Personal Lifestyle and Health

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Society exists only as a mental concept; in the real world there are only individuals.

-- Oscar Wilde

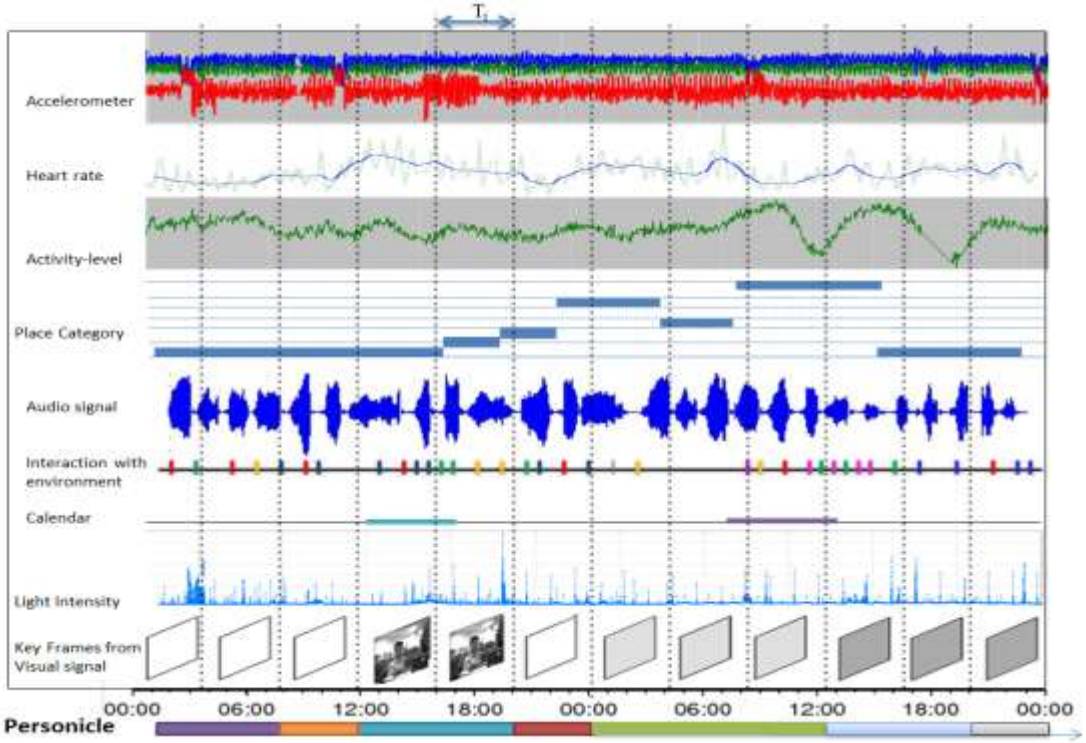

Wearables: Watches, camera, …
I don’t care for money;
I care for what money buys.
I don’t care for wearables;
I care for what wearables do for me.

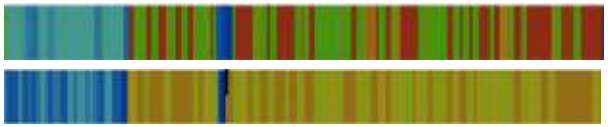
Disruption in Healthcare

When needed, I go to the source of healthcare.

Can healthcare come to me in time?

Healthcare 2020





Event Mining
Machine Learning

Individual Model

Objective Self

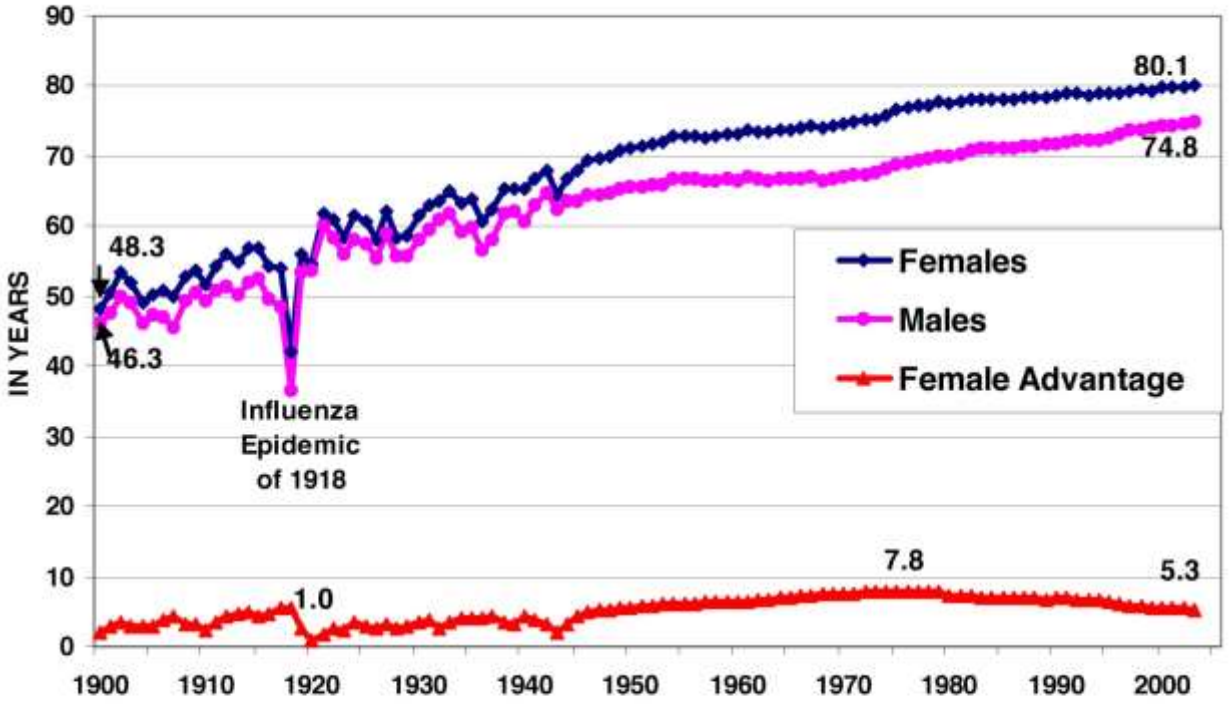
- Individual Model from data.
- Health, social, personal.
- Actionable Predictive use.
- Better disease models.

'Likely to get severe heart attack in 10 minutes – get him help immediately.'

Important Revolution in Health

In the mid-20th century, the primary causes of death worldwide shifted from infections to chronic conditions.

Figure 1. Life Expectancy at Birth, by Sex: 1900 to 2003.



Source: For 1900-2002, CRS analysis based on data contained in NCHS, United States Life Tables, 2002, *National Vital Statistics Report*, vol. 53, no. 6, Nov. 10, 2004. For 2003, CRS analysis based on NCHS, Deaths: Final Data for 2003, *National Vital Statistics Report*, vol. 54, no. 13, Apr. 19, 2006.

Dream: Immortality

Problem: Longest people can live is 122 Yrs.

Realizable Dream: 100+ Years of Happiness

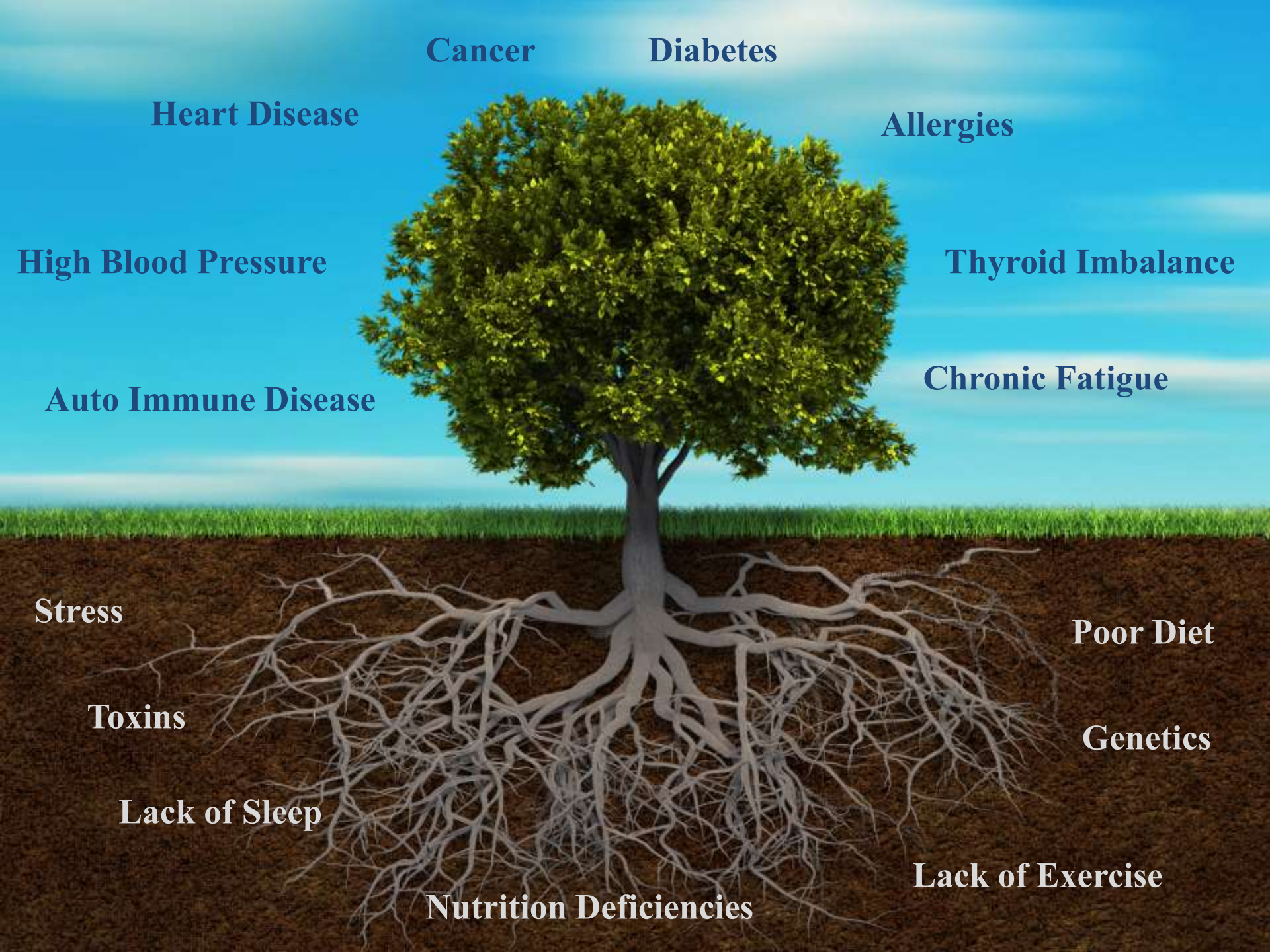
Personal Health

my life
my health

=

+

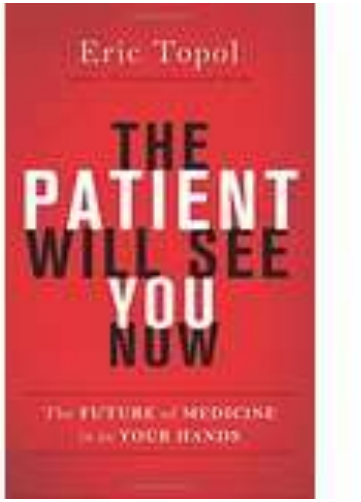
What's Lifestyle got to do with it?


Cancer
Diabetes
Heart Disease
Allergies
High Blood Pressure
Thyroid Imbalance
Chronic Fatigue
Auto Immune Disease
Stress
Poor Diet
Toxins
Genetics
Lack of Sleep
Lack of Exercise
Nutrition Deficiencies

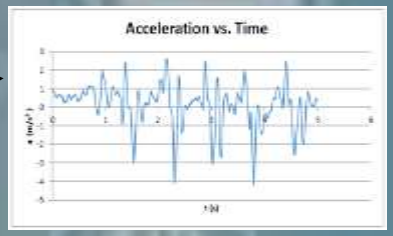
Needed: Medical Emancipation

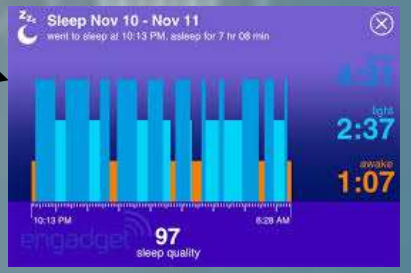
Doctor Knows the Best.

Patient Knows the Best.



Smartphone + Wearables := Personalized 24/7 Recording Stethoscope





LIFESTYLE


Financial
Intellectual
Social
Emotional
Environ-
mental
Spiritual
Sexual
Physical

Big 3: Lifestyle Factors

Popular now: Output and state

Starting to happen:
Input

Coming soon:
Surround

Healthcare Analytics is Data Rich Now

Past: Data is expensive and small

- **Input data is mostly from clinical trials**
- **Models are small since data is limited**
- ***Personal information is anecdotal***

Today: Data is cheap and large

- **Longitudinal data**
- **Heterogeneous data**
- ***Diverse data from Electronic Health Records and wearable/smartphone***

Disruption Time

Until recently, you were a folder.

Now

“Shallow men believe in luck or in circumstance. Strong men believe in cause and effect.”

— Ralph Waldo Emerson

If you can't measure it, you can't control it!

Measure

Understand

Control

Improve

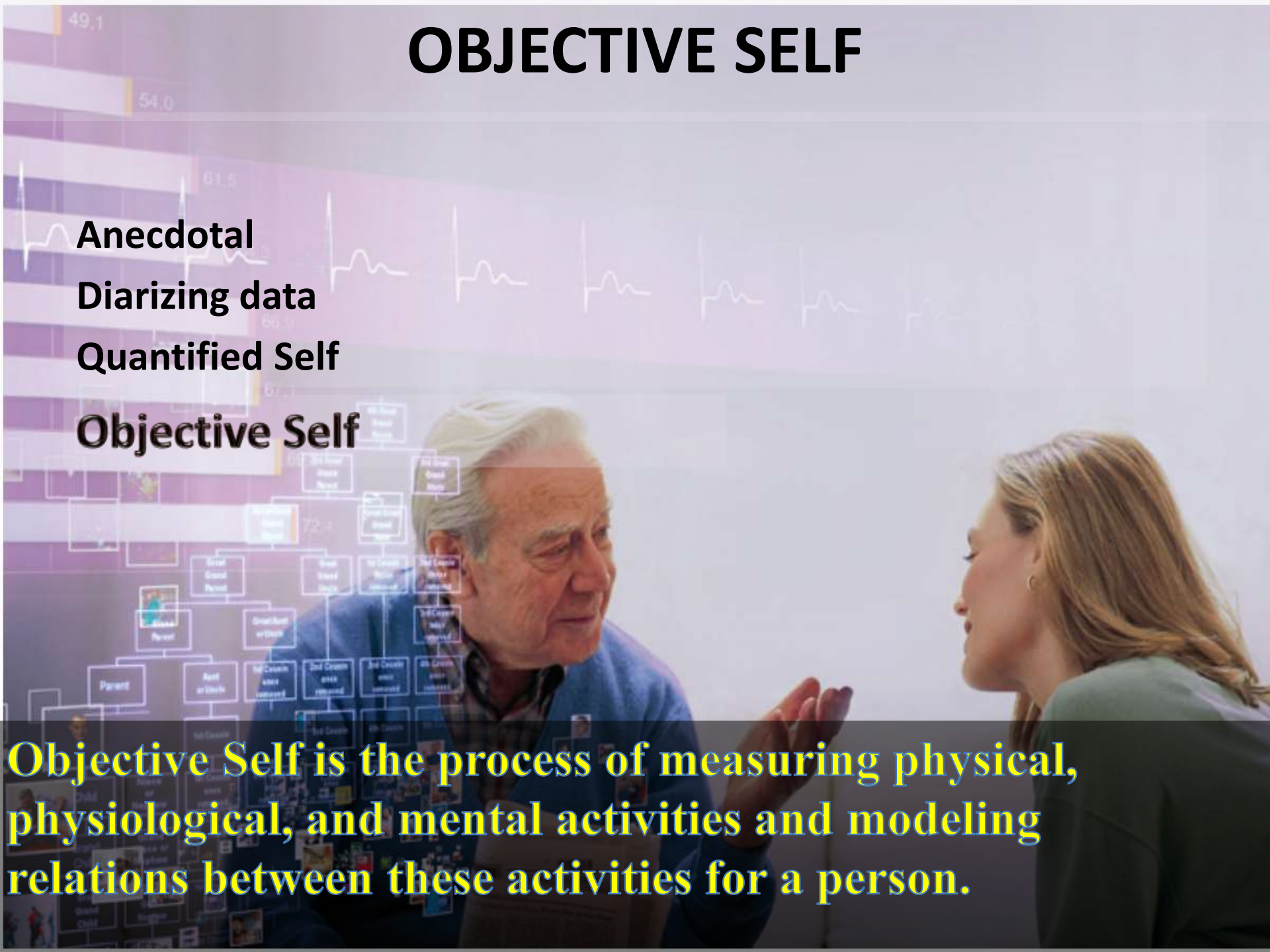
OBJECTIVE SELF

Anecdotal

Diarizing data

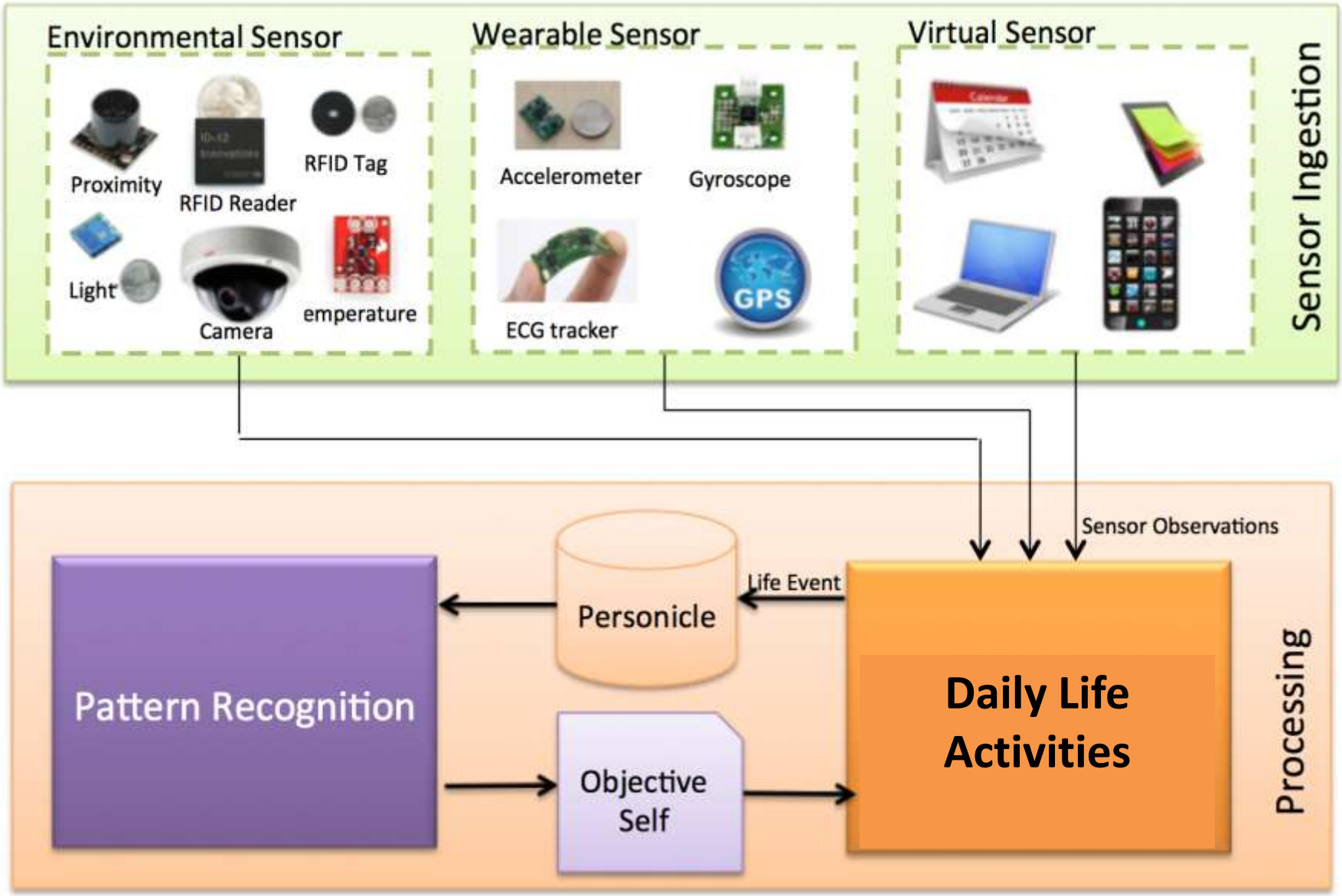
Quantified Self

Objective Self

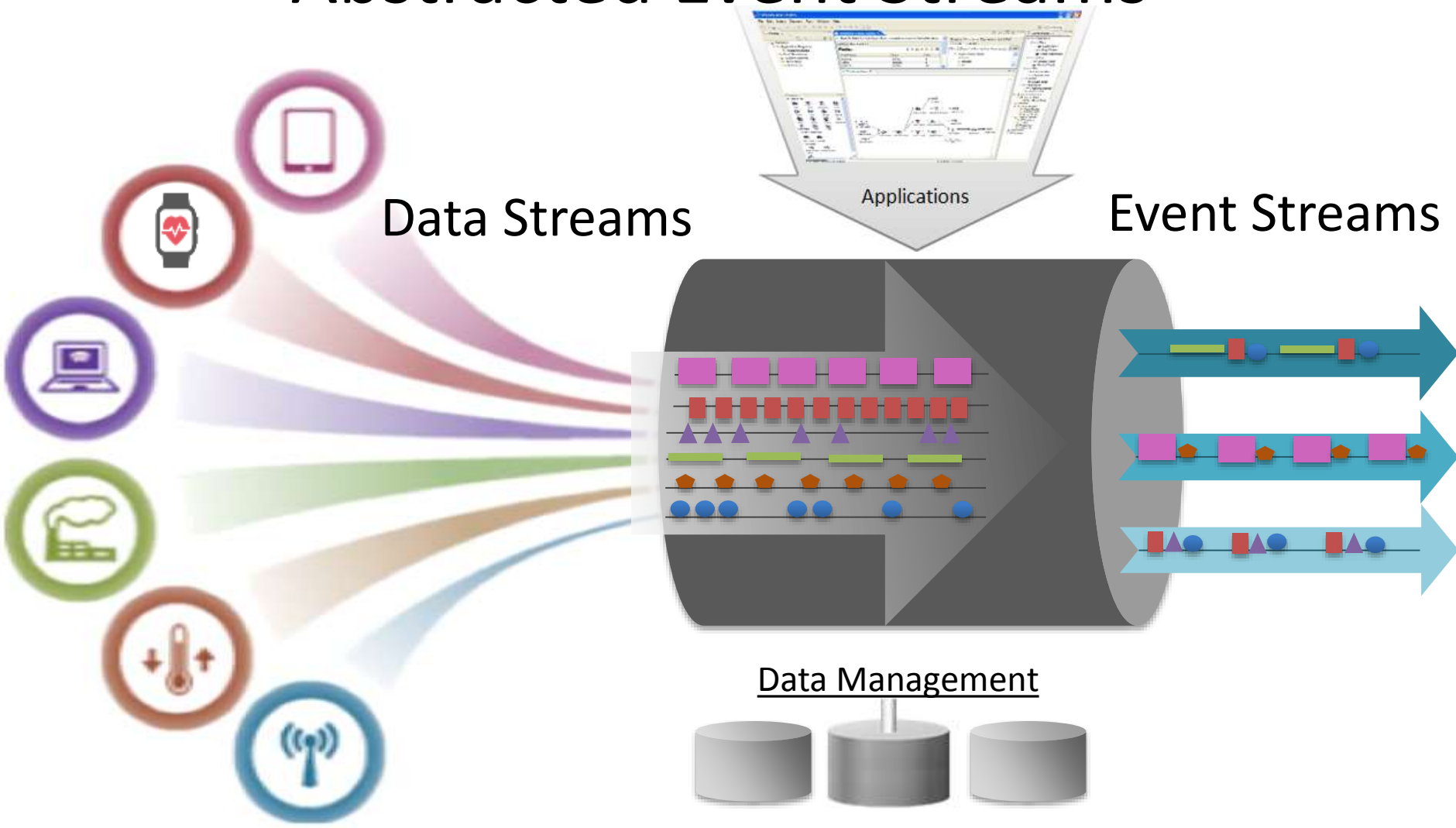


Objective Self is the process of measuring physical, physiological, and mental activities and modeling relations between these activities for a person.

Data Streams to Objective Self



Data Variety: From Data Streams to Abstracted Event Streams



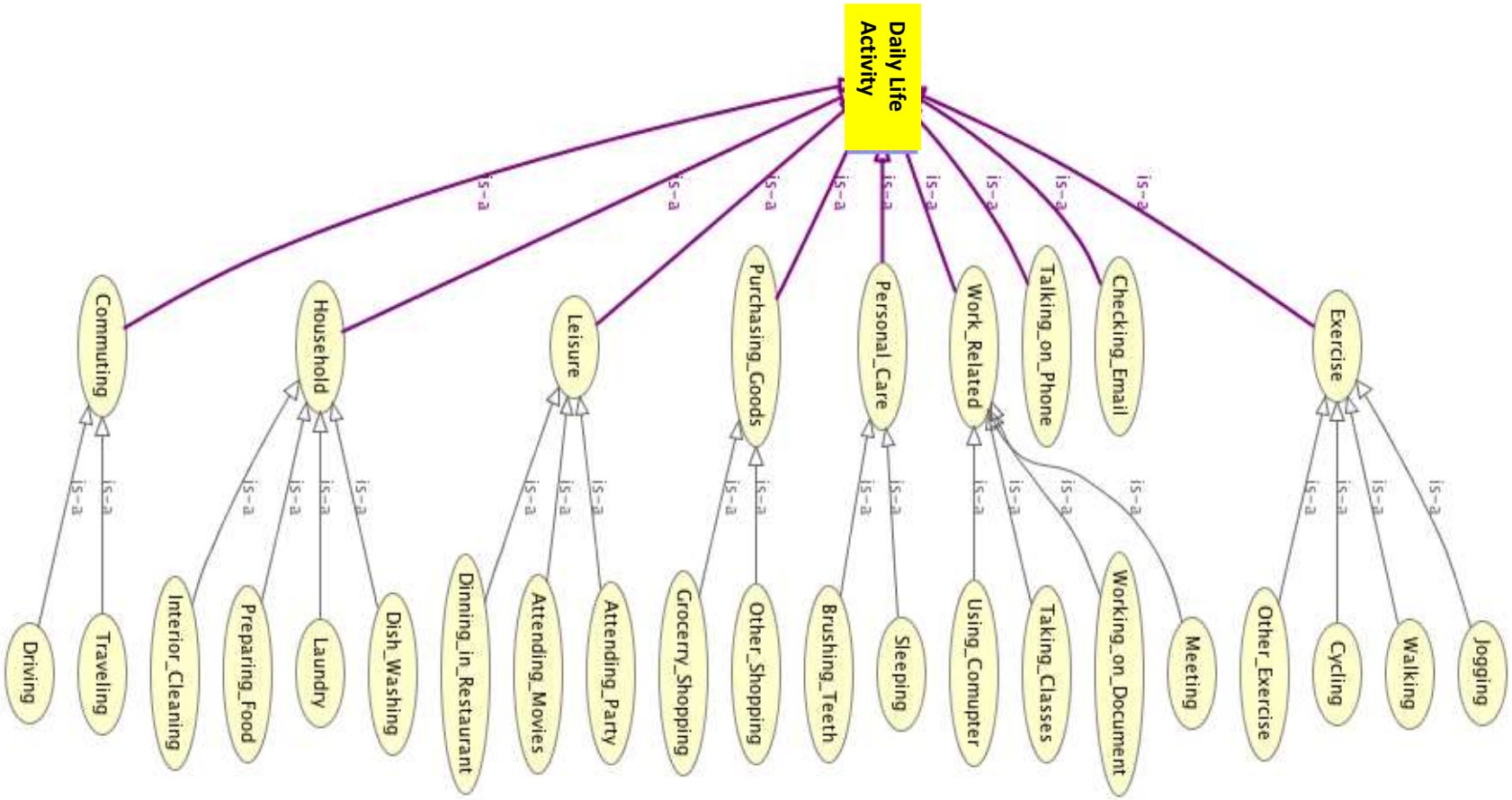
Computational Model of Events.

Event Stream

Temporal: { "start-time": "2014-01-01T09:00:00" ; "duration": 65 }
Spatial: {"lat": 33.5748; "lon":-127.6479 ; "location-name": "Aldrich Park"; "location-type": "park" }
Informational: { "event-id": "LE001" ; "motion": "jog" ; "category": "jogging" ; "intensity": "high"; "steps":4987; "calories-burned": 646 }
Structural: { "sub-event-of": "exercise" }

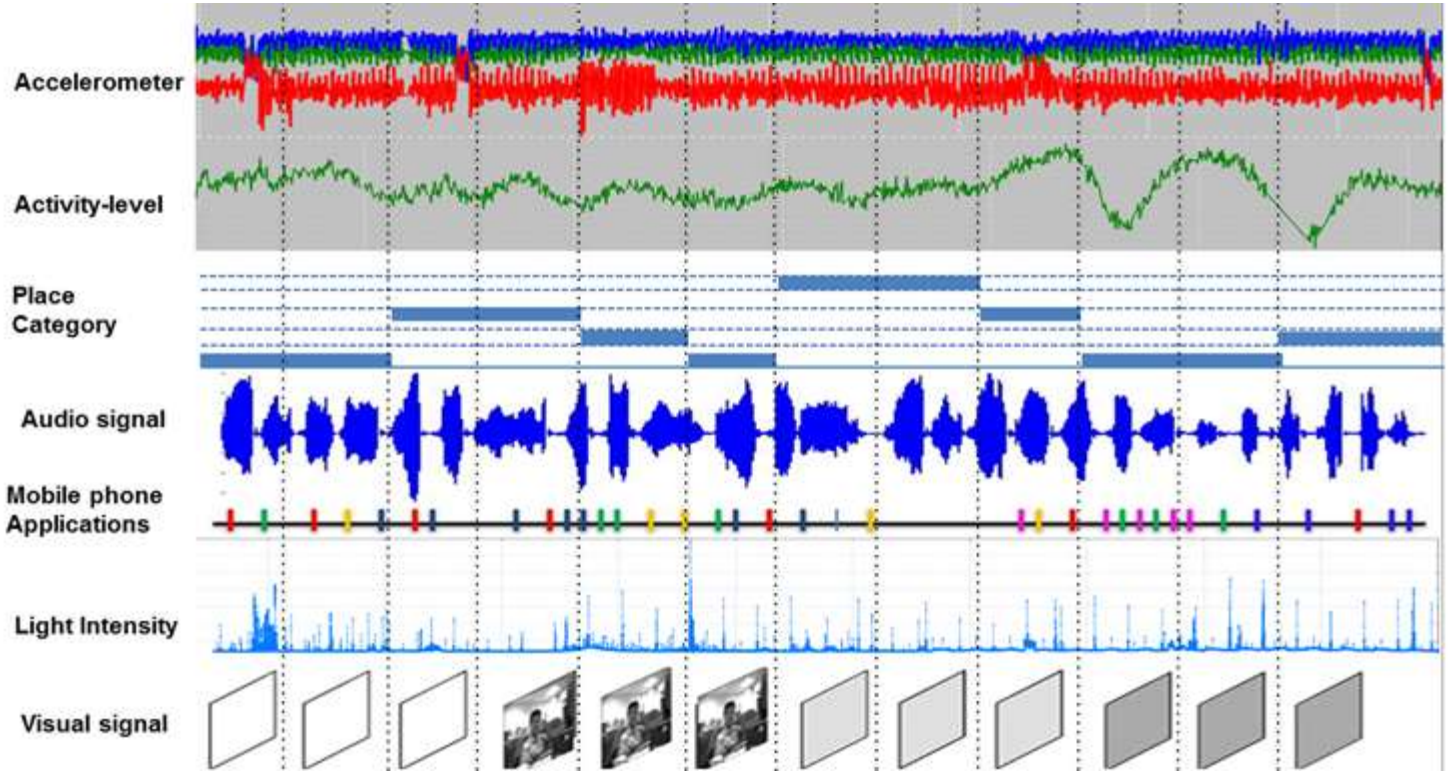
Temporal: { "start-time": "2014-01-01T12:00:00" ; "duration": 60 }
Spatial: {"lat": 33.5748; "lon":-127.6479 ; "location-name": "DBH building"; "location-type": "university" }
Informational: { "event-id": "LE005" ; "motion": "sit" ; "category": "meeting" ; "participants":[{"pid":"p005", "pname": "jain"}, {"pid":"p007", "pname": "laleh"}] }
Structural: { "sub-event-of": "work" }

Daily Life Activities: How we use time.

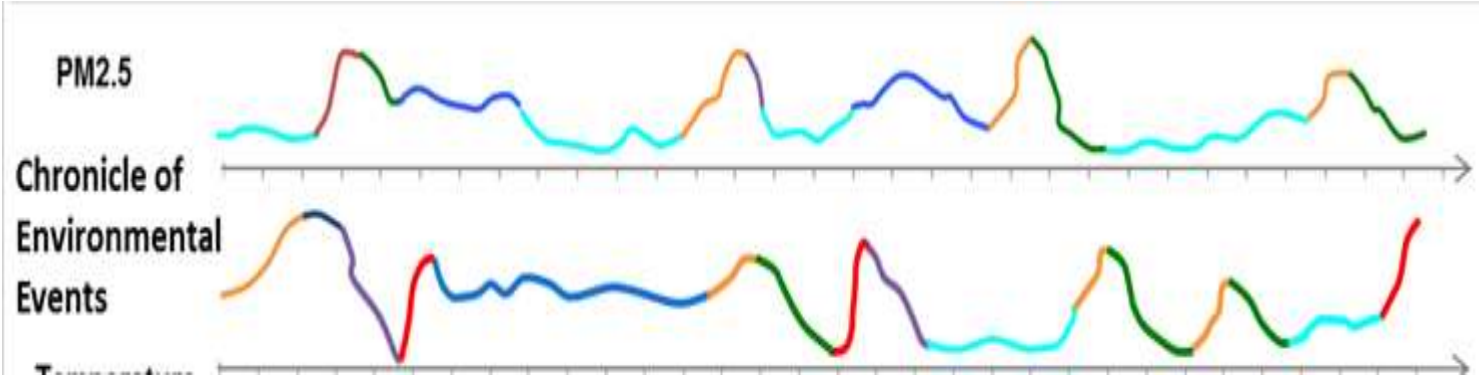


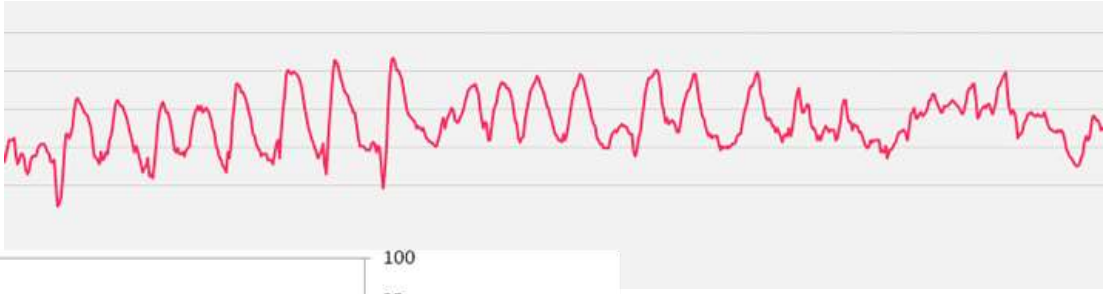
ATUS: American Time Use Survey

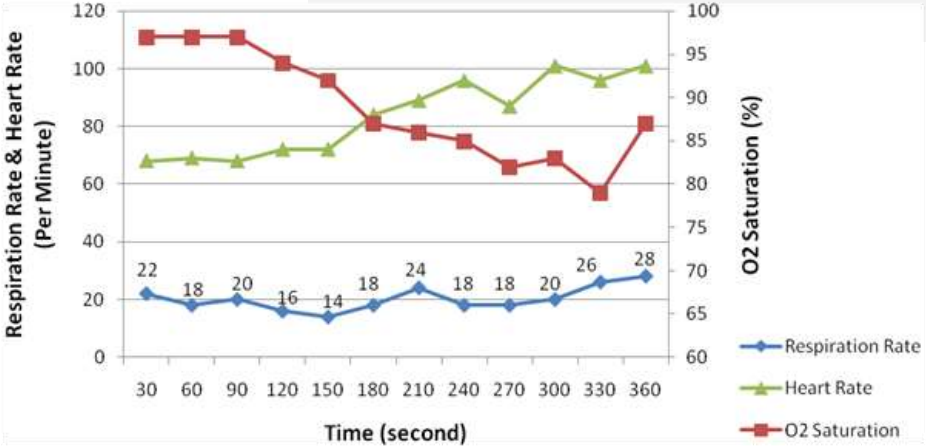
Daily Life Activities: How we enter them?

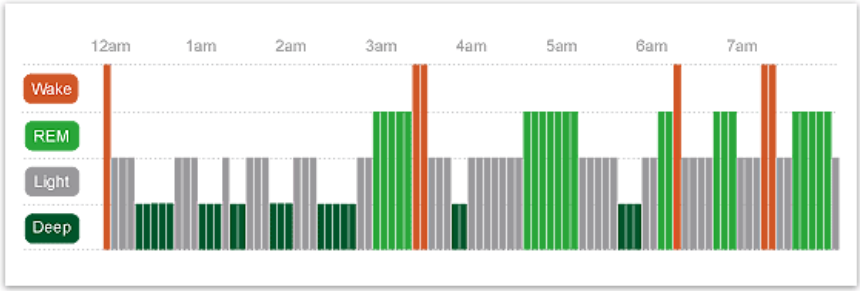


We collect diverse signals.

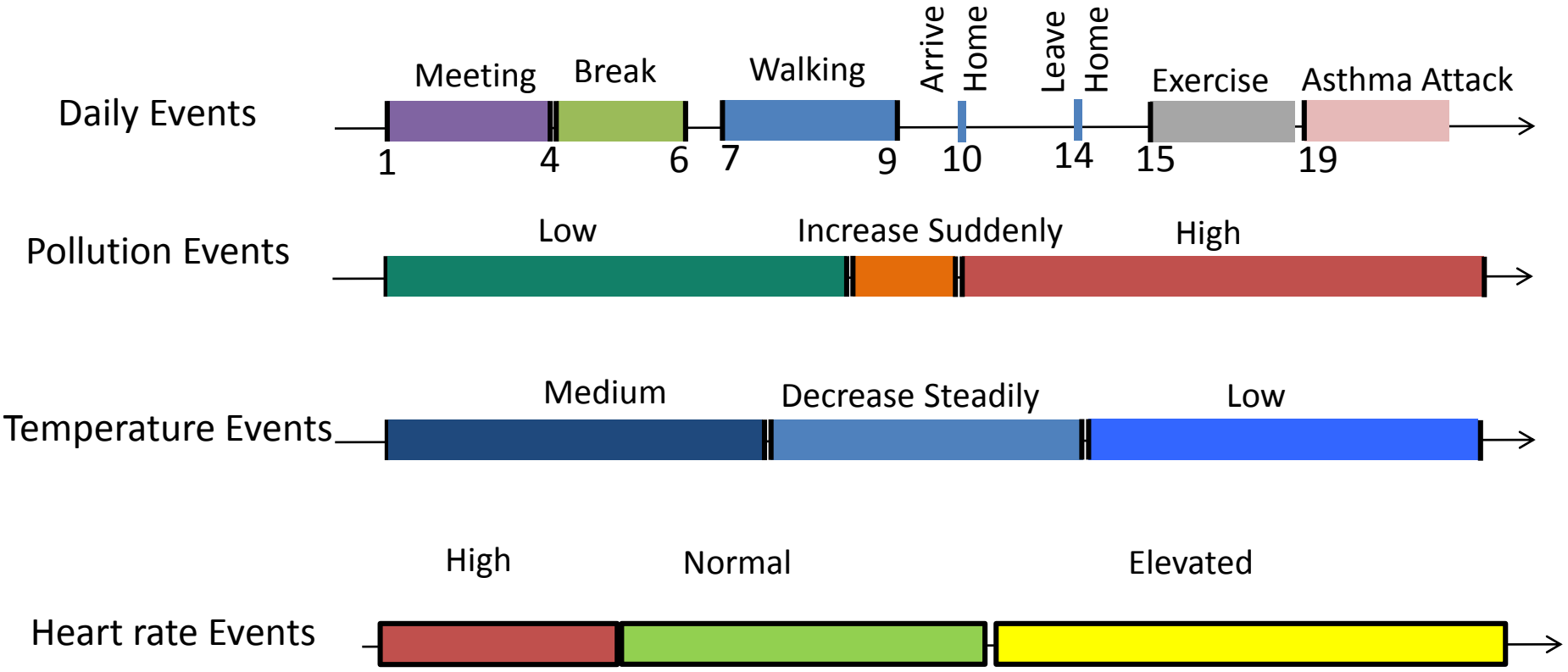






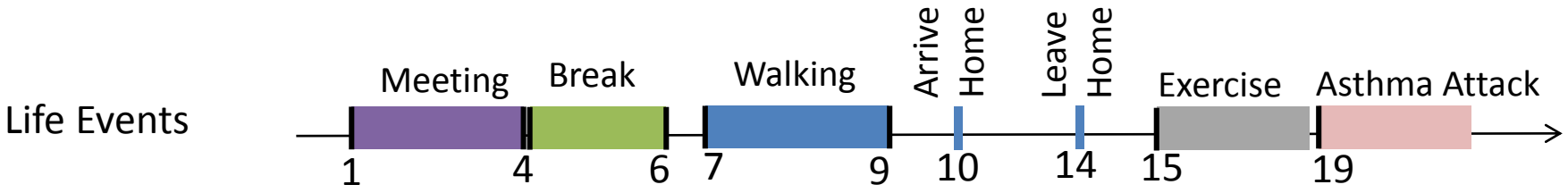


Running Example



Definitions

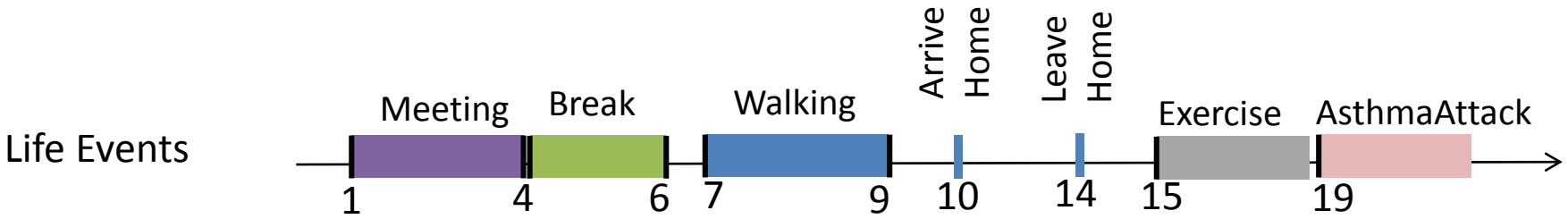
- Time Interval: $[\partial, t_s, t_e]$ $\partial^+ = t_s$, $\partial^- = t_e$
- Semi Interval: $[\partial^{+/-}, t]$
- Point Event (pE): $e = (v, [E, t])$
- Interval Event (iE): $e = (v, [E, t_s, t_e])$
- Semi-interval Event (sE): $e = (v, [E^{+/-}, t])$



Definitions (Cont.)

- Event Stream: $ES^{(i)} = \{e_1^{(i)}, e_2^{(i)}, ..., e_n^{(i)}\}$
- Multi-Event Stream: $ES = \{ES^{(1)}, ES^{(2)}, ..., ES^{(|I|)}\}$
- Pattern: $\rho = (X_1 \odot_1 X_2 \odot_2 ... \odot_{k-1} X_k)$

  $X_i \in \{ pE, iE, sE \}$ and $\odot_i \in \{ ; , ;\omega_{\Delta t} , \amalg , | \}$

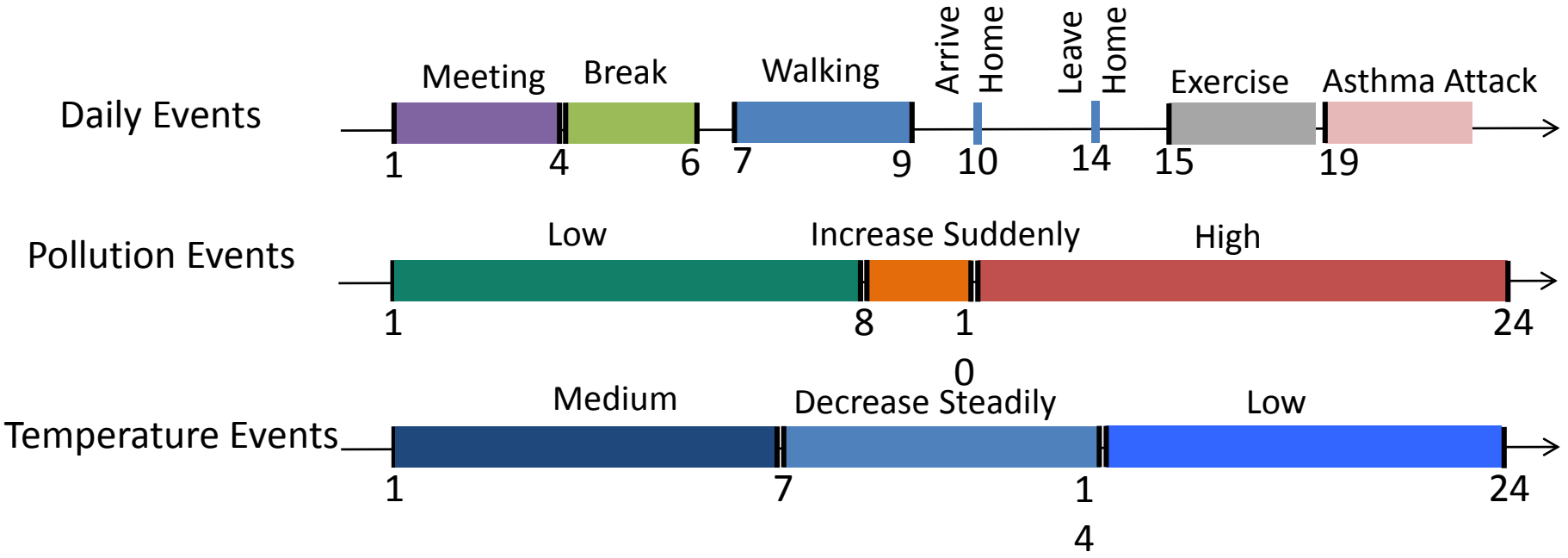


(Meeting ; Break)

(Walking ; ArriveHome)

(Exercise$^+$ $;\omega_{[5]}$ AsthmaAttack)

Representations



((Exercise$^+$ || Pollution.High) ;$\omega_{[5]}$ AsthmaAttack)

((Exercise$^+$ || Temp.Low) ;$\omega_{[5]}$ AsthmaAttack)

((Exercise$^+$ || (Pollution.High | Temp.Low)) ;$\omega_{[5]}$ AsthmaAttack)

Pattern Mining Operators

Sequential Co-occurrence $SEQ\_CO_{[\Delta t]}(ES, ES')$

$$Seq\_Co_{[\Delta t]}(E_i, E_j) = \frac{Count(E_i; \omega_{\Delta t} E_j)}{Count(E_i)}$$

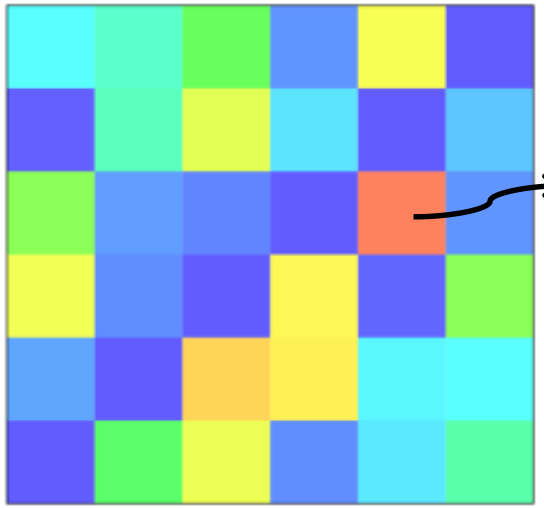
Concurrent Co-occurrence $CON\_CO(ES, ES')$

$$Con\_Co(E_i, E_j) = \frac{Count(E_i \underline{\|} E_j)}{\frac{1}{2}(Count(E_i) + Count(E_j))}$$

Co-occurrence Matrix Visualization

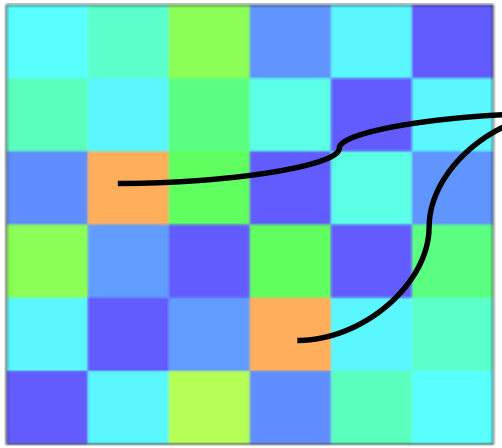
	E_1	E_2	E_3	E_4	E_5	E_6
E_6	0.25	0.31	0.47	0.11	0.68	0
E_5	0.01	0.33	0.64	0.19	0	0.16
E_4	0.52	0.12	0.09	0	0.88	0.11
E_3	0.67	0.1	0	0.7	0.03	0.52
E_2	0.13	0	0.75	0.71	0.23	0.25
E_1	0	0.43	0.66	0.1	0.2	0.35

Δt



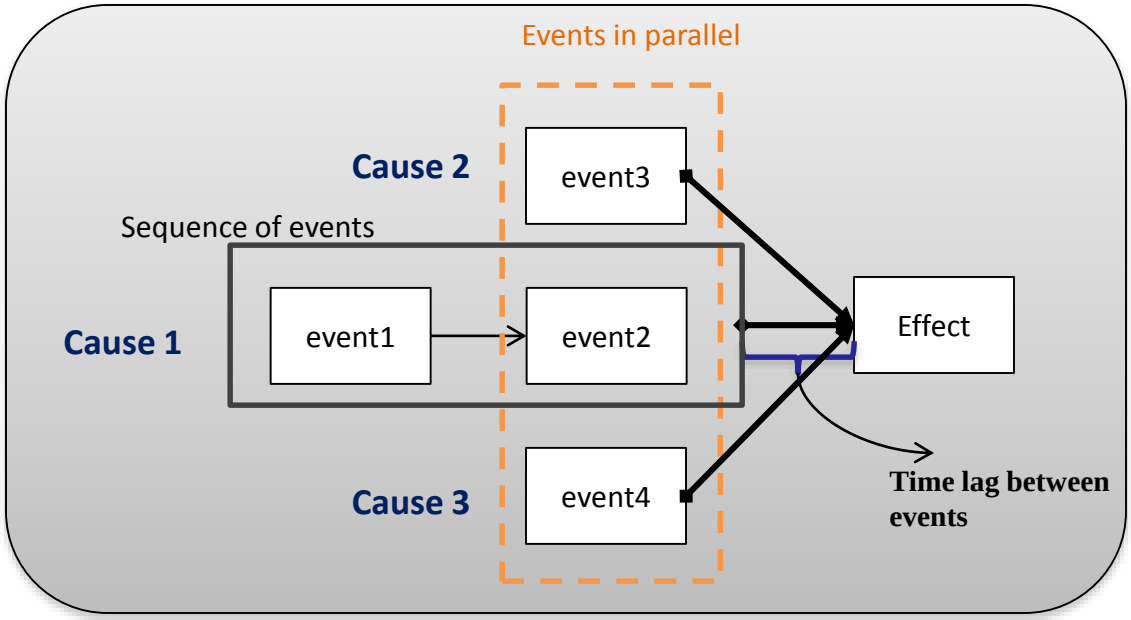
$Seq\_Co_{[\Delta t]}(E_4, E_5)$

	E_1	E_2	E_3	E_4	E_5	E_6
E_6	0.33	0.31	0.52	0.11	0.23	0
E_5	0.25	0.23	0.4	0.28	0	0.23
E_4	0.1	0.82	0.45	0	0.28	0.11
E_3	0.56	0.12	0	0.45	0.4	0.52
E_2	0.23	0	0.12	0.82	0.23	0.31
E_1	0	0.23	0.56	0.1	0.33	0.25



$Con\_Co(E_2, E_4)$

Cause - Effect Pattern Structure



Formulate and query complex patterns:

Exercise $\xrightarrow{\Delta t}$ Asthma attack

(No medication ; Exercise) ➔ Asthma attack

(Exercise || Pollen high) ➔ Asthma attack

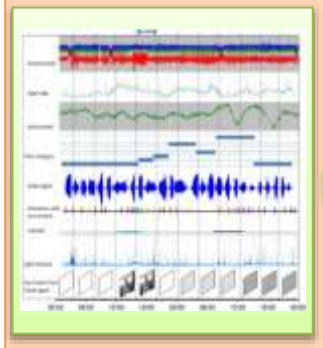
(Exercise || Pollution high) ➔ Asthma attack

(Exercise || (Pollen high | pollution high)) ➔ Asthma attack

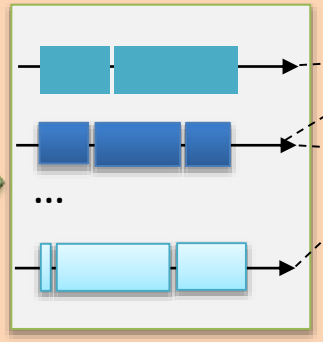
Interactive Event Mining

Data-Driven Analysis

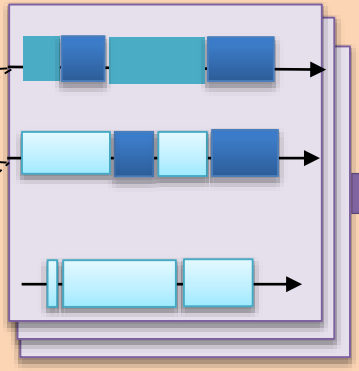
Data Streams



Event Streams



Semi-interval Event Sequences



Pattern Mining

Hypothesis-Driven Analysis

While air pressure is high, pollution starts increasing gradually, within **T** time units asthma outbreak happens.

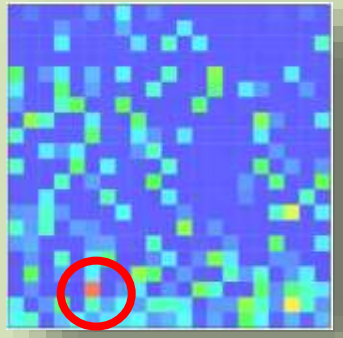
Example:

((pollution_inc_steadily ;ω_T asthma_outbreak) || airpressure_stayshigh)

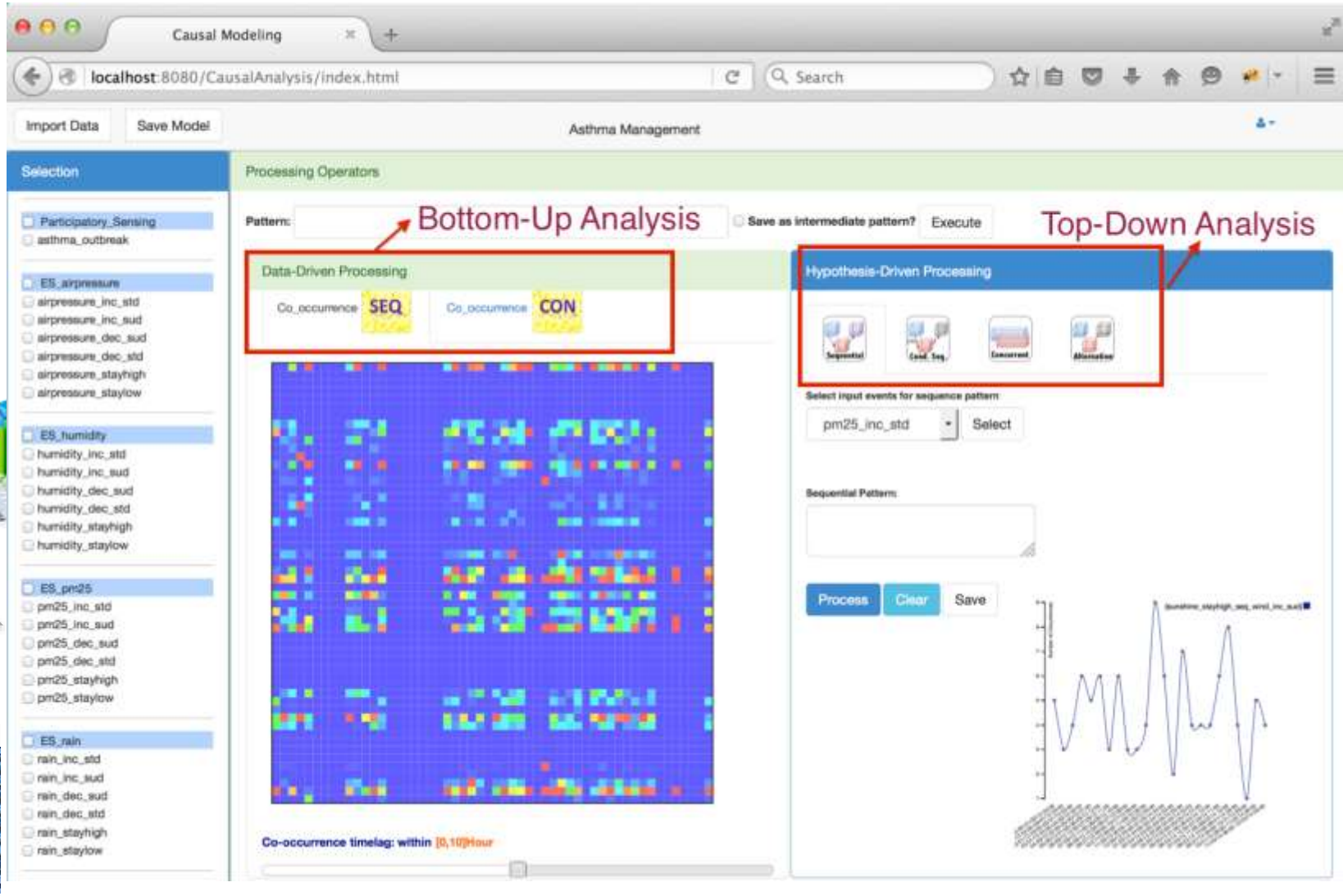
High level Pattern Formulation

Pattern Query

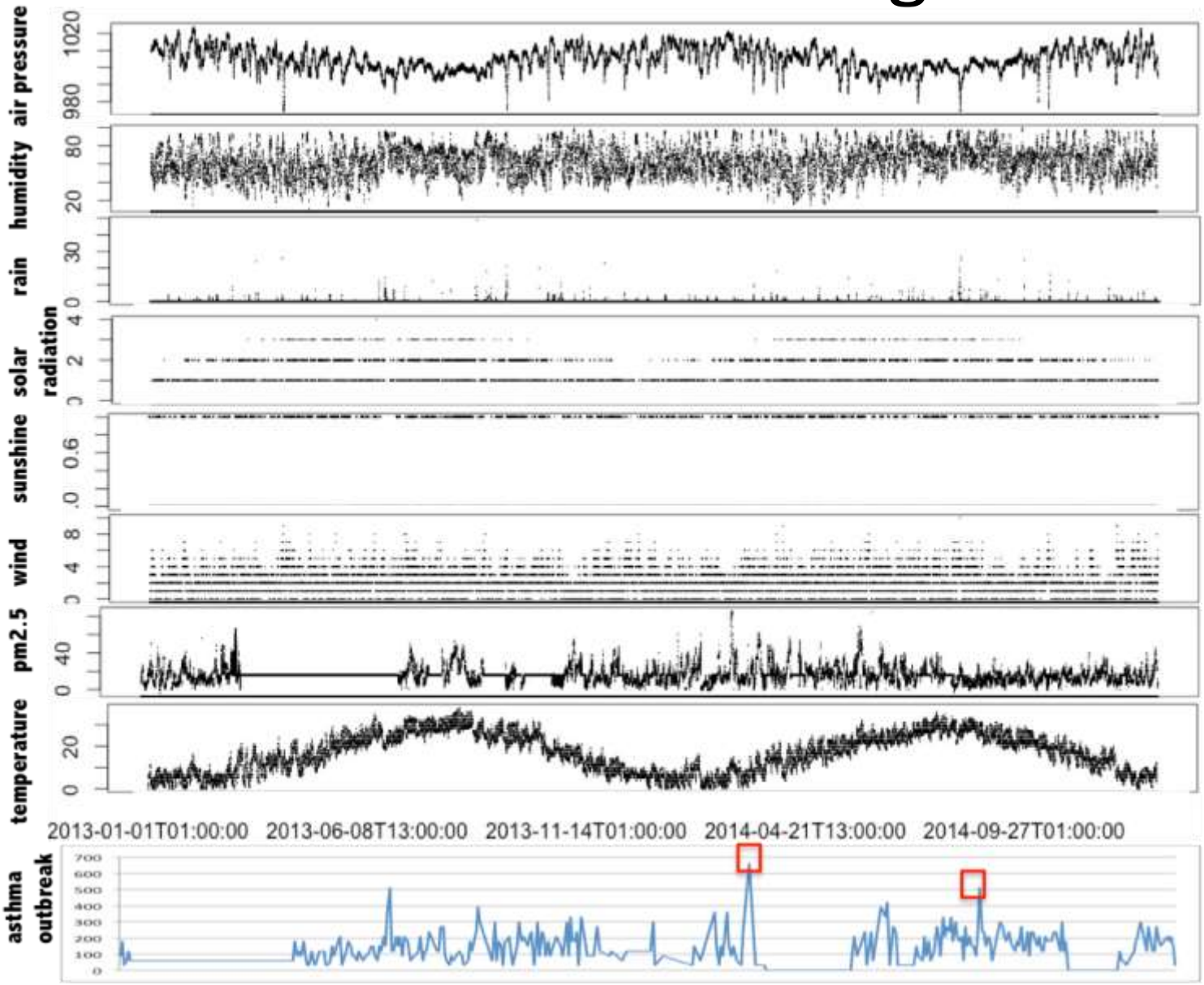
Interactive Visualization



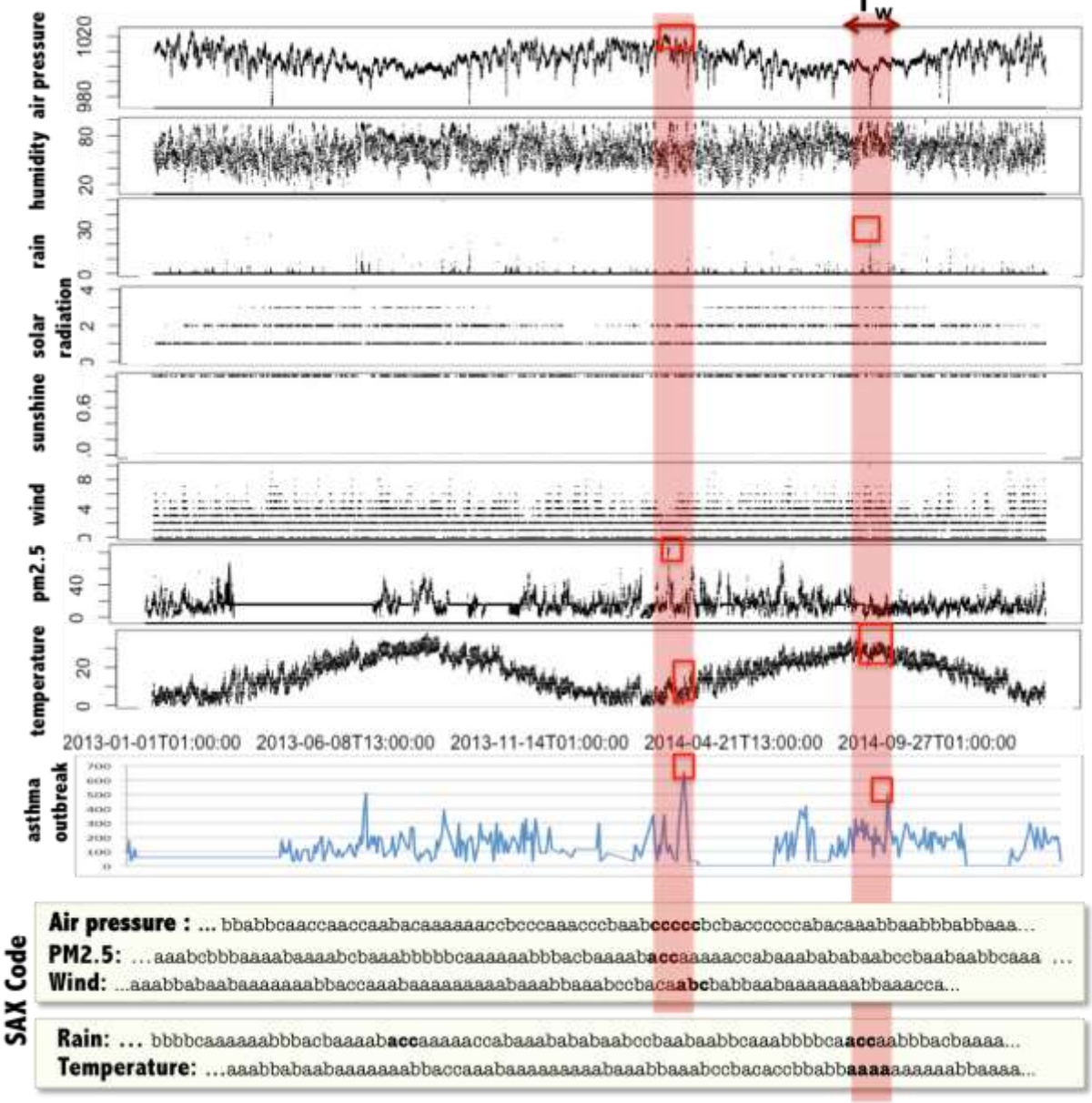
User Interface for Interactive Knowledge Discovery and Model Building



Pollution and Meteorological Data



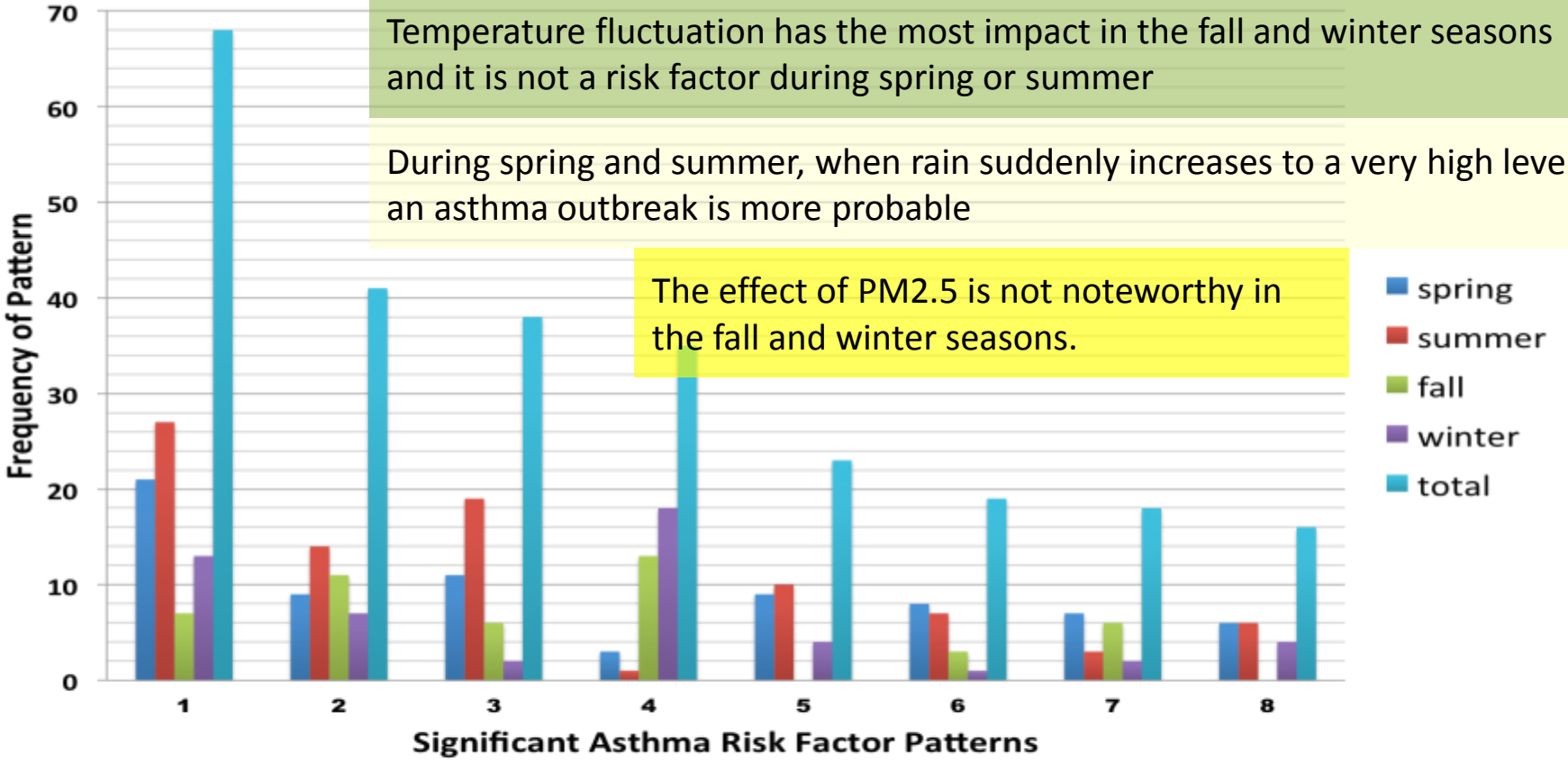
Asthma Risk Factor Recognition



1) Pollution increases suddenly followed by high wind while temperature increases slightly will cause an asthma Outbreak within 2 days.

2) Thunderstorm followed by temperature decreases steadily will cause an asthma outbreak within 1 day.

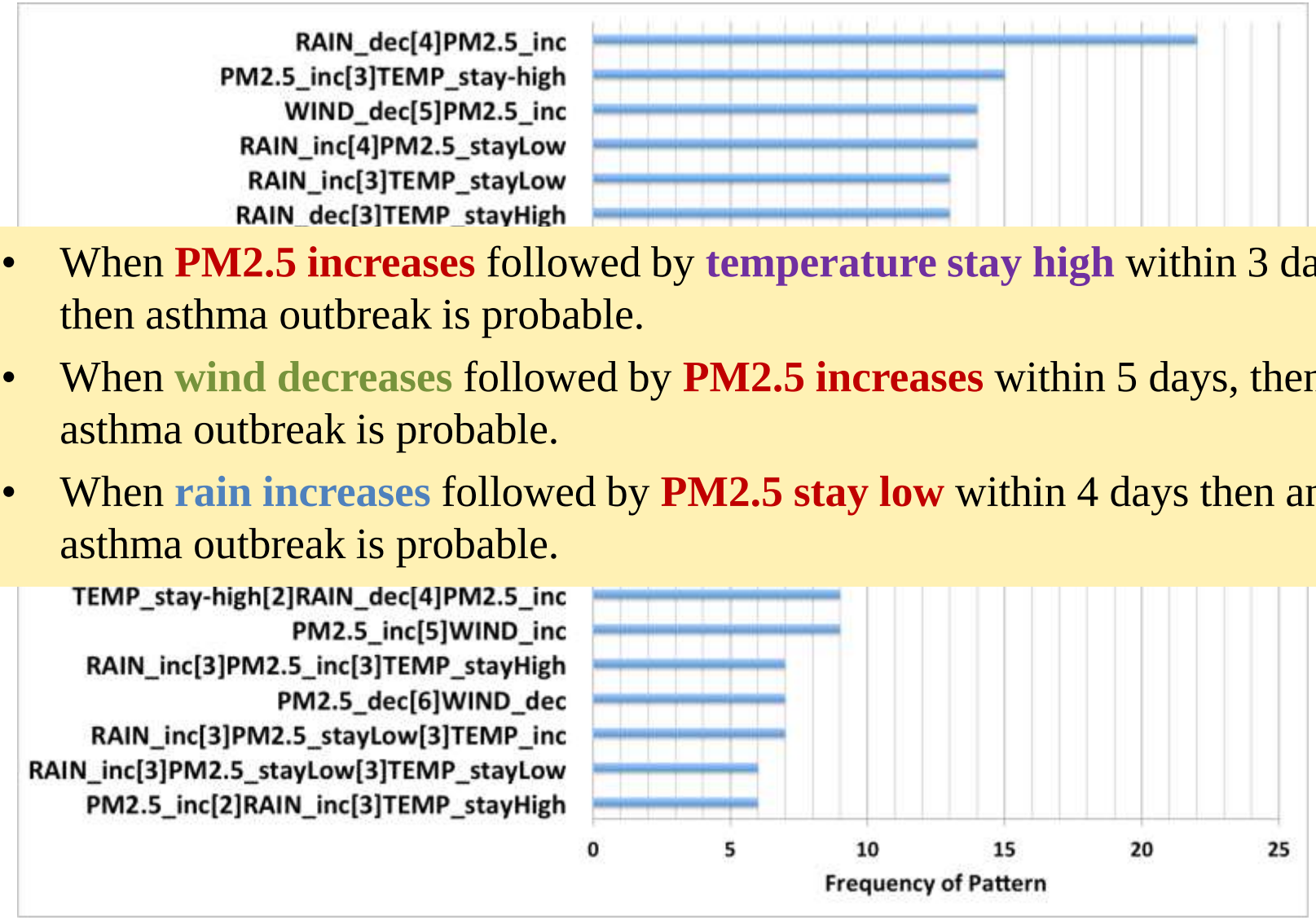
Results



1=PM2.5_inc ;[3] Asthma_outbreak
2=TEMP_stayHigh ;[4] Asthma_outbreak
3=RAIN_sudinc ;[2] Asthma_outbreak
4=TEMP_stayLow ;[3] Asthma_outbreak

5=PM2.5_sudinc ;[4] Asthma_outbreak
6=WIND_dec ;[3] Asthma_outbreak
7=WIND_inc ;[4] Asthma_outbreak
8=PM2.5_stayHigh ;[5] Asthma_outbreak

Results (Cont.)



- When **PM2.5 increases** followed by **temperature stay high** within 3 days, then asthma outbreak is probable.
- When **wind decreases** followed by **PM2.5 increases** within 5 days, then asthma outbreak is probable.
- When **rain increases** followed by **PM2.5 stay low** within 4 days then an asthma outbreak is probable.

Individual Insight

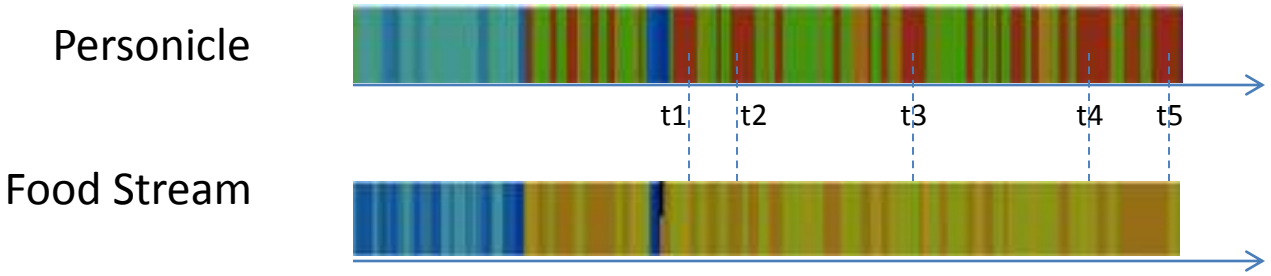
- ***Exposure to polluted air is a risk factor of asthma attack within X hour?***

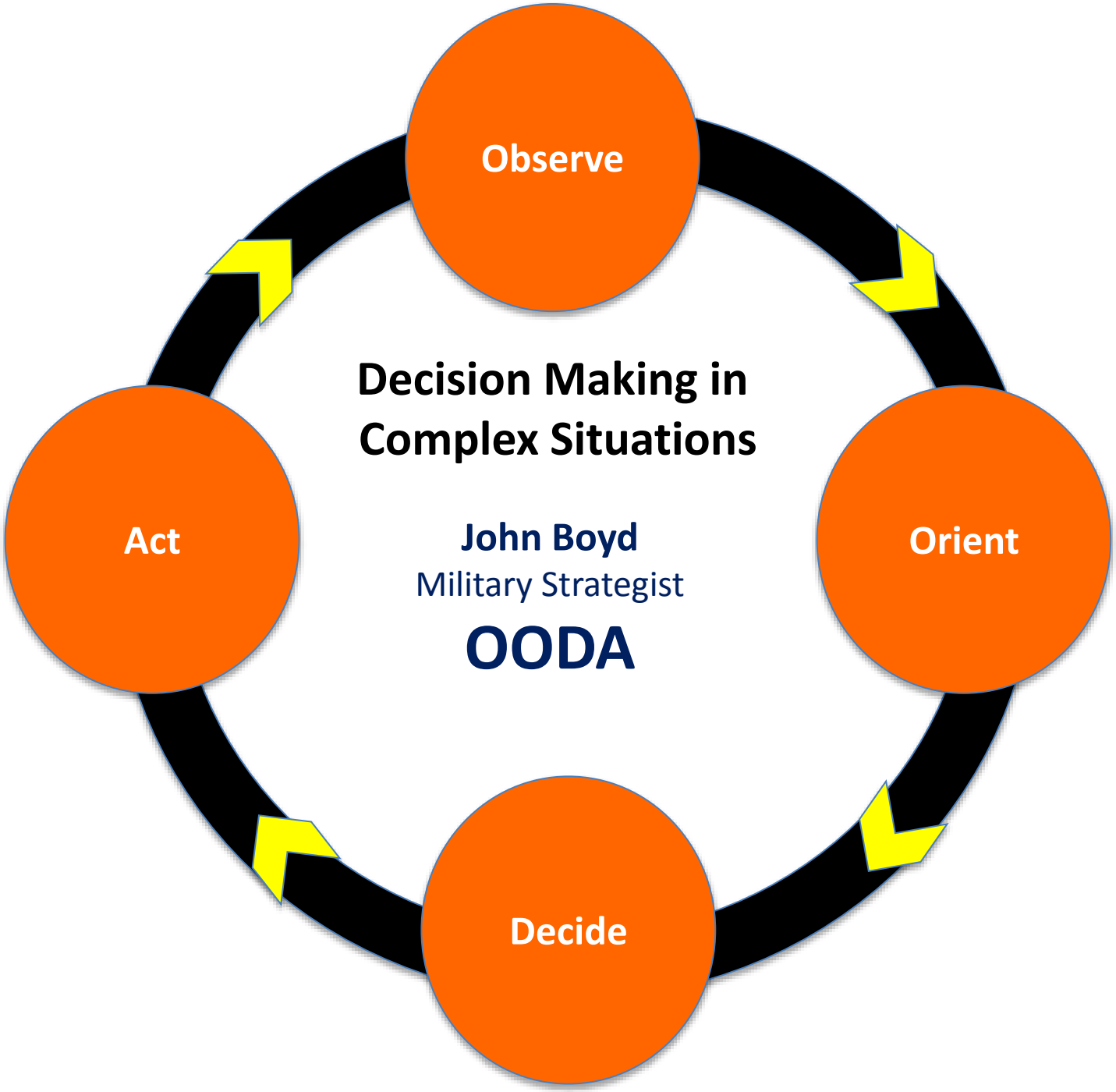
Personicle case

Environmental factors

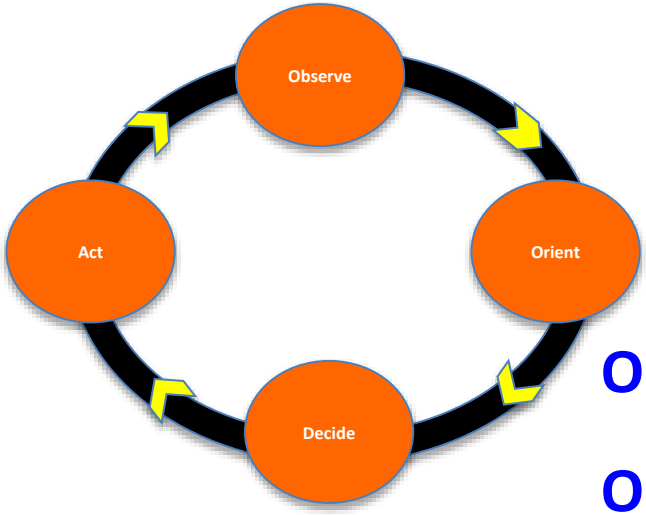
Insight: Sleepless Nights

Spicy Indian food and 2 glasses of wine result in severe acidity and sleepless nights.




Observe
Orient
Decide
Act
Decision Making in Complex Situations
John Boyd
Military Strategist
OODA

Situation awareness is knowing what's going on around you.



Observe + Orient = Situational Awareness

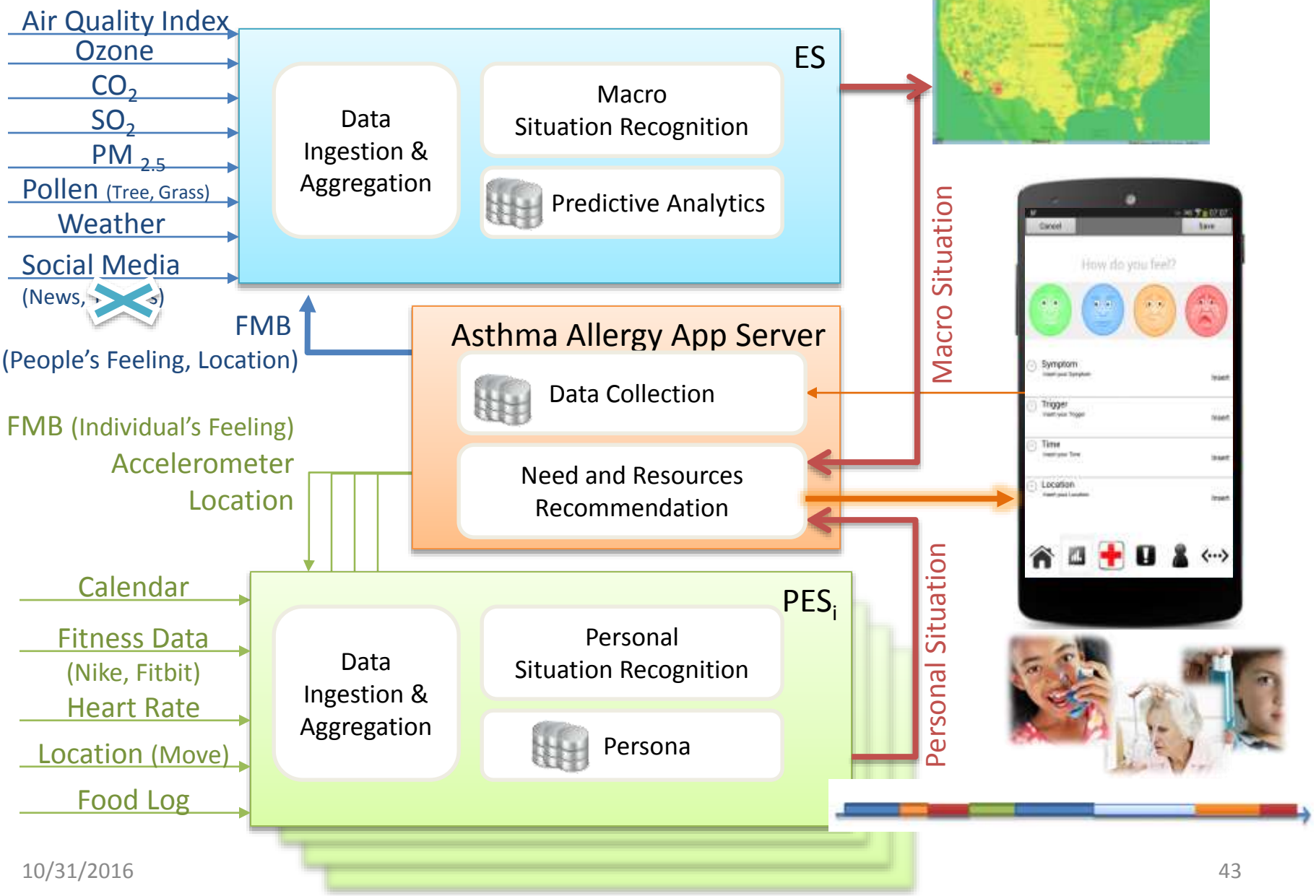
Orient: Baselines, Goals, and Action Plans

Situation awareness is required for every decision in life.

Dashboards Display Data and Information

Operators use *relevant* information to understand situation to decide relevant Action.

Use Case: Asthma Allergy System



Great Opportunity: Wearable

- Wearable building personal models.
- Using personal model to make people aware of their situation.
- Informing relevant people about the situation.
- Helping people make

Right Decision,
Right Moment,
Right Place.

Thanks.

Questions?

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