50033353	127.01273837	55.2000007629	4.75	232.4	10.0
20120518091520	ACTION	Bus						
20120518091521	PRX	1						
20120518091521	GPS		37.50032388	127.01269763	55.5999984741	4.0	233.7	8.485281
20120518091521	ACTION	Bus						
20120518091522	PRX	1						
20120518091522	GPS		37.50031194	127.01265899	55.7000007629	4.0	235.1	8.485281
20120518091522	ACTION	Bus						
20120518091523	PRX	1						
20120518091523	GPS		37.50029014	127.01263501	55.59999			
20120518091523	ACTION	Bus						
20120518091524	PRX	1						
20120518091524	GPS		37.50026934	127.01260041	55.79999			
20120518091524	ACTION	Bus						

이동 경로 학습



이동 경로 학습



이동 경로 클러스터링

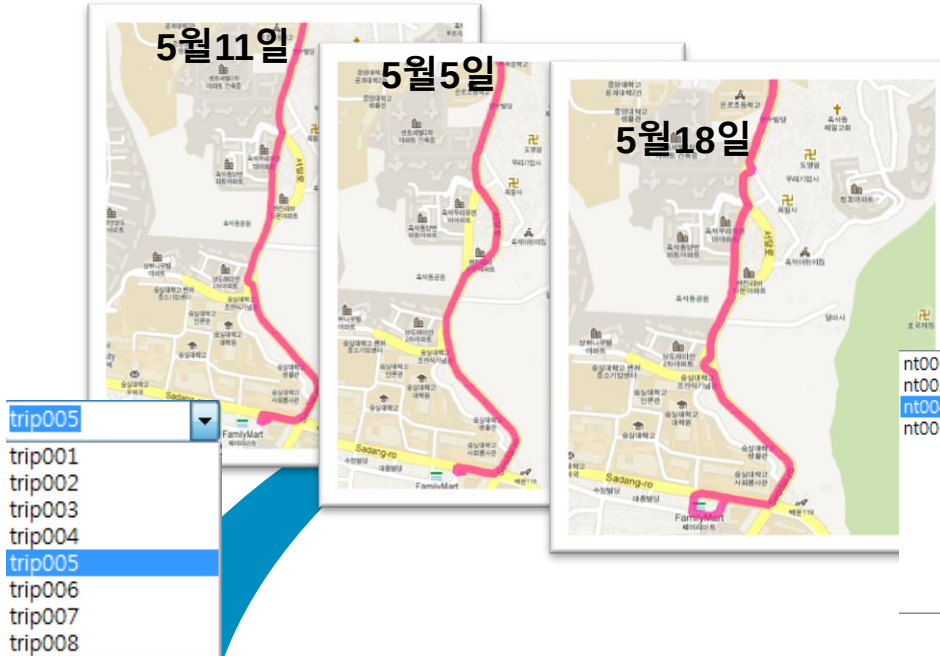
Action
Reasoner

장소 및
경로 추론

확률모델
학습

실시간
추론

유사한 이동 경로 추출



nt001.txt / afternoon
nt002.txt / afternoon
nt004.txt / morning
nt005.txt / afternoon

이동 경로 클러스터링

이동 경로 데이터

```
[trip001={nt003.txt}]
[trip002={nt004.txt}]
[trip003={nt005.txt}]
[trip004={nt003.txt,nt004.txt,nt001.txt,nt002.txt}]
[trip005={nt004.txt,nt005.txt,nt001.txt,nt002.txt}]
[trip006={nt003.txt,nt005.txt,nt001.txt,nt002.txt}]
[trip007={nt003.txt,nt004.txt,nt005.txt,nt001.txt,nt002.txt}]
```

