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People Monitoring in the context of Smart Health

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29.02.2016, CDS Group Seminar

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Motivation/Contextualization

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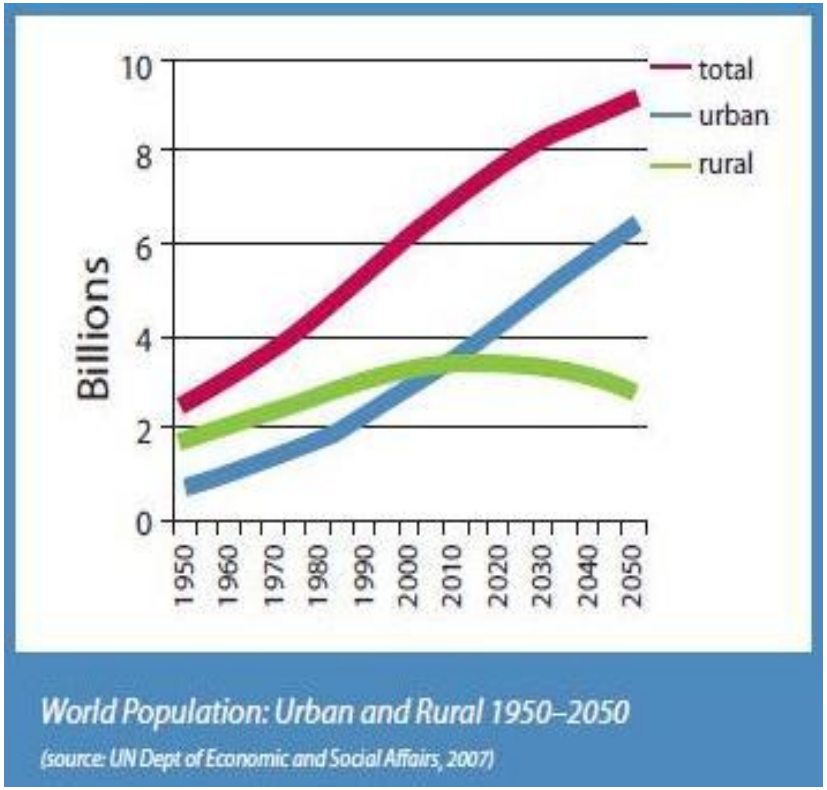
- Increase in World Population
- High rate of migration from rural areas to cities
- Refugee crisis coming from countries in war to the european cities

- Tremendous pressure on the management of Cities in order to provide services in effective ways

Emergence of the concept of Smart Cities



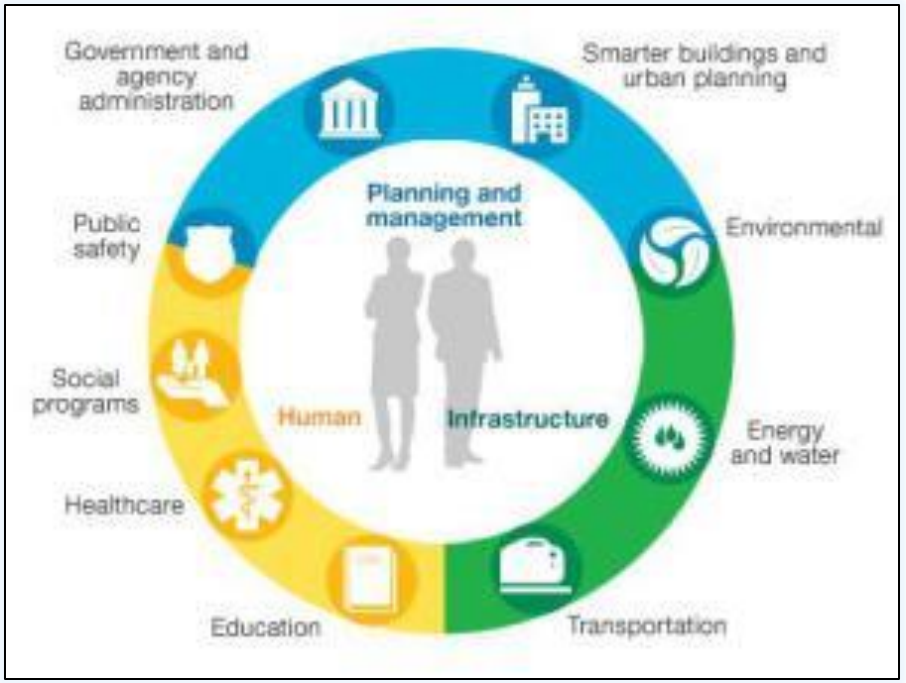
World Population: Urban and Rural 1950–2050

(source: UN Dept of Economic and Social Affairs, 2007)

Smart Cities: Areas

> **Smart Cities:** related to the use of technology advances to increase the levels of services provided to citizens.

> Smart City areas



Smart Health : Health within Smart Cities

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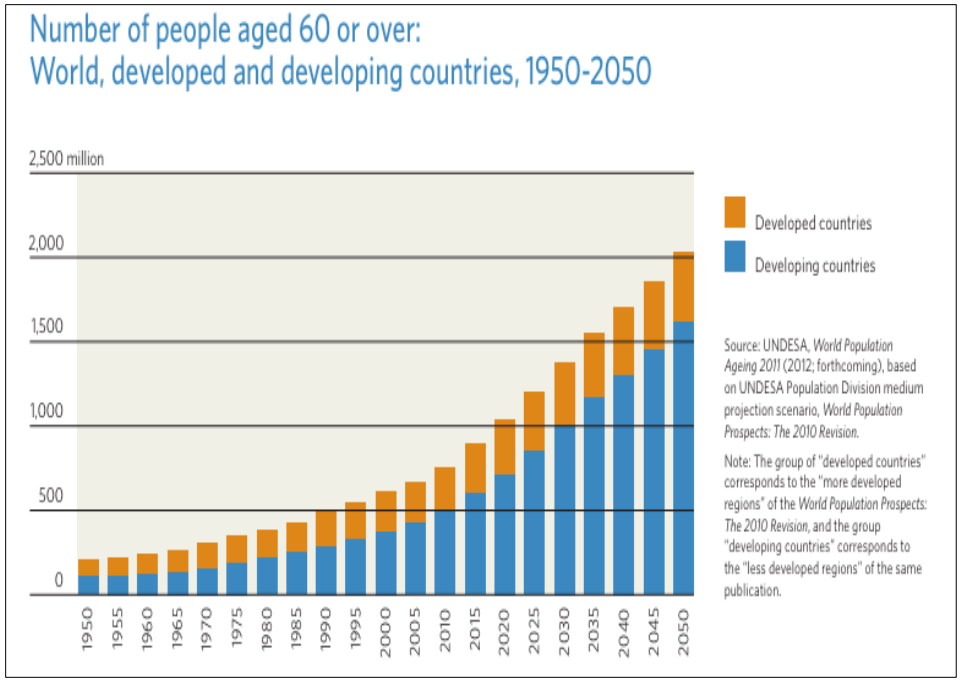
In the Health Sector the challenges of Smart Cities are even higher

> As the World Population grows it is also ageing;

> Several health problems are directly associated with the age of the patients



Sensors, Mobile and Cloud Computing

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The developments on these 3 technologies have been pushing forward the field of Smart Health

- **New sensing technologies:** provide the ability to continuously sense human body and the environment and collect information in effective and low cost ways;
- **Mobile technology:** brings the advantage of ubiquity which enables users to have permanent access to data and services;
- **Cloud Computing:** Allows the execution of computationally intensive tasks in the cloud hiding in this way the limitations of mobile devices;

Smart Health : Some advantages

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- Data collection and communication with minimal intervention of patients;
- Use of small devices to collect data which increases patients' acceptance;
- Reduction of the amount of visits that patients are required to perform to medical centers;
- Reduction in costs when compared with existing wired alternatives;
- Scalability advantages since the number of sensors may change as needs also change;
- Continuous monitoring of physiological and environmental data;
- Providing long term profiles of patients' history;
- Access to medical services on the go;

Work 1: Indoor patient monitoring through Wi-Fi and mobile computing

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Problem Statement

- Many health problems present better responses to treatment if the problem is detected in its earlier stages and some health problems can even be avoided if early signs are detected and appropriate actions are carried out.

- So: ***We believe that by efficiently monitoring people, it is possible to detect changes in their behavior that can be interpreted as early signs of health issues***

Proposed Solution

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- This work proposes a mechanism based on Wi-Fi signal strength for monitoring the patterns of room occupation by people inside their home using smartphone;
- The range of Wi-Fi signal intensities at each room were previously measured and stored, enabling devices to perform the comparisons required by this mechanism;
- Requirements: No extra infrastructure should be required for its implementation besides existing Wi-Fi infrastructure and users' smartphones;
- Output: A report containing the dates and time when the user entered each of the rooms of her/his home or went outside and the amount of time spent at each room;

Proposed Solution II

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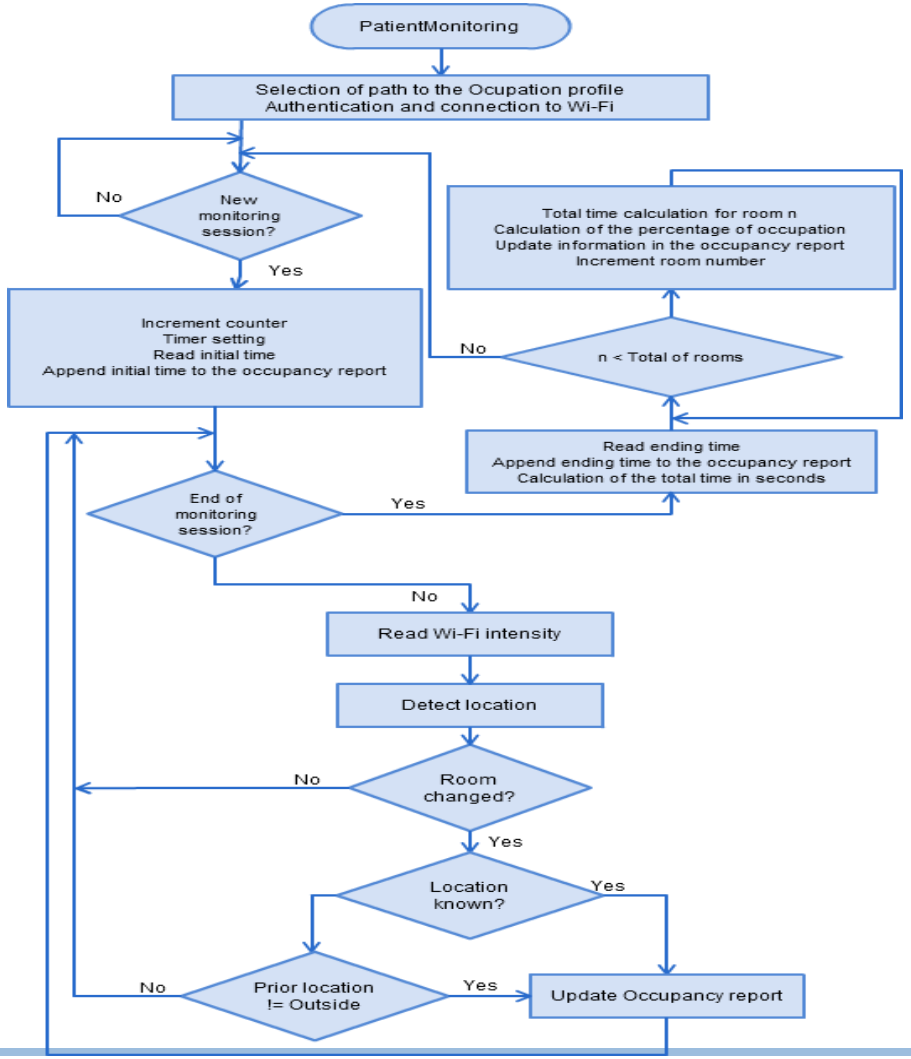
- The ultimate goal of this report is to allow the tracking of changes in the behavior of the user that can potentiate the uncovering of health issues.

- For example, a person that is staying more time than usual in the bedroom or that is staying inside at the time when she/he was used to go outside for a walk or is leaving home for work at varying times may have started experiencing health problems such as stress or depression even though disease symptoms are not yet being clearly perceived.

Flow diagram



Simplified Algorithm

```
1  PeopleMonitoring():
2  path establishment for the output file
3  Wi-fi network authentication and connection
4  Timer configuration
5  Get Wi-fi Intensity
6  if roomChanged then
7      if intensity is in range 1 then
8          handle message 1
9      else
10         if intensity is in range 2 then
11             handle message 2
12     else
13         if intensity is in range 3 then
14             handle message 3
15     else
16         handle message 4
```

```
17 Handler(message):
18     Get System Date and Time
19     Create the output file if necessary
20     switch message do
21     case 1 do
22         Open output file
23         Append Room ID
24         Append System Date and Time
25         Close the file
26     .
27     .
28     .
29     case 4 do
30         Open output file
31         Append Room ID
32         Append System Date and Time
33         Close the file
```

Performance Analysis - Methodology

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- This mechanism was tested in Android smartphones;
- A small 35 m^2apartment was used for testing purposes. This testing environment consisted of a bedroom, a bathroom, a kitchen-living room and the outside room which represents any location outside of the apartment.
- A set of 10 experiments were carried out at different time and dates.
- A set of random points near the borders between rooms were selected for each experiment: 15 points in the bedroom, 15 points in the kitchen, 5 points in the bathroom and 5 outside points located near to the kitchen door

Apartment plan

Results

Total of Samples	Samples per Room/Correct Result							
	Bedroom		*Bathroom*		*Kitchen*		*Outside*	
400	150	145	50	49	150	147	50	50
Overall Efficiency = 97.75%								

```
---------Monitoring ID = 2 -----------
Starting Time = Aug 4, 2015 3:30:03 PM

Details:
Kitchen : Aug 4, 2015 3:30:03 PM
Bathroom : Aug 4, 2015 3:35:18 PM
Kitchen : Aug 4, 2015 3:38:12 PM
Bedroom : Aug 4, 2015 4:07:23 PM
Kitchen : Aug 4, 2015 4:17:09 PM
Outside : Aug 4, 2015 4:17:35 PM
Kitchen : Aug 4, 2015 4:23:11 PM
Bedroom : Aug 4, 2015 3:23:19 PM

Ending Time = Aug 4, 2015 4:30:02 PM

Kitchen -- 58.405%
Bedroom -- 27.480%
Bathroom -- 4.279%
Outside -- 9.340%
```

Applicability

- Correlating this data with more information provided by the monitored person it is possible to infer the activities that were performed during the time of monitoring.

- According to the activities that were performed during each day changes in the behavior can then be detected.

Future Work

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- Include data from other types of sensors such as accelerometers, gyroscope and magnetometer to provide more information such as the orientation of the person inside a room and activities being performed;
- Including building plans to provide visual feedback of the location of the patient;
- Assess the feasibility of this mechanism in other types of devices such as smartwatches;
- Include AI components to propose actions to be performed according to the outputs;

Work II

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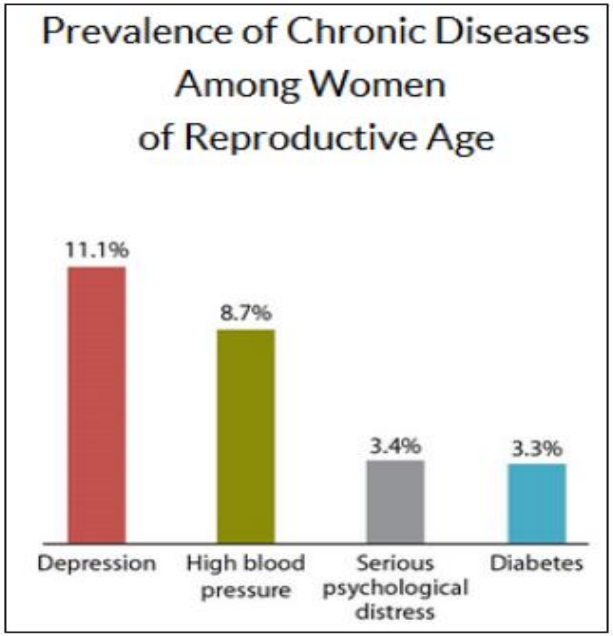
What are other major problems in which we could contribute in the context of Smart Health ?



[CDC US Government]

Related Work

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- *Doryab, A., Min, J. K., Wiese, J., Zimmerman, J., & Hong, J. I. (2014). Detection of behavior change in people with depression. AAAI.* (Carnegie Mellon University)

- Saeb S, Zhang M, Karr CJ, Schueller SM, Corden ME, Kording KP, Mohr DC. *Mobile Phone Sensor Correlates of Depressive Symptom Severity in Daily-Life Behavior:* An Exploratory Study J Med Internet Res 2015; (Northwestern University,)

- Burns, M. N., Begale, M., Duffecy, J., Gergle, D., Karr, C. J., Giangrande, E., & Mohr, D. C. (2011). Harnessing Context Sensing to Develop a Mobile Intervention for Depression. *Journal of Medical Internet Research*, *13*(3), e55. http://doi.org/10.2196/jmir.1838

Related Work II

Available work are based on one or more of the following types of inputs:

- Social behavior
- Sleep Behavior
- Number of minutes of use of phone
- Daily geographical locations
- Mobile phone usage (call, SMS, location and screen on/off)
- Human voice
- Communication history
- Predictability of time of arrival at residence
- Mobility
- Weight
- Heart rate and pulse

GPS
Bluetooth
Accelerometers
Wi-Fi
Surveys
Step Counters
Ambient light sensor
HRM sensor
Temperature

Related Work III

Wang, R., Chen, F., Chen, Z., Li, T., Harari, G., Tignor, S., ... & Campbell, A. T. (2014, September). ***Studentlife: assessing mental health, academic performance and behavioral trends of college students using smartphones.*** In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (pp. 3-14). ACM.

(Dartmouth College)

Related Work IV

Fairly complete work:
The authors present the StudentLife: A continuous sensing app for assessing the impact in académic performance:

- Workload
- Stress
- Sleep
- Activity
- Mood
- Sociability
- Mental well-being

They monitored a class of 48 students during 10 weeks (A complete term) at Dartmouth College using Android phones.

Related Work V

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They identified correlation between:

- Sensed data and some well-known mental wellbeing measures, specifically, PHQ-9 depression, perceived stress (PSS), flourishing, and loneliness scales.

- Conversation, activity, mobility, and sleep with mental wellbeing.

- Academic performance with mental well-being.

- Usage patterns of an online educational tool (i.e., Piazza) with academic performance.

Related Work VI

They identified that students start the term with high positive affect and conversation levels, low stress, and healthy sleep and daily activity patterns.

As the term progresses and the workload increases:

- Stress rises
- Positive affect, sleep, conversation and activity drop off

The StudentLife dataset is publicly available on the web (52.6 GB).

Related Work VII

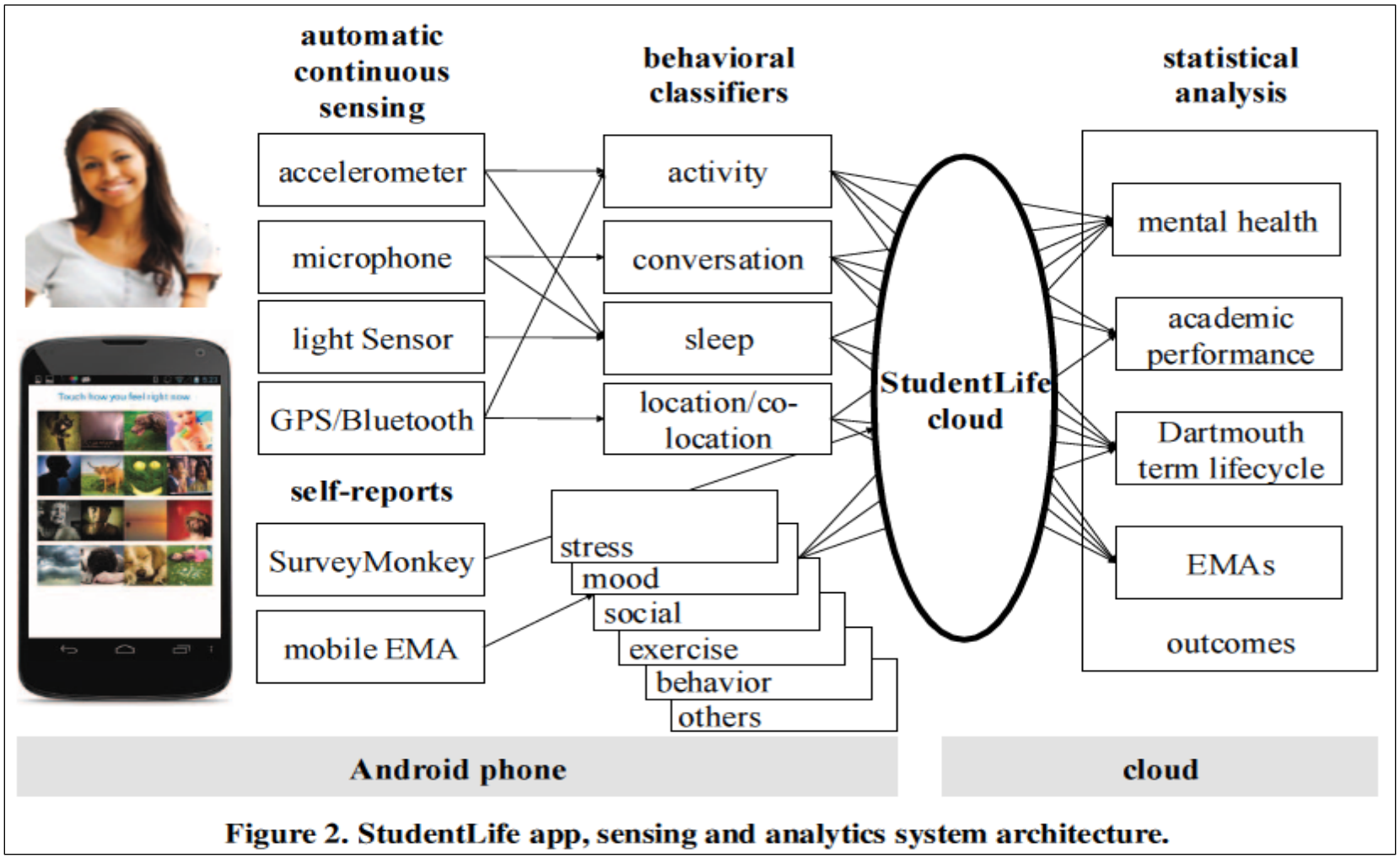

Figure 2. StudentLife app, sensing and analytics system architecture.

Related Work VIII

Students were given incentives during the data collection phase to ensure they continue collaborating

All data were uploaded and stored in secure ways

Main question now?

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How we can extend such a very complete work?

- Feedback to users?
- Find new correlations in the collected data?
- Improve some of the mechanisms used to collect data?
- Correlate this data with other inputs such as weather?
- Etc

Thank you!!!