MONARCA

The Life Cicle of an ICT Project on Multidisciplinary Clinical Research: The MONARCA European Project Experience

UBIHEALTH Project Winter School
Puebla, Mexico, January 2014

OSCAR MAYORA IBARRA
Project Coordinator

EU Call on Personal Health Systems

- *technological solutions, using multiparametric monitoring systems*
- Include d*ecision support for treatment planning….*
- *provision of warnings and motivating feedback.*
- *The solutions will combine wearable, portable or implantable devices, with appropriate platforms and services*.
- *Scenario-based design and user-oriented approach will be inherent in the proposed solutions*.
- *Proposals will address patient data security and confidentiality, and interoperability issues related to heterogeneous data sources, devices and links with electronic health records*.

MONARCA Project

Total Cost – 5,134,000E
Funded by EC – 3,670,000 E
Feb. 2010 – Aug. 2013

CREATE-NET

UNIVERSITÄT PASSAU

tilak Universitätskliniken LKH Innsbruck

Scuola Universitaria Professionale della Svizzera Italiana SUPSI Dipartimento Tecnologie Innovative

Universität Bielefeld

MEDITRAINMENT fit für mehr... www.meditrainment.com

IT University of Copenhagen (ITU)

Aipermon Welcome Your Health

REGION Psykiatrisk Center Rigshospitalet

systema HUMAN INFORMATION SYSTEMS A CompuGROUP COMPANY

BITZ

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

Bipolar Disorder

MANIAC – DEPRESSIVE PSYCHOSIS

Symptoms

- Recurrent thoughts of death, Suicidal ideation
- Diminish of productivity/performance at work
- Significant variations in weight/appetite
- Diminished interest in activities
- Irregular sleeping
- Feelings of guilt
- Indecisiveness

- Increase in goal-directed activity (typically socially, at work, school, etc.)
-involvement in risky activities
- Pressure to keep talking
-Psychomotor agitation
- Attention variability
-Decrease sleep

IMPACT

Number of suicides per day in Europe
equals fully occupied Jumbo Jet (747)

37,5 % of these are bipolar

Bipolar disorder results in 9.1 years reduction in expected life span

IMPACT

Cost in DALYS

TYPE OF DISABILITY	Cost in DALYs
Unipolar major depression	42.97
Tuberculosis	19.67
Road traffic accidents	19.6
Alcohol abuse	14.8
Self-inflicted injuries	14.6
Bipolar disorder	13.1
War	13.0
Violence/Criminality	12.9
Schizophrenia	12.5
Iron deficiency anemia	12.4

Disability Adjusted Life Years (DALYS) measure of overall disease burden, expressed as the number of years lost due to ill-health, disability and early death.

STATE OF THE ART TREATMENT

BASED ON PHARMACOLOGICAL AND PSYCHOTHERAPEUTIC TECHNIQUES (E.G. BRAMS, HAMD, SELF ASSESSMENTS)

MANIA	+3							
	+2							
	+1							
NORMAL								
DEPRESS.	-1							
	-2							
	-3							
	day	1	2	3	4	5	6	7

SLEEP Number of hours							
Extern reason							

ANXIETY							
IRRITABILITY							

ALCOHOL, number							
COFFE Number of coops							

PERSONAL TRIGGER / WARNING							

MEDICATION name - mg							

10 tips for reaching out and building relationships

1. Talk to one person about your feelings.
2. Help someone else by volunteering.
3. Have lunch or coffee with a friend.
4. Ask a loved one to check in with you regularly.
5. Accompany someone to the movies, a concert, or a small get-together.

6. Call or email an old friend.
7. Go for a walk with a workout buddy.
8. Schedule a weekly dinner date
9. Meet new people by taking a class or joining a club.
10. Confide in a counselor, therapist, or clergy member.

Healthy sleep habits for managing bipolar disorder

- Go to bed and wake up at the same time each day.
- Avoid or minimize napping, especially if it interferes with your sleep at night.
- Avoid exercising or doing other stimulating activities late in the day.
- No caffeine after lunch or alcohol at night. Both interfere with sleep.

Warning signs of depression

- I quit cooking meals
- I no longer want to be around people.
- I crave chocolate.
- I start having headaches.
- I don't care about anybody else.
- People bother me.

Warning signs of mania or hypomania

- I find myself reading five books at once.
- I can't concentrate.
- I find myself talking faster than usual.
- I feel irritable.
- I'm hungry all the time.
- Friends tell me that I'm crabby.

Monarca Concept

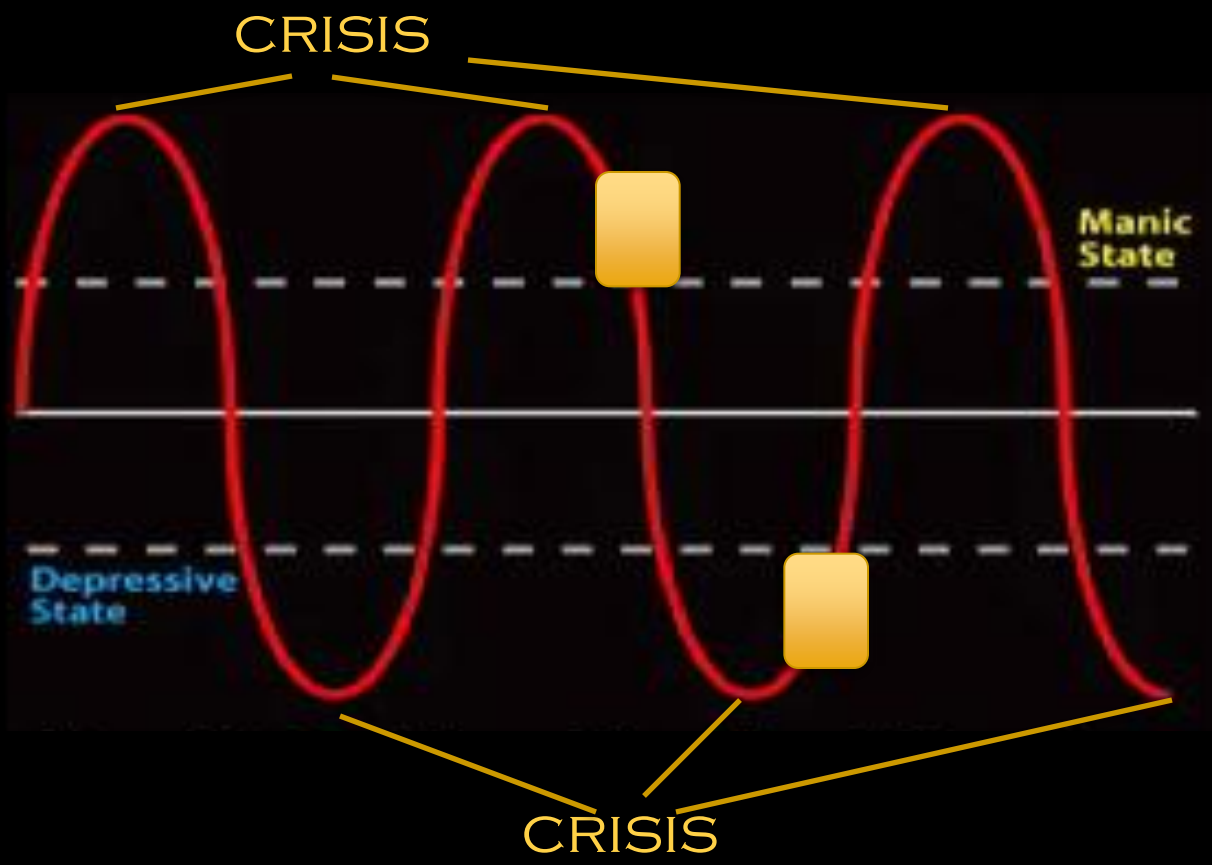
WHY "MONARCA" ?

MONitoring, treAtment and pRediCtion of bipolAr Disorder Episodes

Mapa de Migración

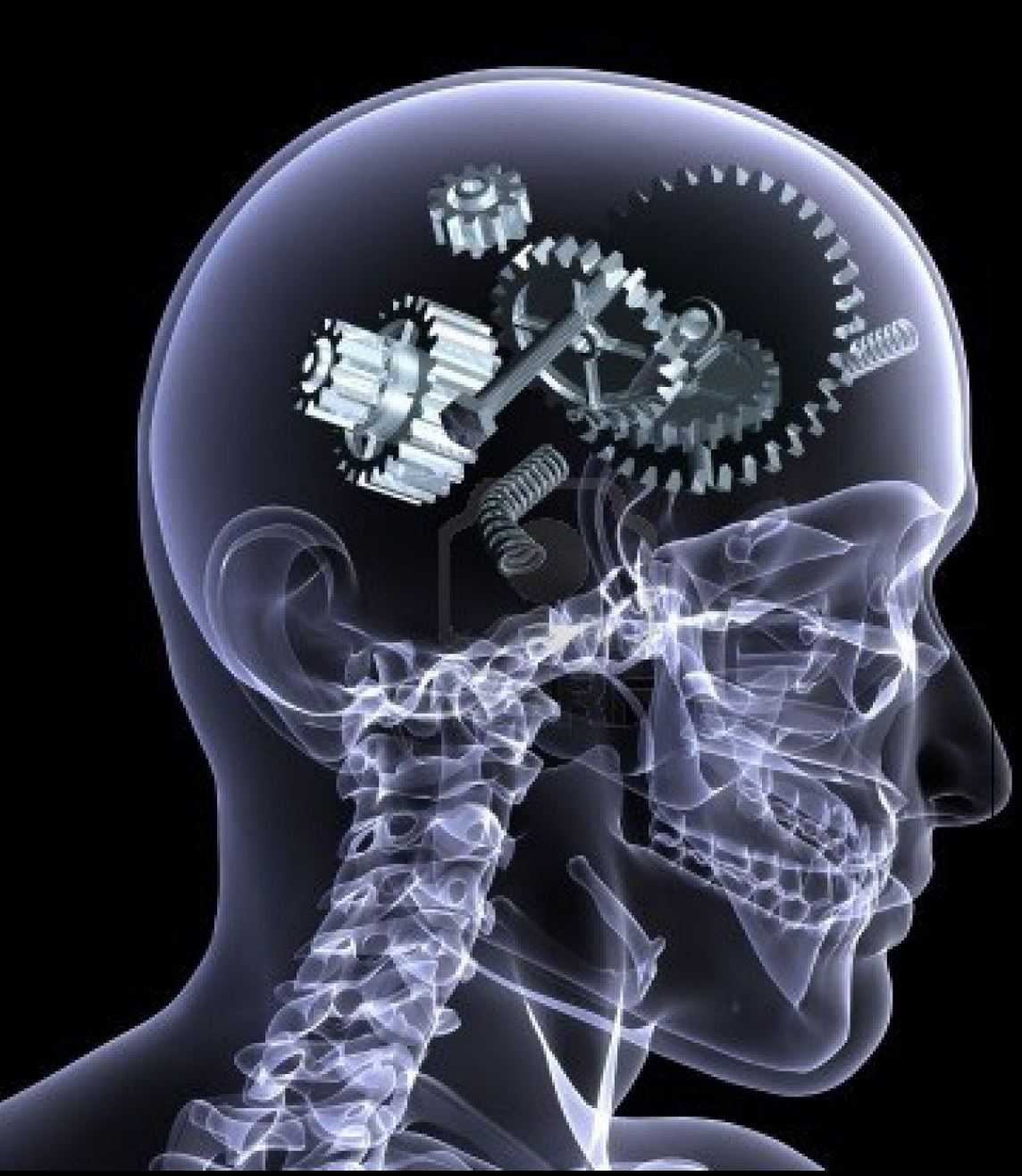

SANTUARIO DE LA MARIPOSA MONARCA
El mas Grande del Mundo
BIENVENIDOS
RECOMENDACIONES

MONARCA



PREVENTION

ASSESSMENT



MONARCA CONCEPT

"The X RAYS of Bipolar Disorder"

Christian Haring

GRADUAL INTRUSIVENESS

Intrusiveness, risk and deployment threshold

MINIMAL INTRUSIVENESS

Compass

GPS

Bluetooth

Microphone

Wireless LAN

Camera

Accelerometer

Gyroscope

Monarca Design

Participatory Design

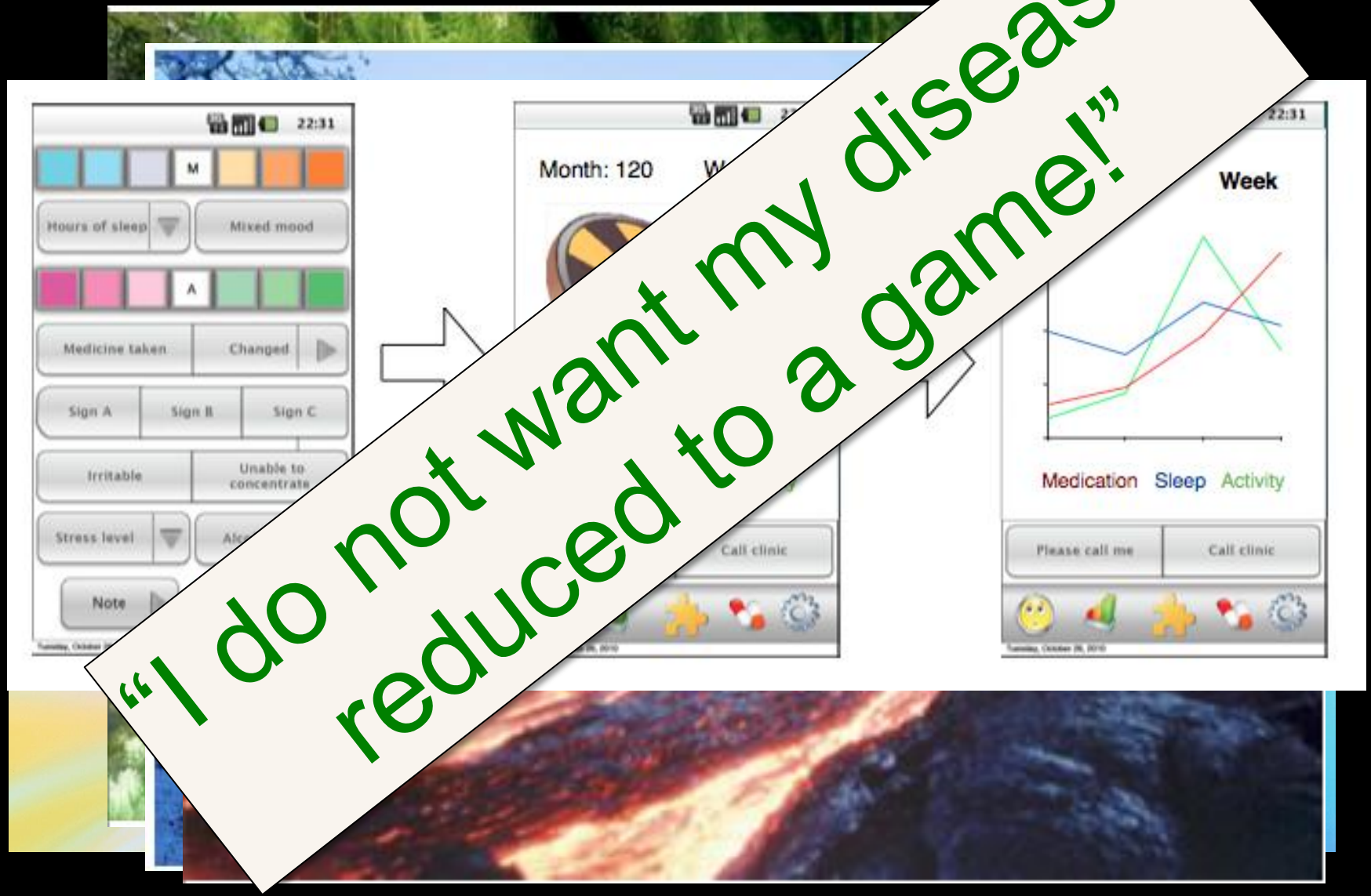
- Involving a set of “users”
  - patients, doctors & nurses
- Weekly design workshops were conducted with an iterative design process applying Wizard-of-Oz techniques
- The design was present across the different stages of the project including design, prototyping, testing, etc.


Mockups of self-report questionnaire

Persuasive Feedback

- Encourage healthy living
  - Sleep : regular sleep
  - Activity : stay active (socially + physically)
  - Medicine : medicine adherence

PATIENTS FEEDBACK



"I do not want my disease reduced to a game!"

PATIENTS FEEDBACK

CLOSED-LOOP FEEDBACK

- Doctors
  - Therapy Assessment
  - Planning Medication
  - Scheduling Appointments
- Caregivers
  - Warnings and Risk Profiles
- Patients
  - Self-Monitoring and Assessment
  - Motivation, Coaching and Self-Treatment

BOUNDARY CONDITIONS

- Compliance Privacy Regulations
- Network and Data Security
- Compliance with Medical/Ethical Regulations
- Interoperability with HIS Systems

SOA VS MONARCA

SOA APPROACH

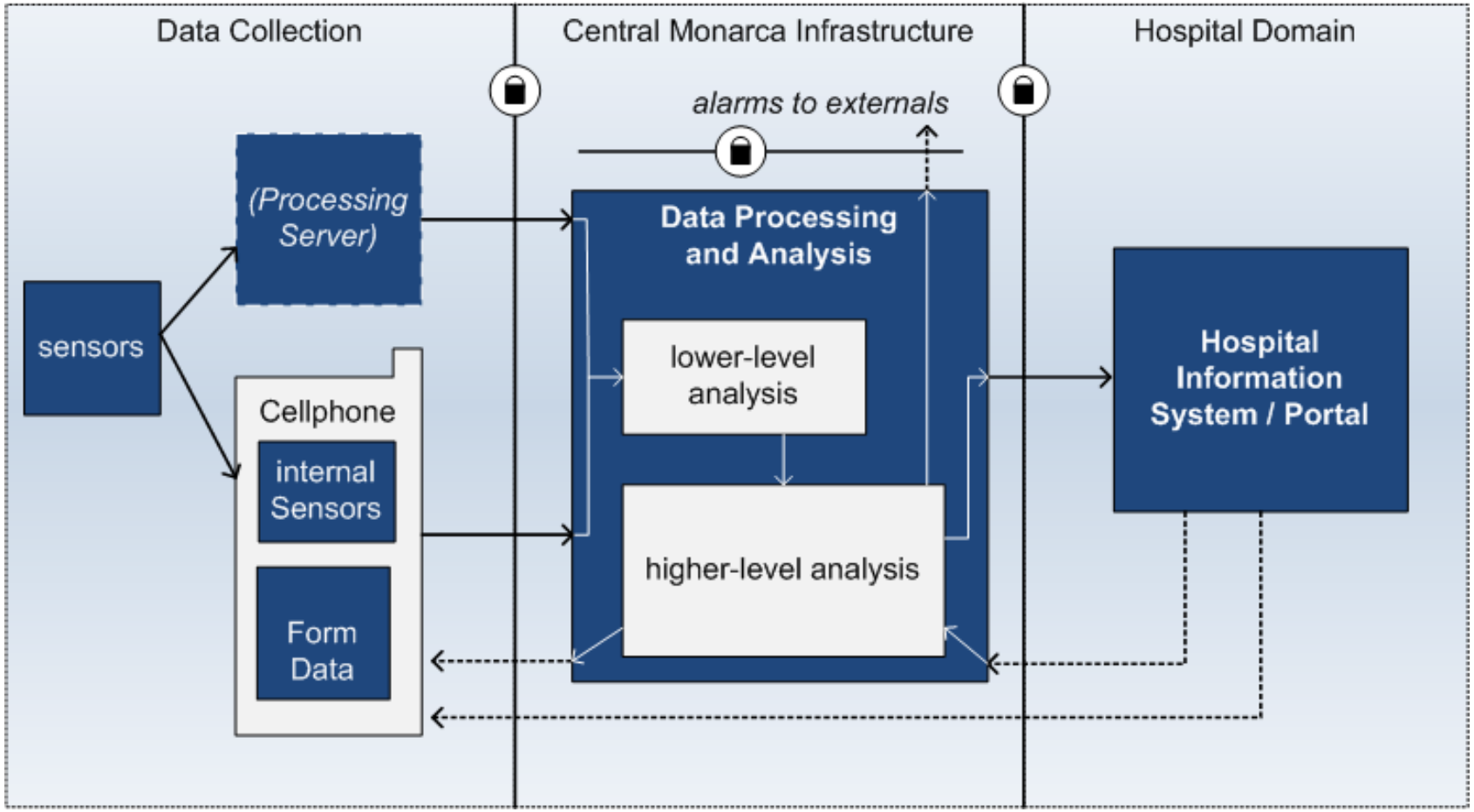
- Assessment based on self-reported experiences typically after crisis (intrinsically subjective data)
- Sporadic assessment through interviews
- Difficulty to assess trends in the short term (implies actions only after manic/depressive episodes)
- Low adherence for self-management of the disease

MONARCA APPROACH

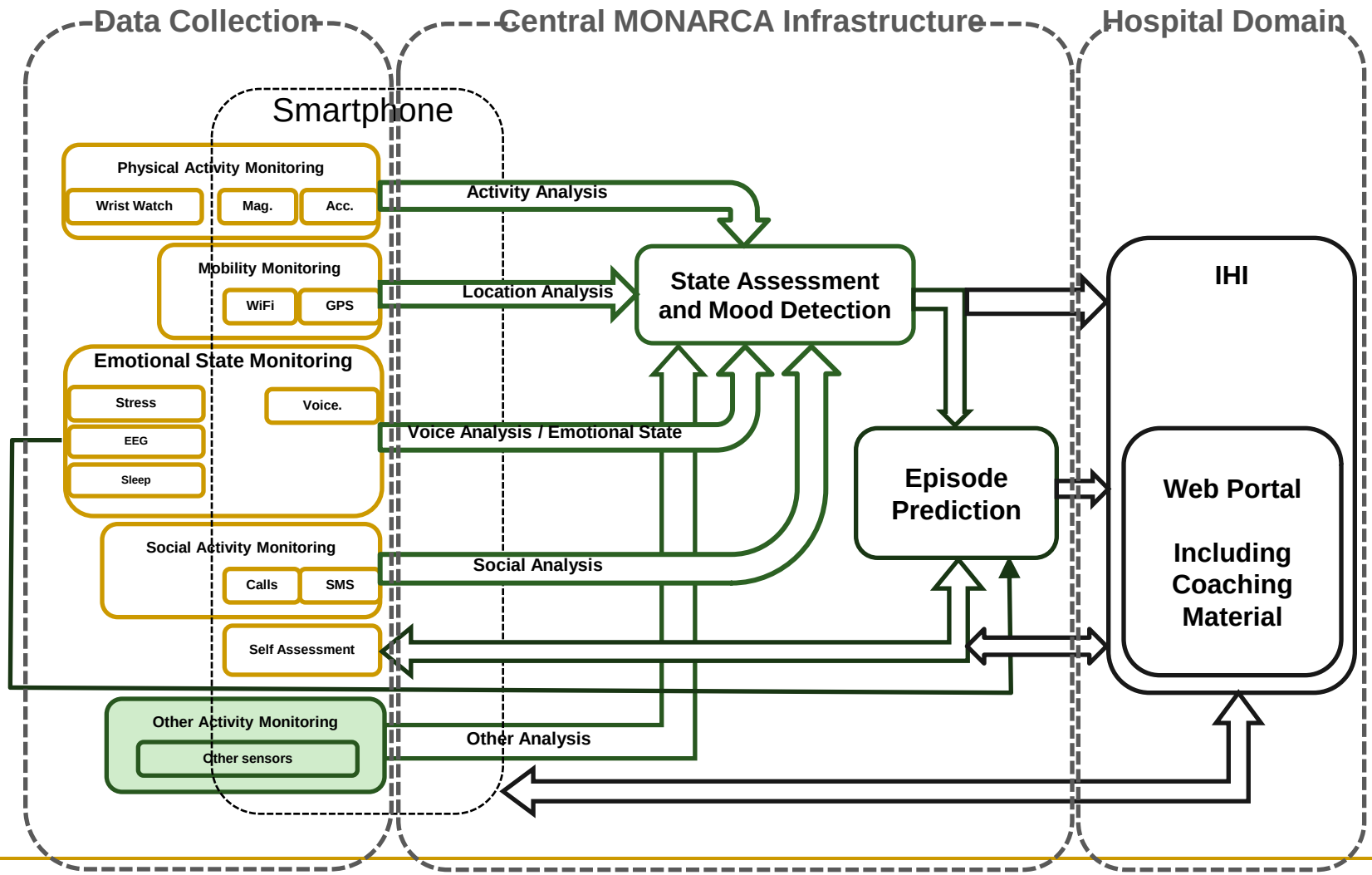
- Assessment based on objective, measurable data
- Continuous state assessment through multi-parametric monitoring
- Timely warnings on "risky" trends (Prevention of crisis)
- Increase awareness through self-monitoring and timely personalized coaching

Monarca Architecture & data collection approach

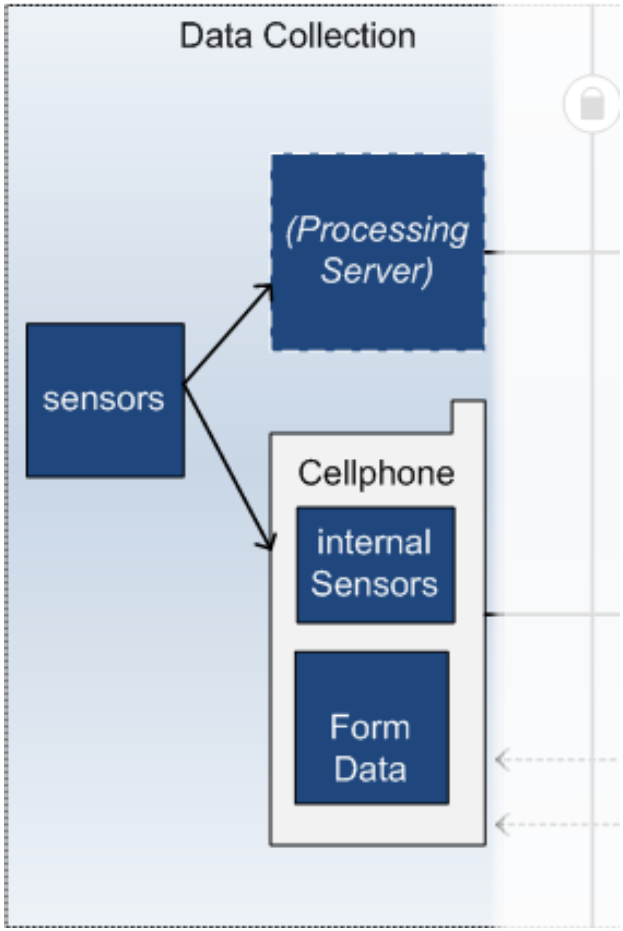
Initial MONARCA Architecture

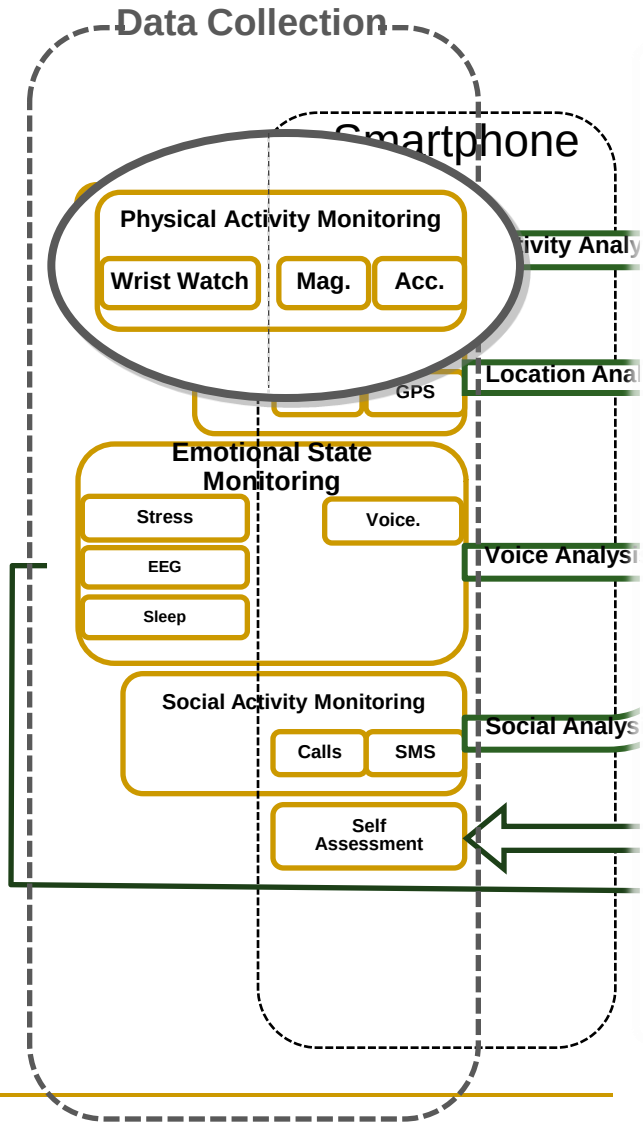


Final MONARCA Architecture



Step By Step – Data Collection





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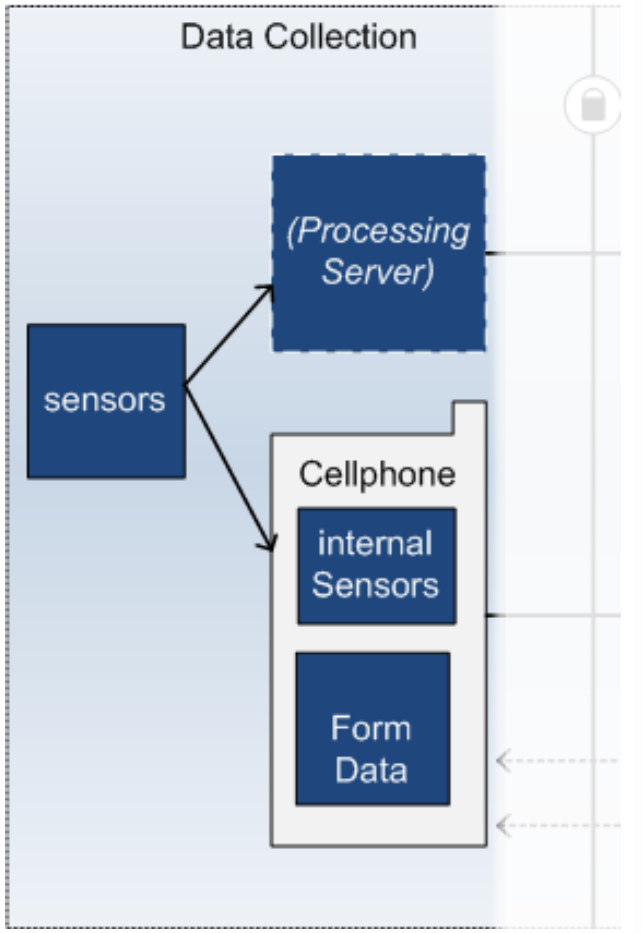

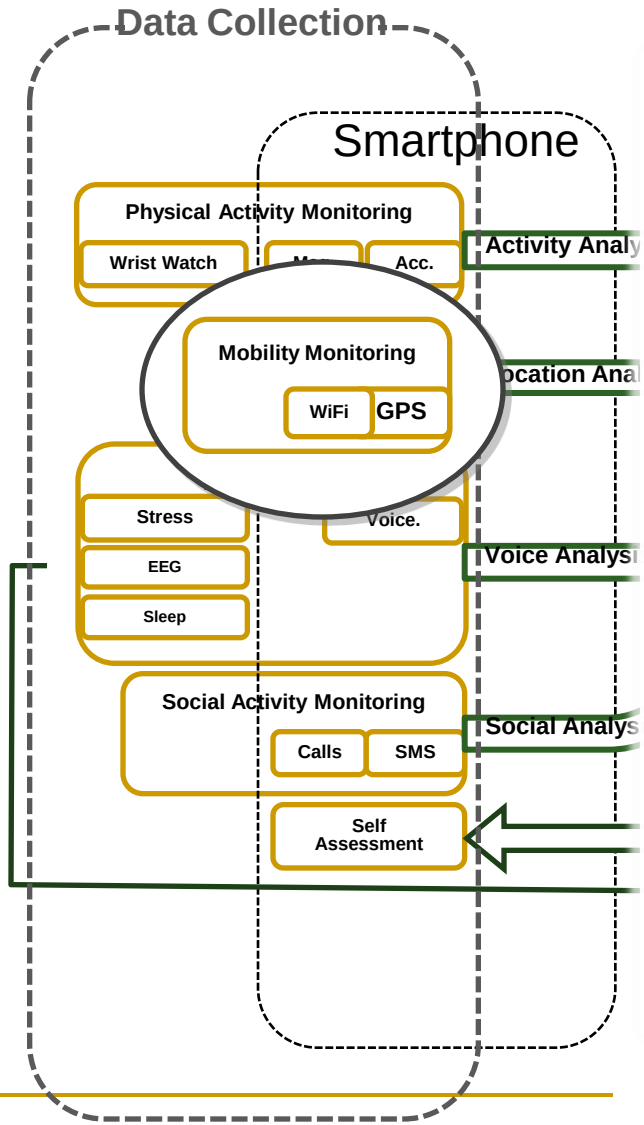

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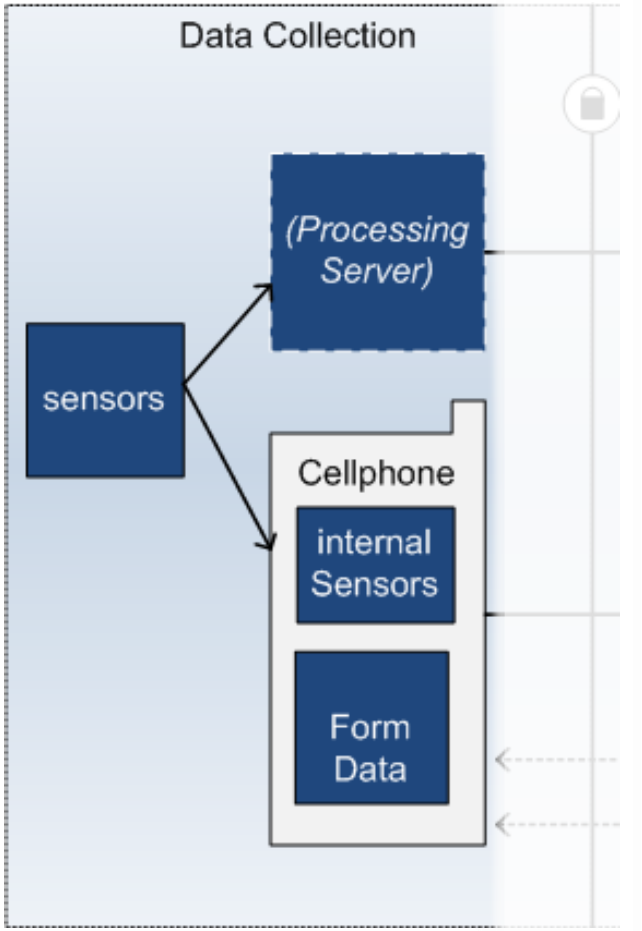

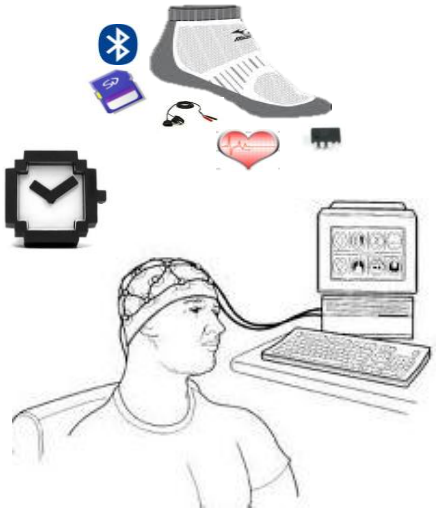

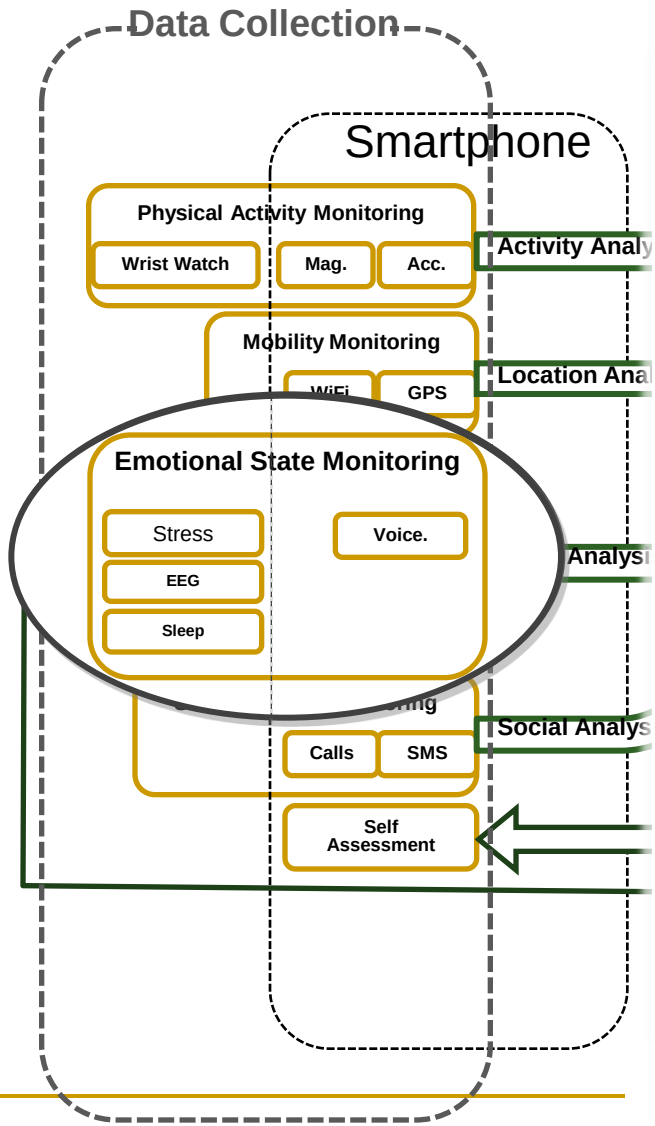

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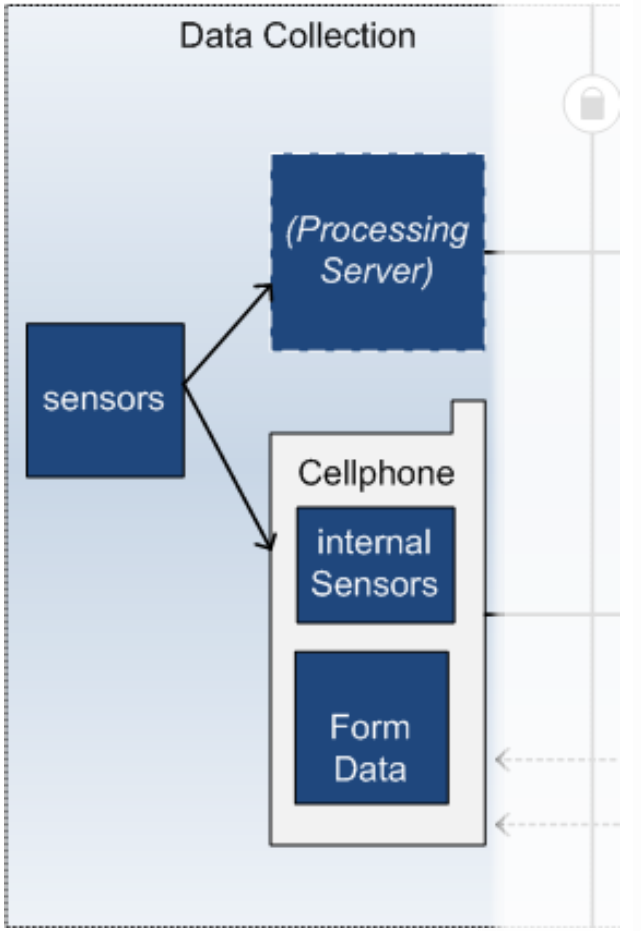

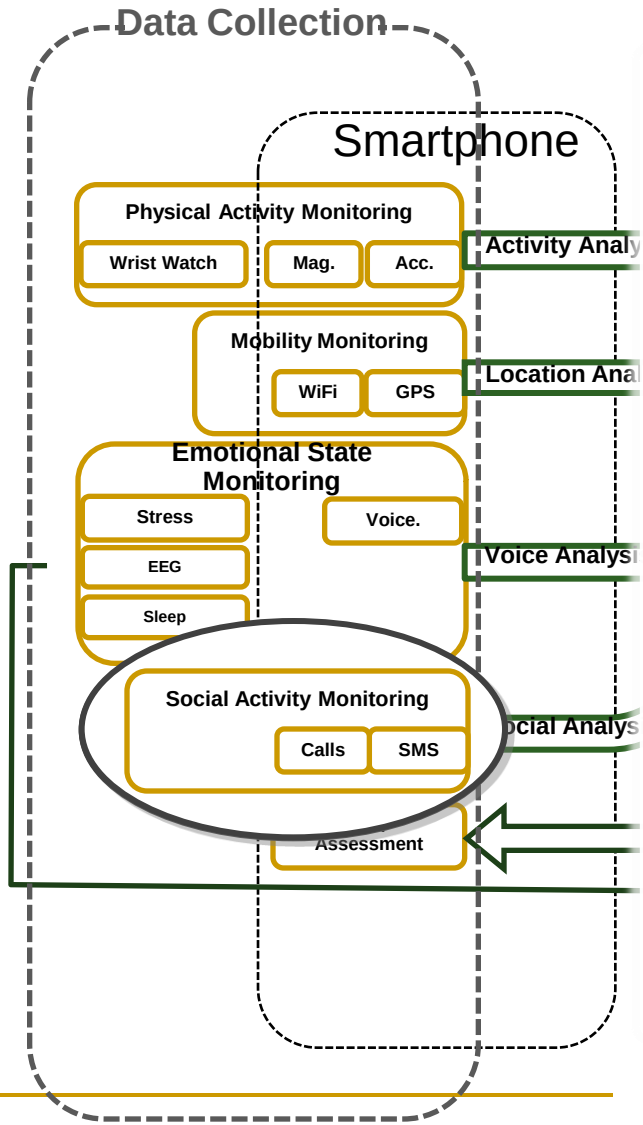

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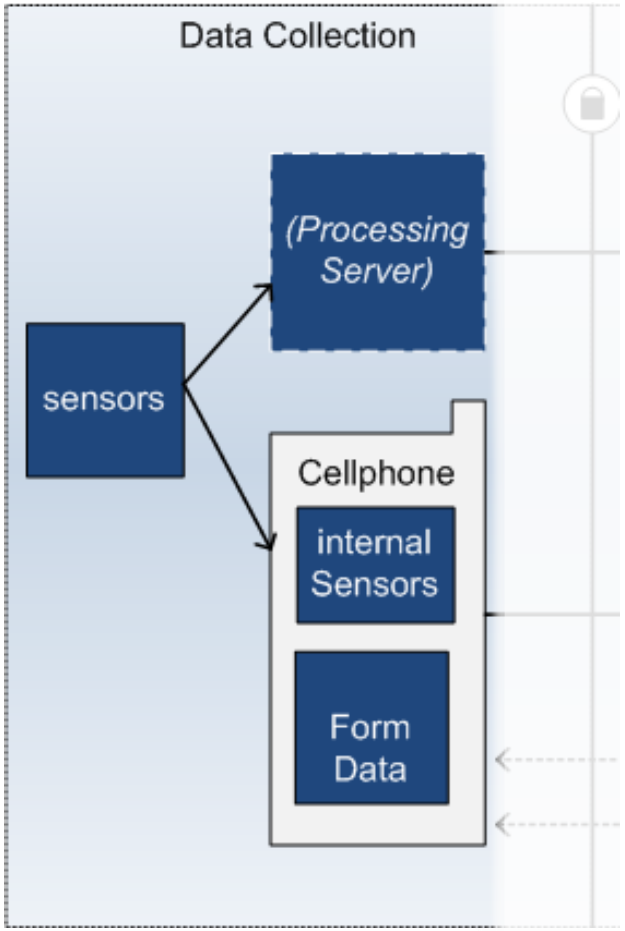
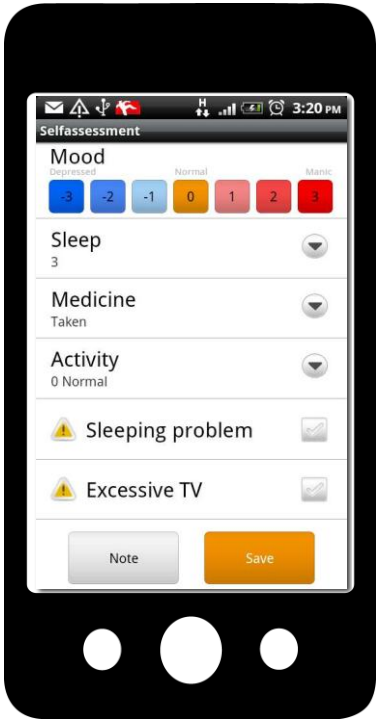
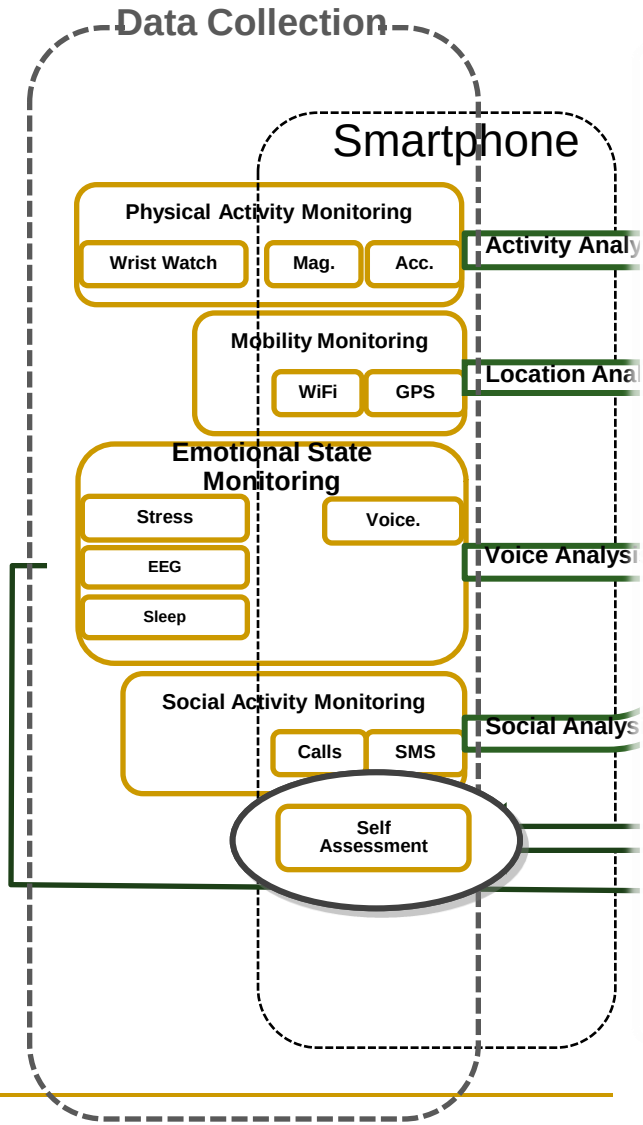
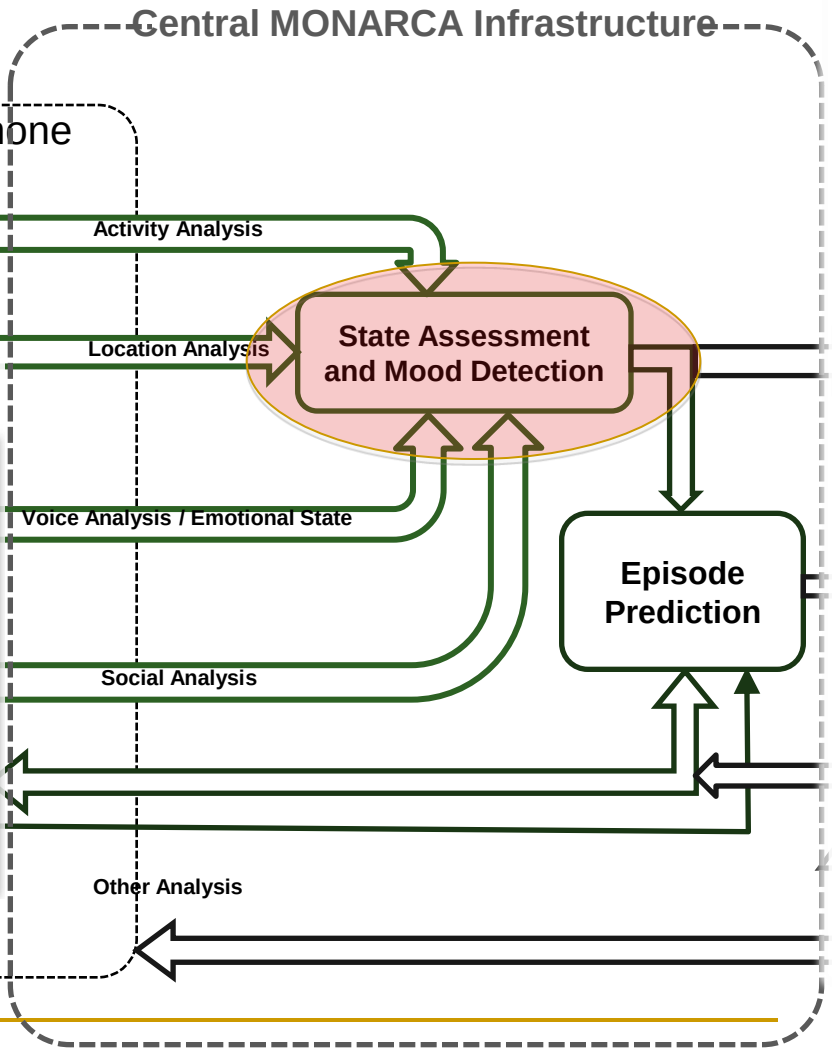






Step By Step – Central MONARCA



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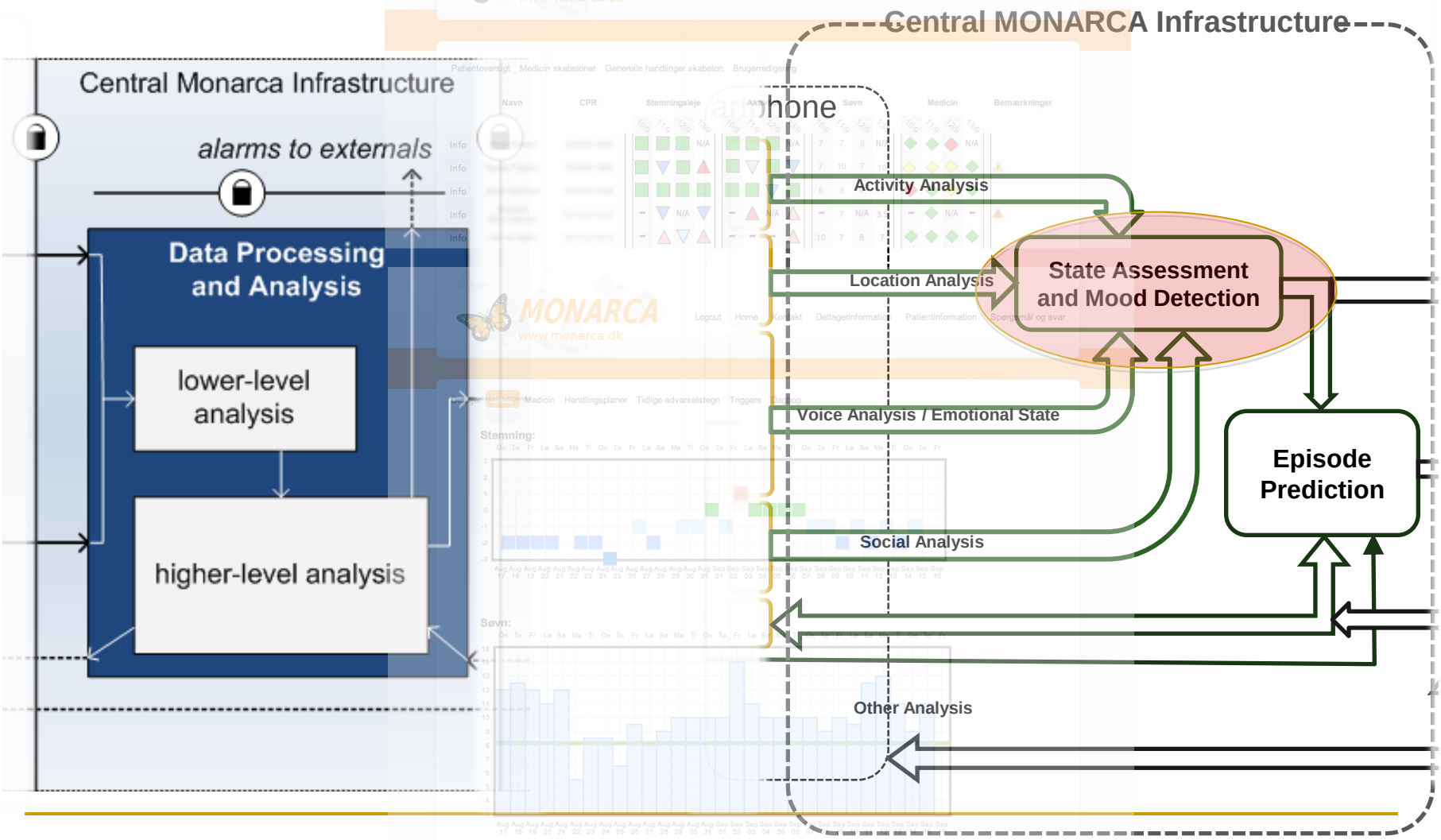

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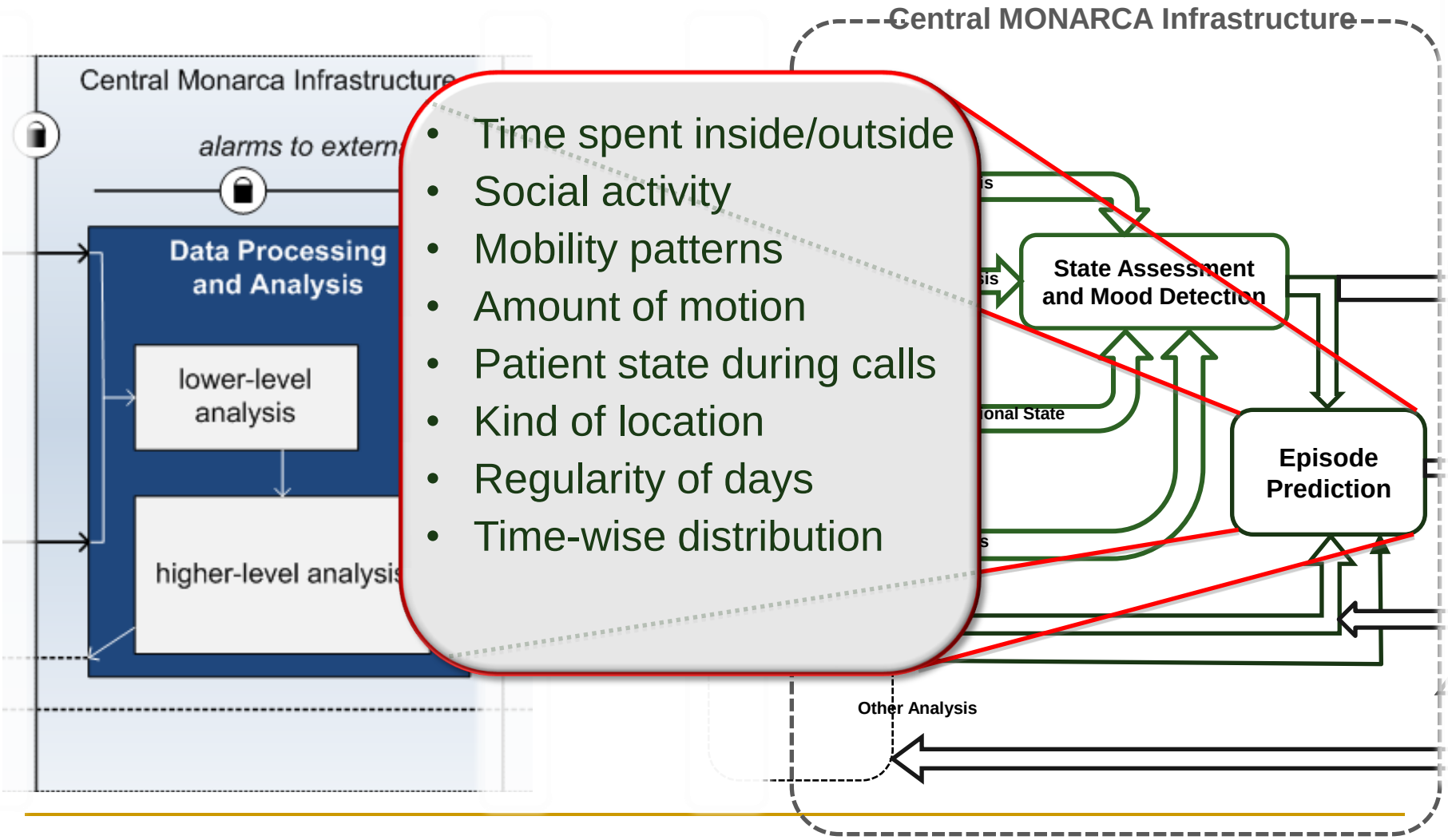
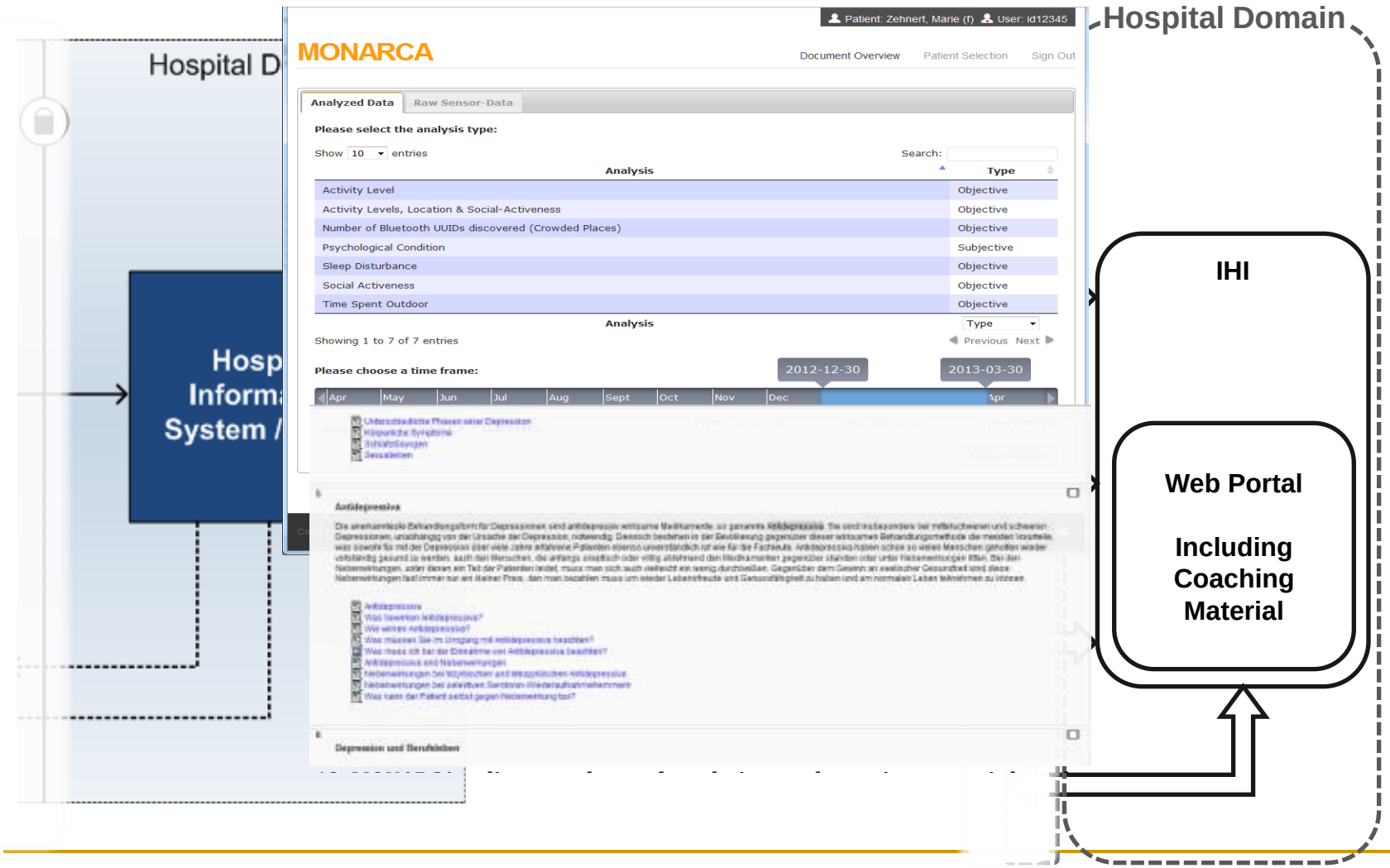
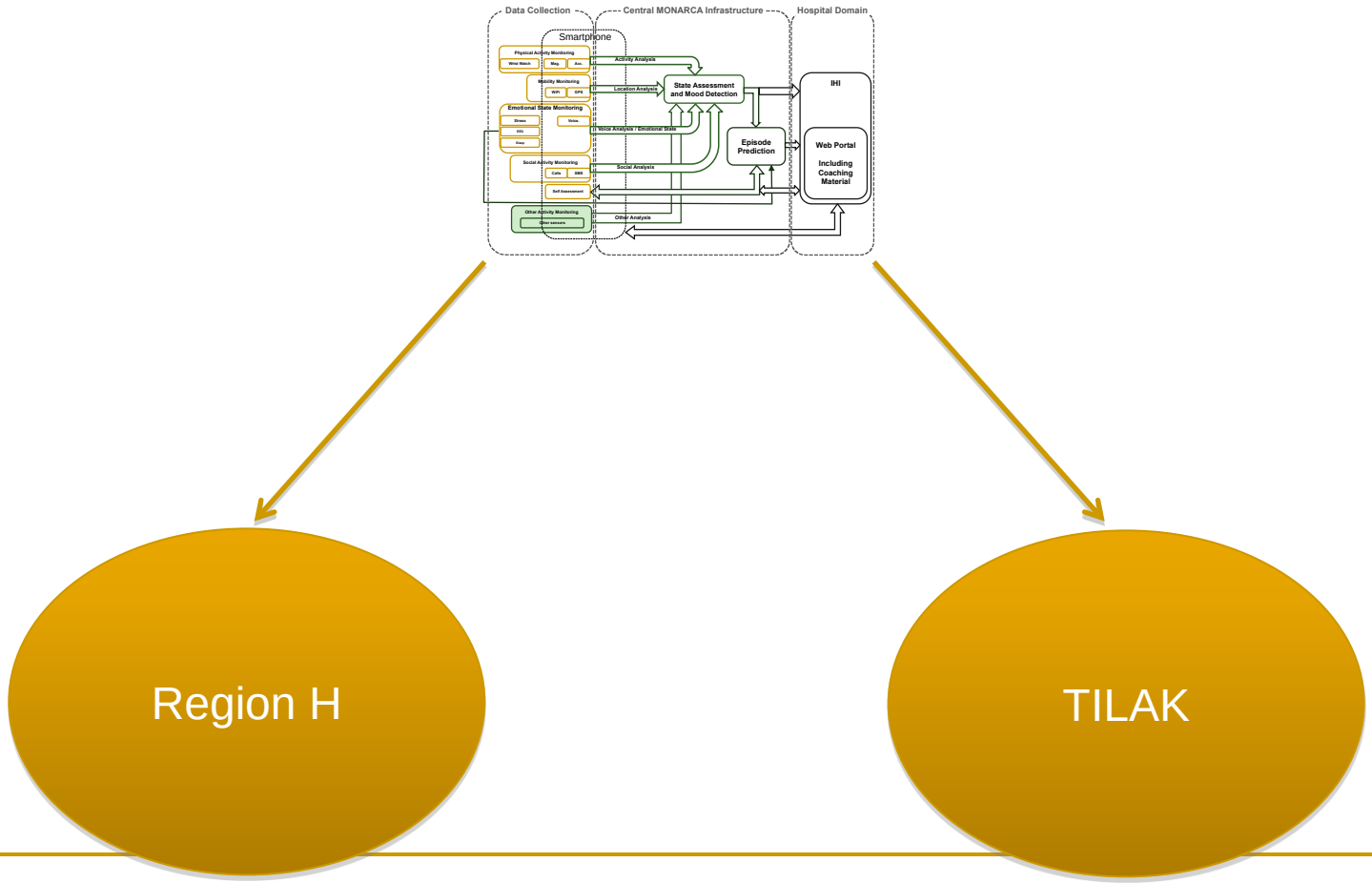


Step By Step – Hospital Domain

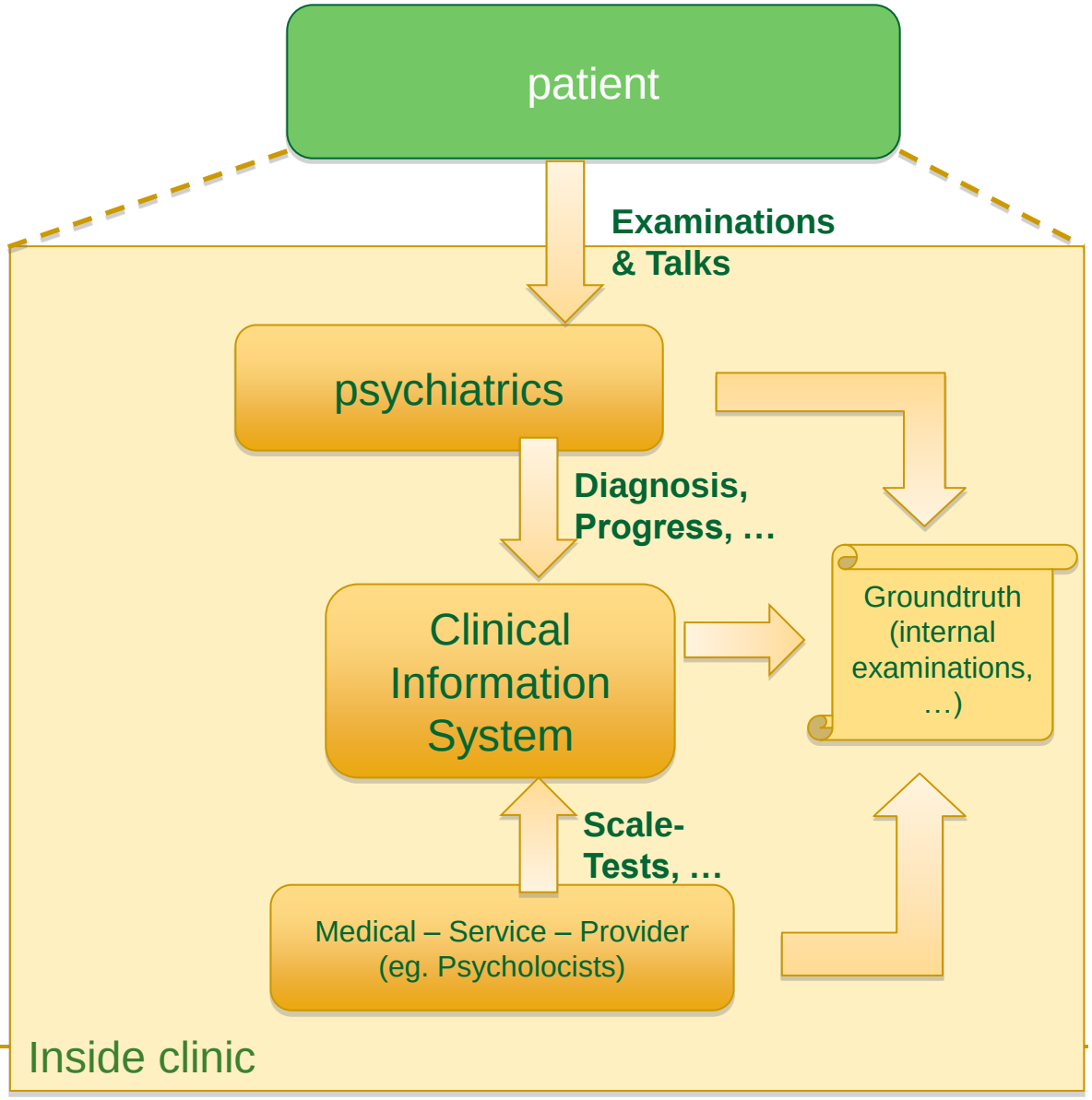


MONARCA System as a Class

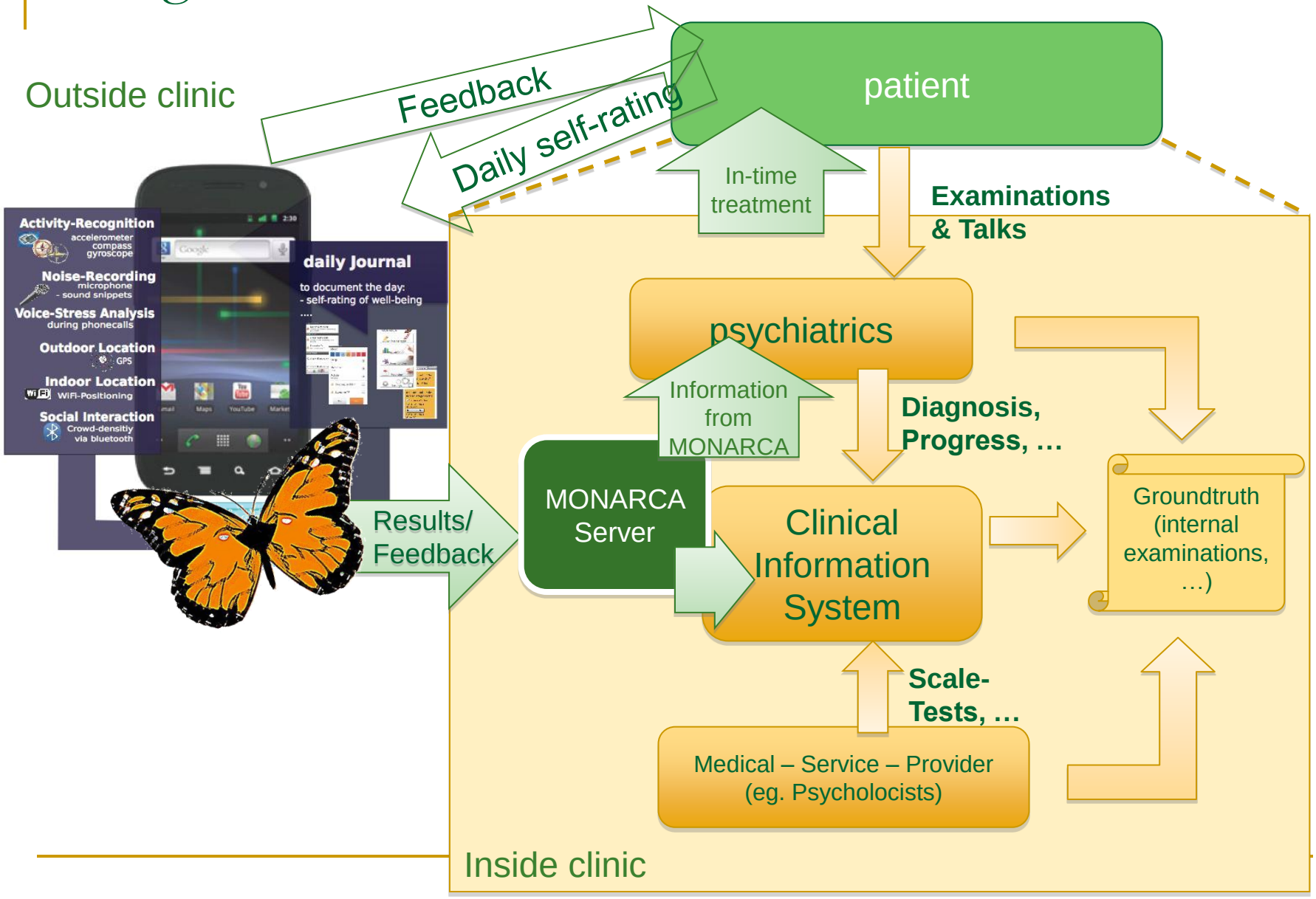


Integration of MONARCA in Clinical Processes

Outside clinic



Integration of MONARCA in Clinical Processes



Monarca Algorithms and trials evaluation

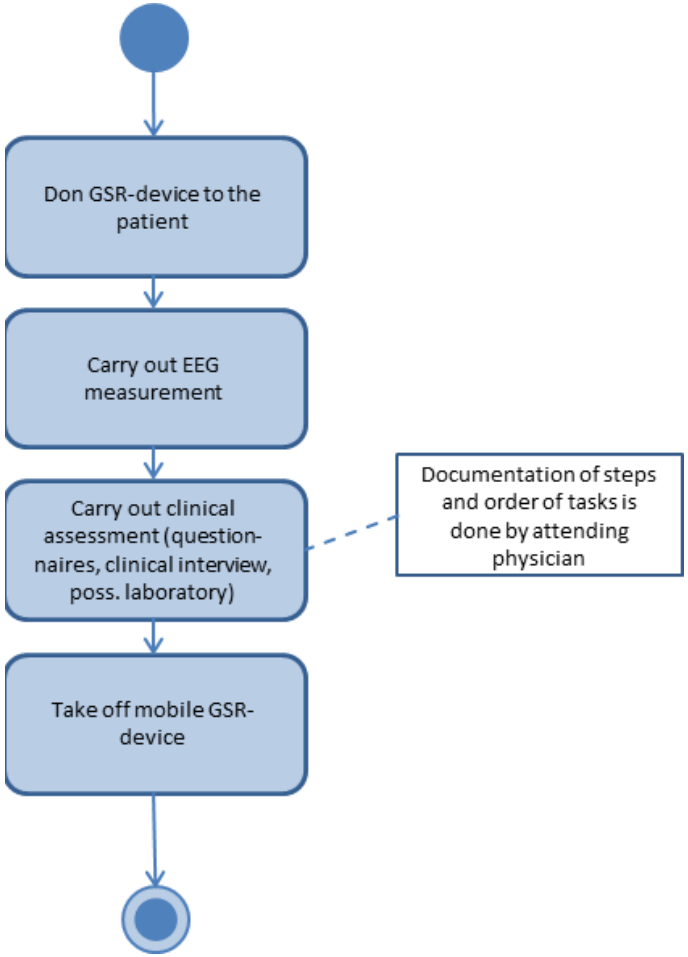
→ Copenhagen, Denmark

Austrian Tirol ←

Tirol Trial Summary (focus on objective monitoring)

- Number of Patients: 12
- Duration: 12 weeks per patient
- Ground Truth:
  - Diagnostic and psychiatric assessment during measurement points every 3 weeks (5 in total)
  - Phone-Interview: in-between of measurements
  - Daily Survey:
    - …
    - 3 self-rating questions about condition (physical, psychological, activity)
    - 2 randomly chosen depression questions (ADS)
    - 2 randomly chosen mania questions (MMS)

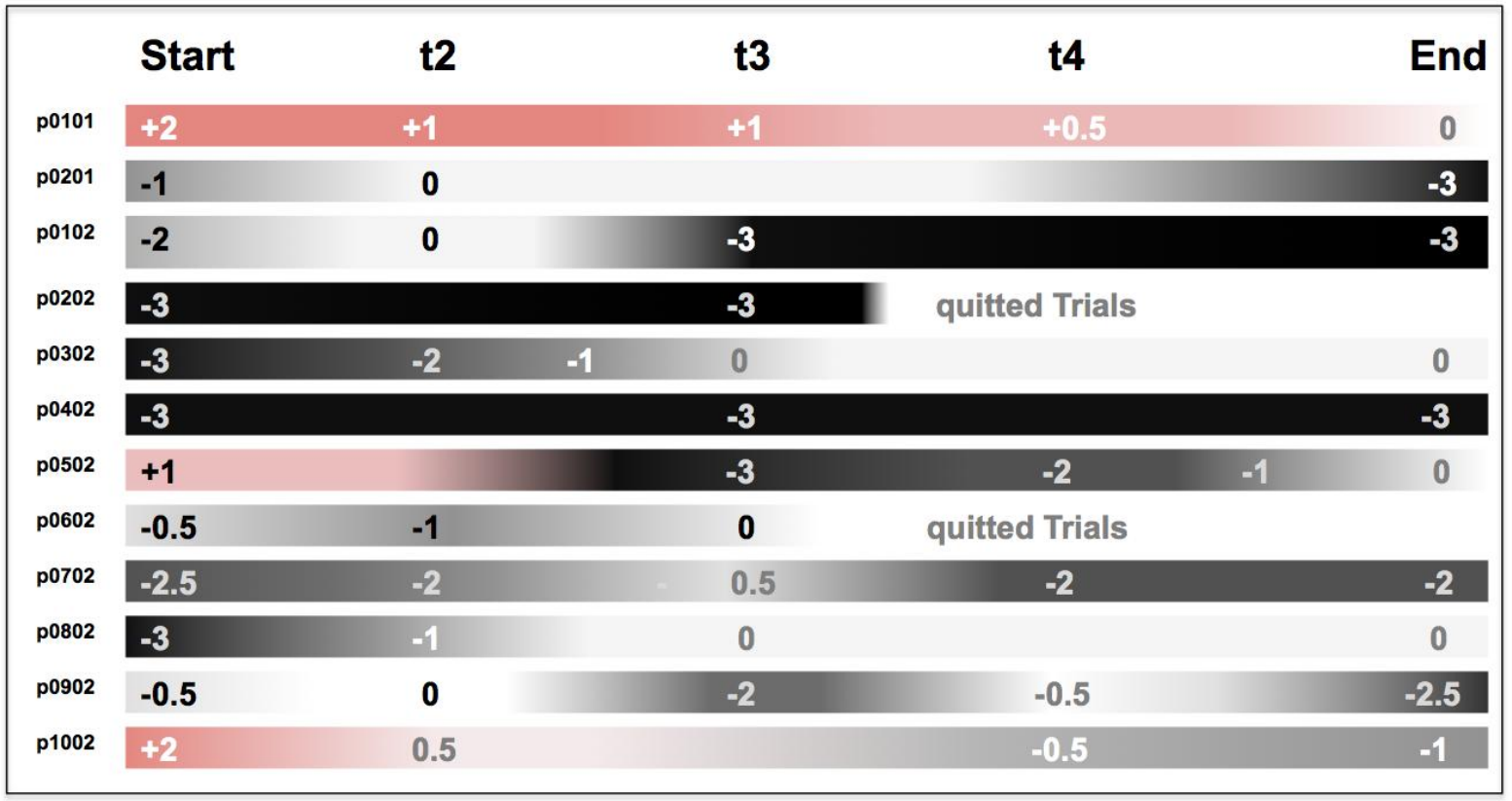
Phase 2 – hospital appointment



Included devices and tests:

- GSR
- EEG
- Psychological Scale Tests
  - HAMD
  - ADS
  - YOUNG
  - MMS
- Psychiatric assessment

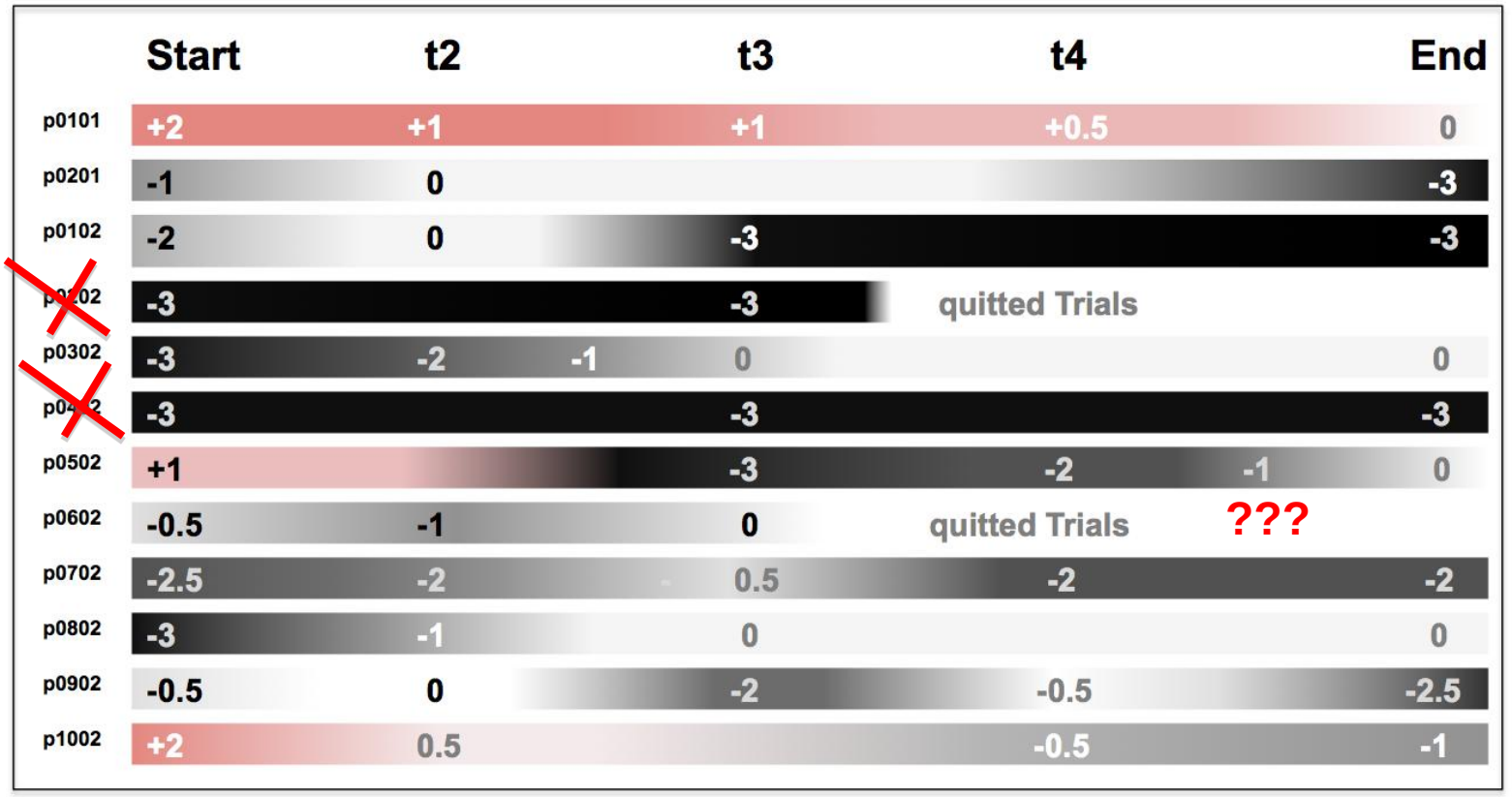
Patient‘s Condition during the Trials



Week 1 **Week 12**

Start, t2-t4 and End: Measurement points at clinic

Patient‘s Condition during the Trials



Week 1 **Week 12**

Start, t2-t4 and End: Measurement points at clinic

Data Issues

- Missing sensor data
  - not carrying the phone
  - GPS/WiFi switched off because of power
  - other sensors switched off accidentally

- Extrapolating the examination ground truth to more days

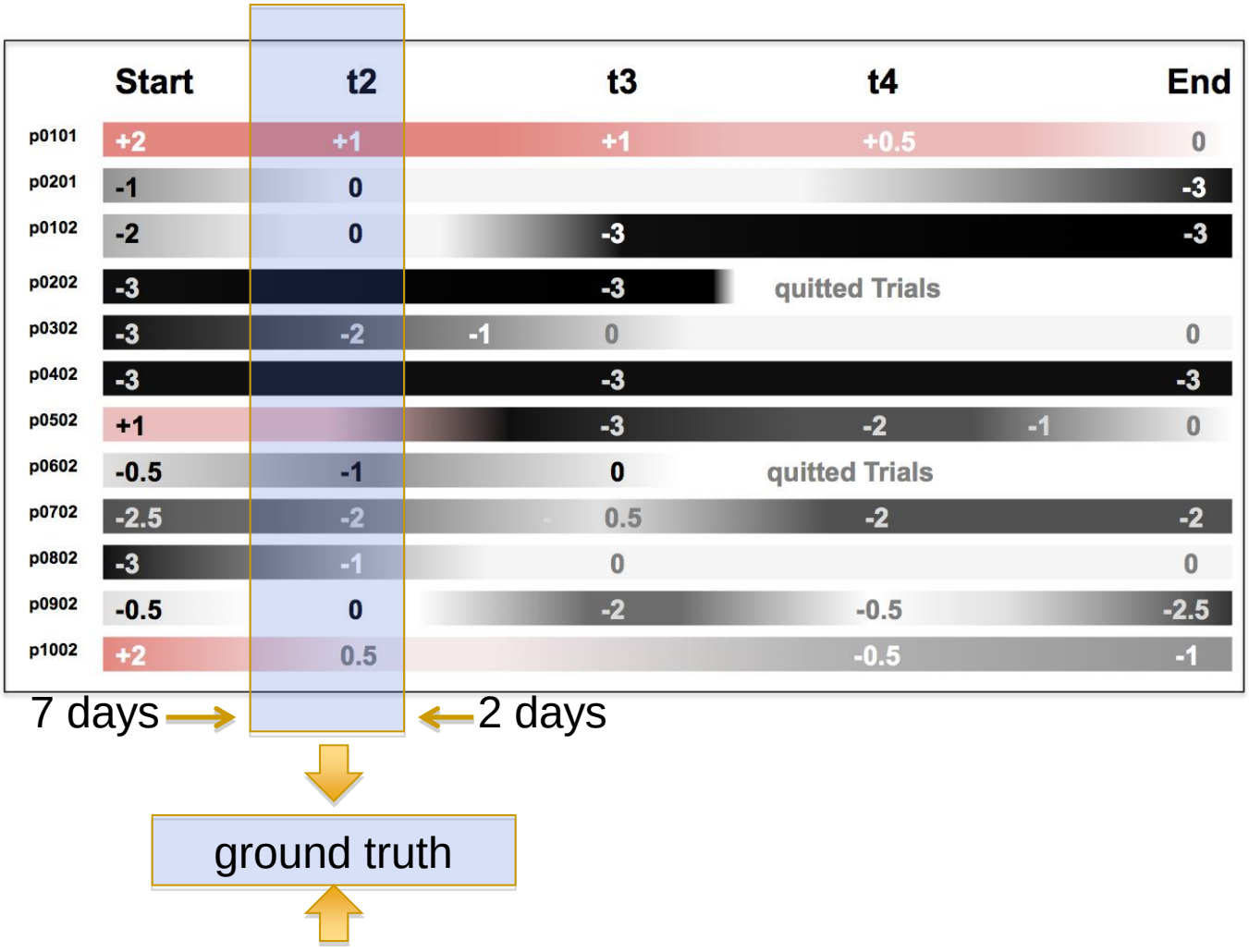
Data Issues

- Missing sensor data
  - not carrying the phone
  - GPS/WiFi switched off because of power
  - other sensors switched off accidentally

- Extrapolating the examination ground truth to more days

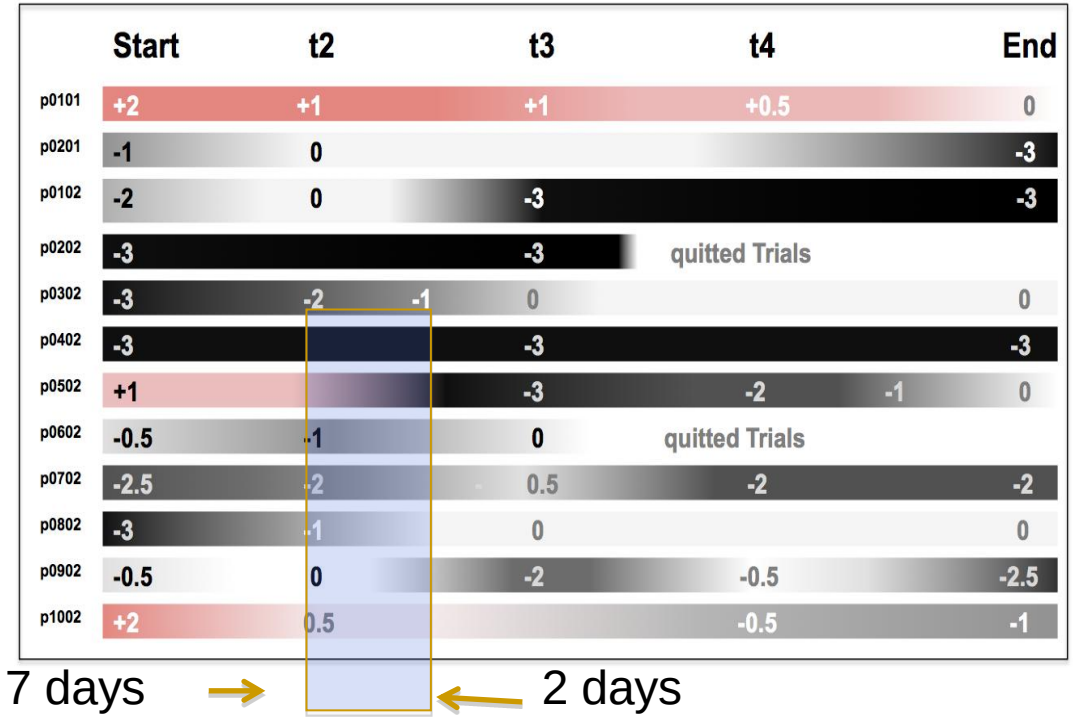
how to get enough labeled data ?

Extrapolating Labels



Change detection

1. We identify the distance from the “reference” state
2. “Reference” State was the one indicated by the doctor with his assessment
3. We obtained accurate Changes Detection



State classification and change recognition works under real world circumstance !

Overview

1. Mobile monitoring algorithms
    1. State recognition
    2. Change detection
    3. Other correlations

Other Correlations

WiFi Analysis

- Compare the number of significant places visited by each patient the week before and week after testing day.
- Each graph is a plot of patient state vs. number of significant places.
- Every patient behaves differently (e.g. some patients tend to visit a certain number of places when in normal state, while another patient who is in normal state, may visit less number of places).

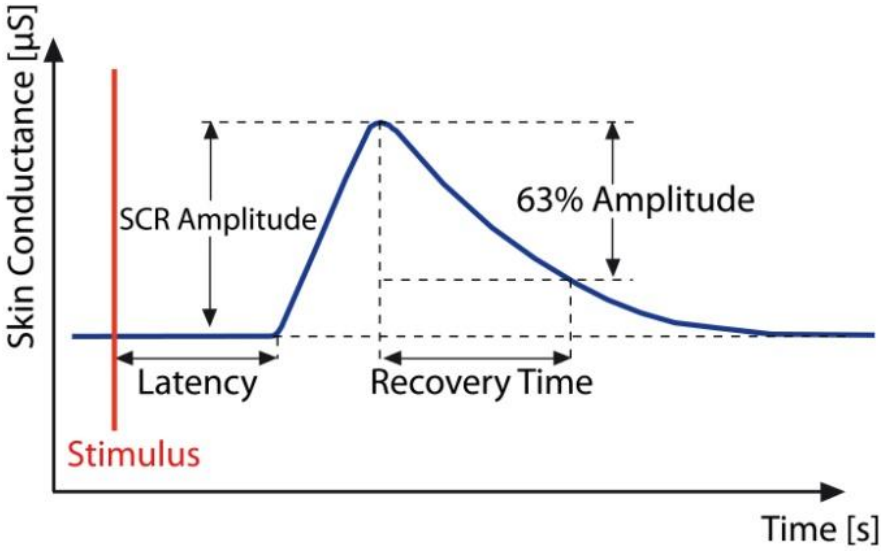
Voice Analysis - Acoustic Features

- Emotion Recognition (EMO)
  - Energy
  - Pitch
  - MFCC
- Social Signal Processing (SSP)
  - Speed of Speech
  - Pauses
  - Turn Takings

Electrodermal Activity (EDA)

- **Skin conductance** ~ sweat secretion ~ nervous system **~ psychophysiological activation**

- EDA is sensitive to
  - **Emotions and stress**
  - Outside and skin temperature
  - Movement
  - the individual



[1] W. Boucsein, Electrodermal activity. New York: Plenum Press, 1992.
[2] Setz et al., Discriminating Stress from Cognitive Load Using a Wearable EDA Device. IEEE Trans. on Inf. Tech. in Biomedicine, 14:2(410-417), 2010.
[3] Cornelia Setz, Johannes Schumm, Martin Kusserow, Bert Arnrich and Gerhard Tröster, Towards Long Term Monitoring of Electrodermal Activity in Daily Life, in: 5th International Workshop on Ubiquitous Health and Wellness (UbiHealth 2010), 2010

Limitations

- Not possible in case of foot injuries
- Inconvenient metal connector
- Proof of concept demonstration in clinical setting

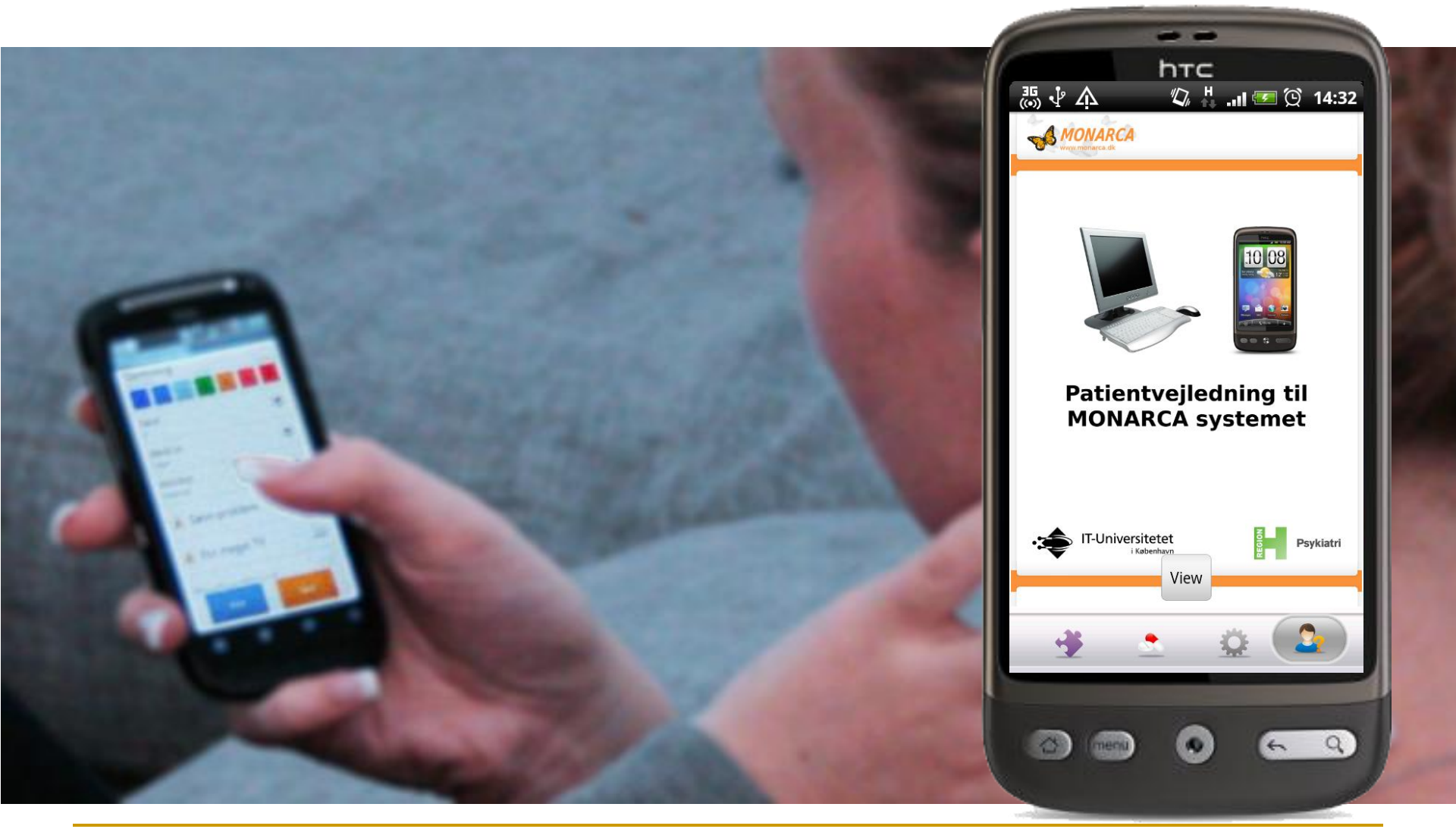
Trials in Copenhagen (Focused on subjective monitoring)

Field trial - In order to gauge the usability and usefulness of the MONARCA self-assessment system, we deployed it in a field trial from May to August 2011, a total of 14 weeks with 12 patients participating. The main objective of this study was to establish the feasibility of the system.

Field Trial of MONARCA 2.0 – Building on experiences from the first trial and the outcome of the trials in Tyrol, we designed, built and tested the version 2.0 of the system with 6 patients for 6 months. The main objective of this study was to establish the feasibility of the system.

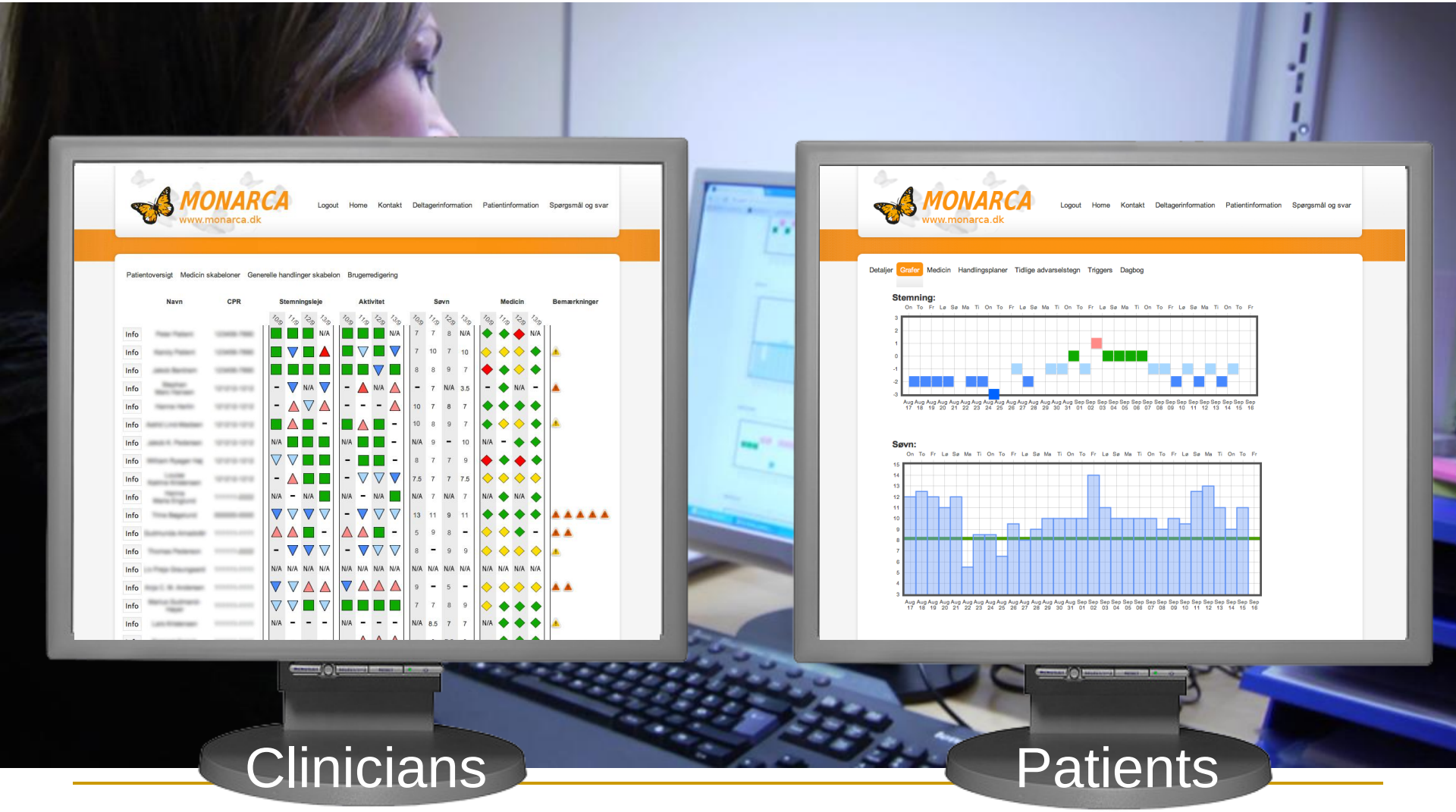
Clinical trial – A double blinded randomized clinical trial started in September 2011 including ~70 patients over a period of 2 years. The patients used the system for 6 months, and the outcome of the trial will be to document the clinical effect.

MONARCA Android app



[Jakob E. Bardram, Mads Frost, Károly Szántó, Gabriela Marcu, "The MONARCA Self-Assessment System – A Persuasive Personal Monitoring System for Bipolar Patients", IHI'12 conference, January 2012, Miami, Florida, US]

Web portal


MONARCA
www.monarca.dk
Logout Home Kontakt Deltagerinformation Patientinformation Spørgsmål og svar
Patientoversigt Medicin skabeloner Generelle handlinger skabelon Brugerredigering
Navn CPR Stemningsleje Aktivitet Søvn Medicin Bemærkninger
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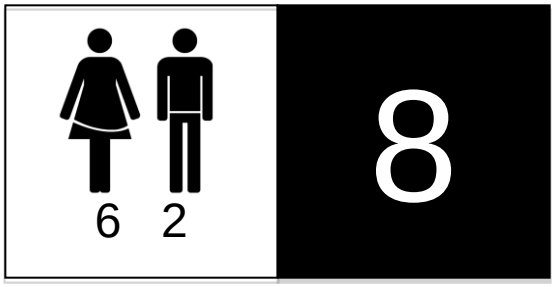
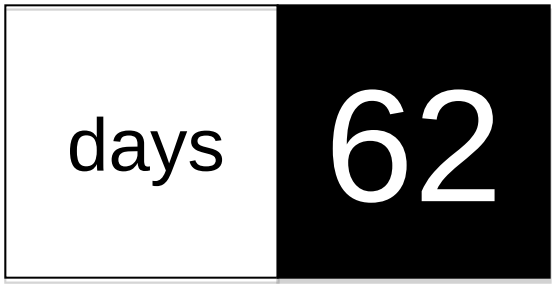
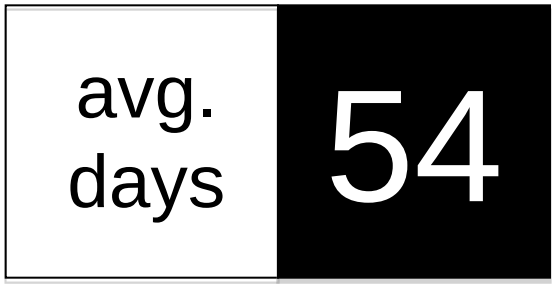
Logout Home Kontakt Deltagerinformation Patientinformation Spørgsmål og svar
Detaljer Grafer Medicin Handlingsplaner Tidlige advarselstegn Triggers Dagbog
Stemning:
Søvn:
Clinicians
Patients

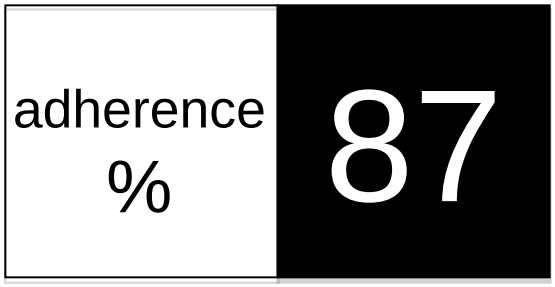
How usable is the system and is it better than existing approaches for self-assessment and data collection?

PAPER BASED SELF-ASSESSMENT





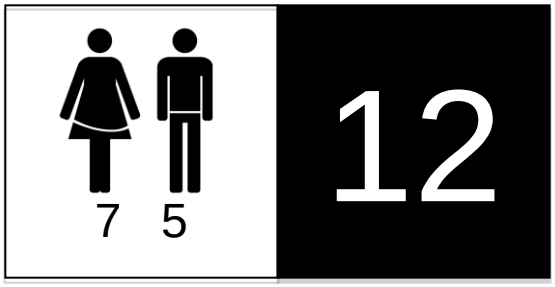




Date

How usable is the system and is it better than existing approaches for self-assessment and data collection?

MONARCA BASED SELF-ASSESSMENT



Paper based 87% = MONARCA system 87%

How usable is the system and is it better than existing approaches for self-assessment and data collection?

MONARCA BASED SELF-ASSESSMENT

12

days 63

avg. days 57

"The paper is more inaccurate – I sometimes put in data for several days at once, because I forget it" [P49]

"I used to fill out the paper for the whole week, just before meeting with my doctor" [P58]

What is the usefulness of the system in term of helping bipolar disorder patients in coping with their disease?

	System usefulness	
	Average	SD
Disease management	3.16	1.55
Self-assessment	2.21	1.06
Triggers	3.59	1.31
Early warning signs	3.44	1.18
Actions to take	3.25	1.52
Visualizations	2.22	1.39
Medication	4.30	1.50
Alarms	2.34	1.44
Website	3.00	1.70
Clinic	4.13	1.63

7-point Likert scale from 'Strongly Agree' (1) to 'Strongly Disagree' (7)

Will this system – if used on a daily basis by bipolar patients – be useful to them in the future?

	System usefulness		Percieved usefulness	
	Average	SD	Average	SD
Disease management	3.16	1.55	2.16	1.02
Self-assessment	2.21	1.06	1.73	0.72
Triggers	3.59	1.31	2.71	1.02
Early warning signs	3.44	1.18	2.36	0.78
Actions to take	3.25	1.52	2.34	0.88
Visualizations	2.22	1.39	1.66	0.78
Medication	4.30	1.50	3.17	1.51
Alarms	2.34	1.44	2.13	1.88
Website	3.00	1.70	2.63	1.76
Clinic	4.13	1.63	2.67	1.06

7-point Likert scale from 'Strongly Agree' (1) to 'Strongly Disagree' (7)

Filed trial conclusions

Study aspects:

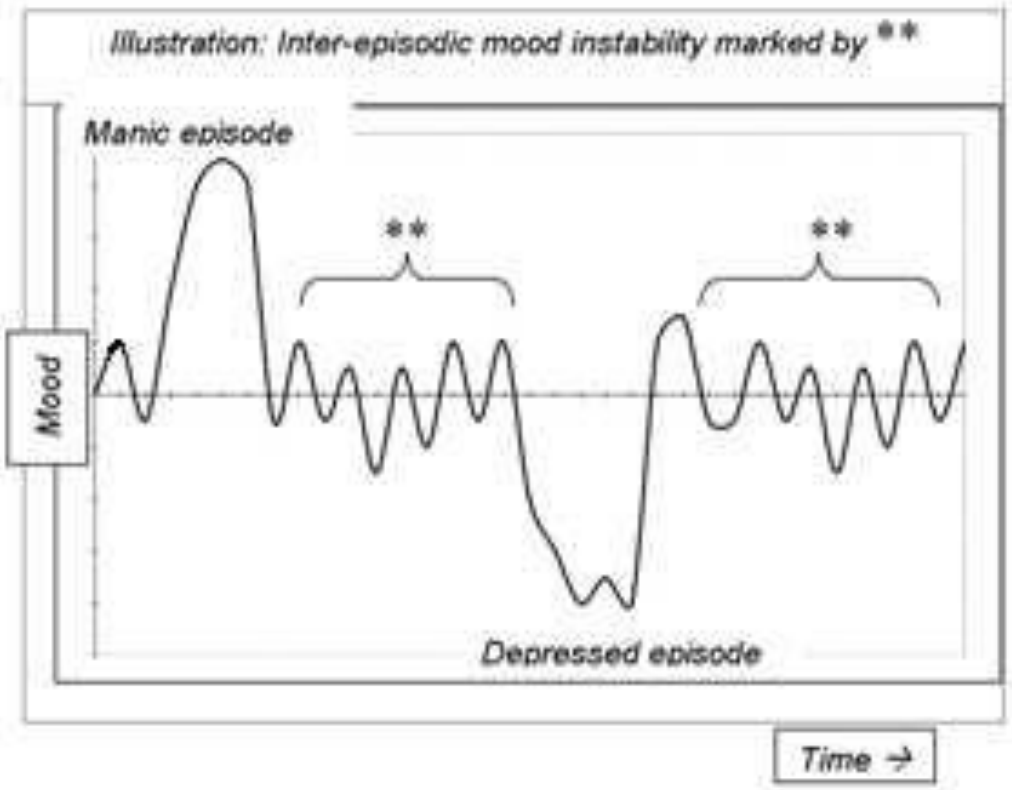
- Adaptation
- Comparison to paper based self-assessment
- Usability
- Usefulness

Results were positive:

- Adherence improved
- System considered easy to use
- High perceived usefulness

Randomize Clinical Trial
Scientific switch in paradigm

- from episode to inter-episodic mood instability



Parameters

- Subjective parameters:
  - Mood (-3 to +3)
  - Medication intake (adherance)
  - Activity (-3 to +3)
  - Mixed mood (yes/no)
  - Irritability (yes/no)
  - Cognitive impairment (yes/no)
  - Stress (0 to 5)
  - Alcohol intake
- Objective parameters;
  - Number of calls and speech duration per 24 hours
  - Number of SMS messages sent per 24 hours

Randomized controlled trial

- 78 outpatients suffering from bipolar disorder recruited from The Copenhagen Mood Disorder Clinic

- Randomization (1:1)
  - Using the active mobile phone program (intervention group)
  - Using a mobile phone to communicate with other patients (control group)

All randomized patients will receive a (android) mobile phone during the study period.

Randomized controlled trial

Blinded

- A study nurse is unblinded as has the daily overview of MONARCA data and feedback to patients/relatives in an interaction with medical doctors
- Researchers are blinded to intervention

Study period per patient: 6 months

Every month during the study period:

- HAMD-17 (depression score)
- YRMS (mania score)
- Psychosocial functioning
- Quality of life (WHOQOL)
- Cognitive function
- Blood samples (serum levels of mood stabilizers- adherence)

Randomized controlled trial

Primary outcomes:

- Difference in HAMD-17(depression score) and YRMS (mania score) scores during the entire 6 months study period between the intervention and the control group (area under the curve)

Secondary outcomes:

- Difference in social functioning, quality of life, cognitive function

Tertiary outcomes:

- Difference in adherence to medication according to serum levels of mood stabilizers

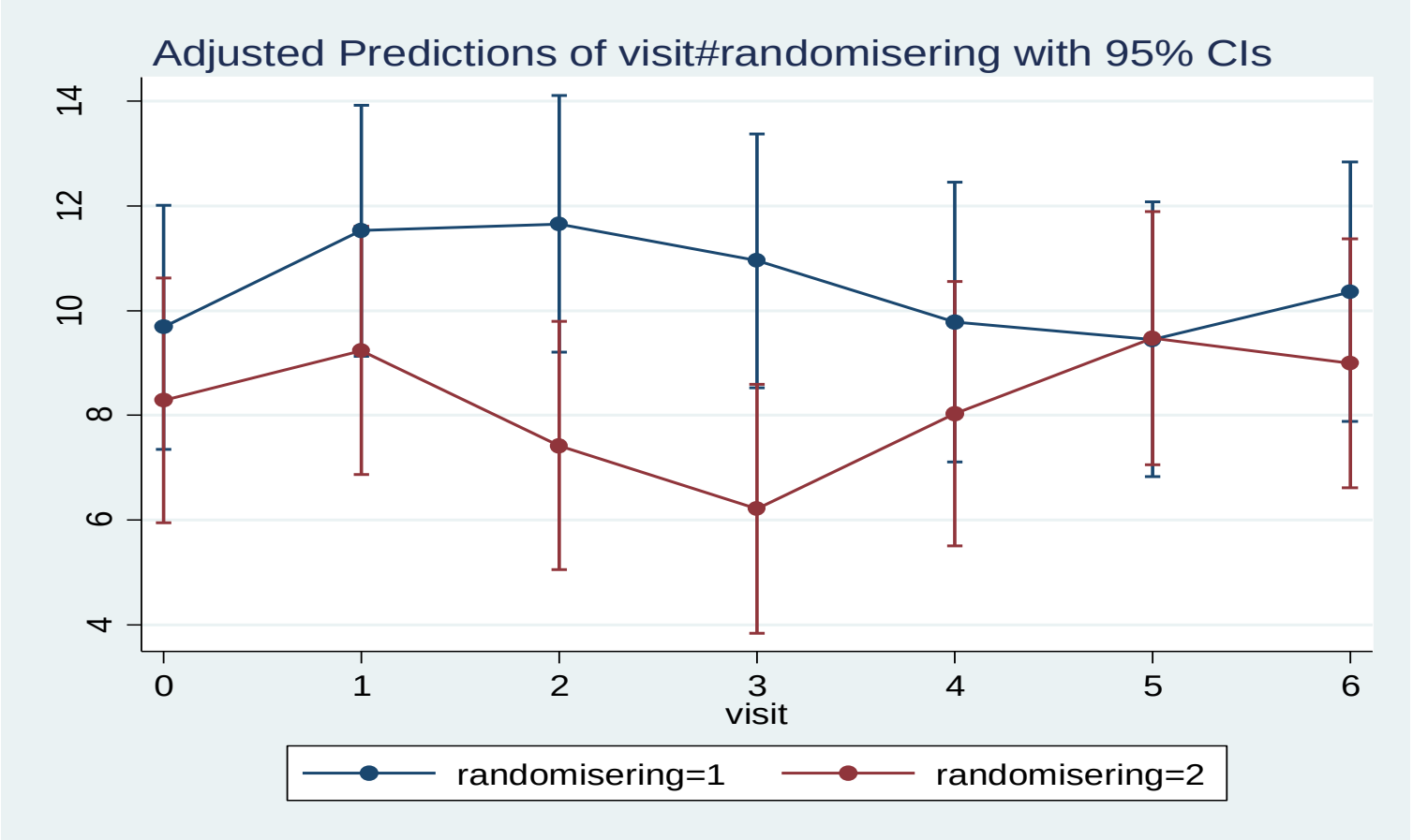
Randomized controlled trial

Status September 2013

- 78 patients included, 70 randomized
- Low drop out rate during 6 months follow-up (< 5%)
- High appeal to patients, relatives and clinicians
- Facilitate concordance between patients, relatives and clinicians

Randomized controlled trial

- Preliminary results:

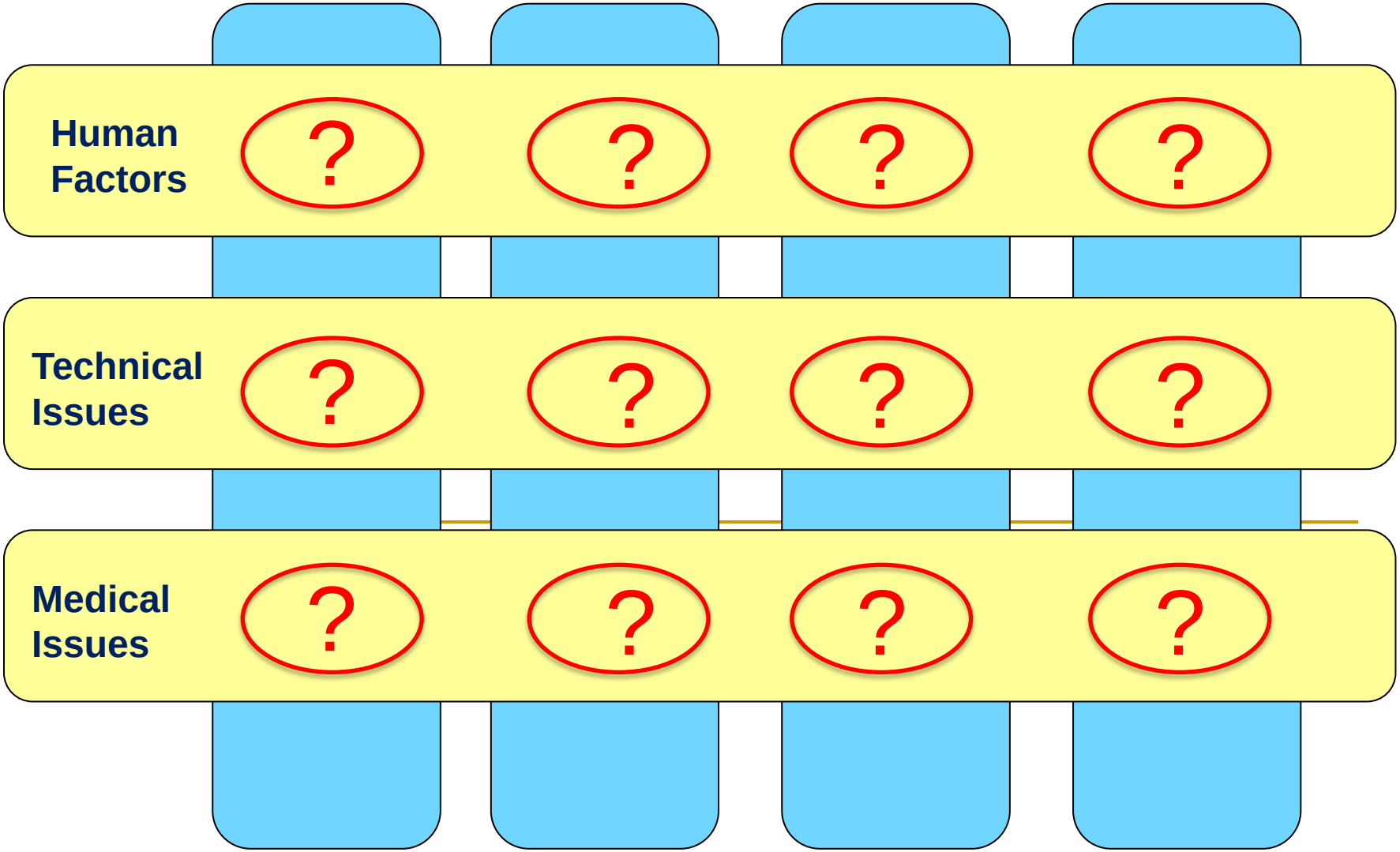


Monarca Lessons learnt and future

If anything can go wrong….

…….is likely that will go wrong!

Several Risks handling Multidisciplinary Clinical Research



Relevant Practical Factors

- Human Factors in Mental Health Research
  - Exposure to Unstable Patients
  - Functional vs non-functional
  - Trust and Transparency
  - Usability and Acceptance in Real Life Conditions

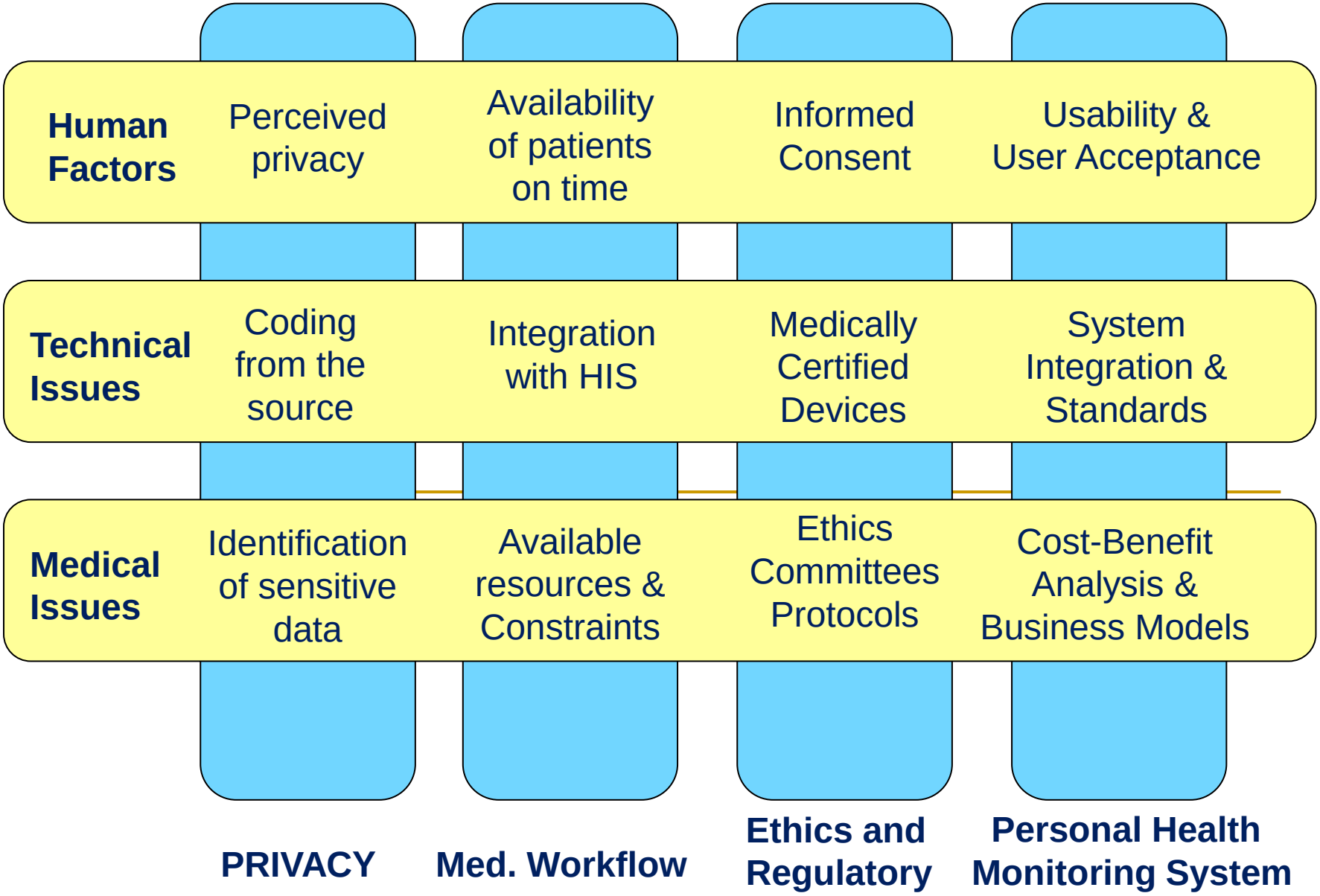
Relevant Practical Factors

- Technological Challenges
  - Need to Technically Obscuring Sensitive Data
  - Flexible Strategies for Data Transmission
  - Software Stability and OS Versions
  - Devices Performance Limitations
  - Physiological Monitoring Constraints
  - Integration Issues

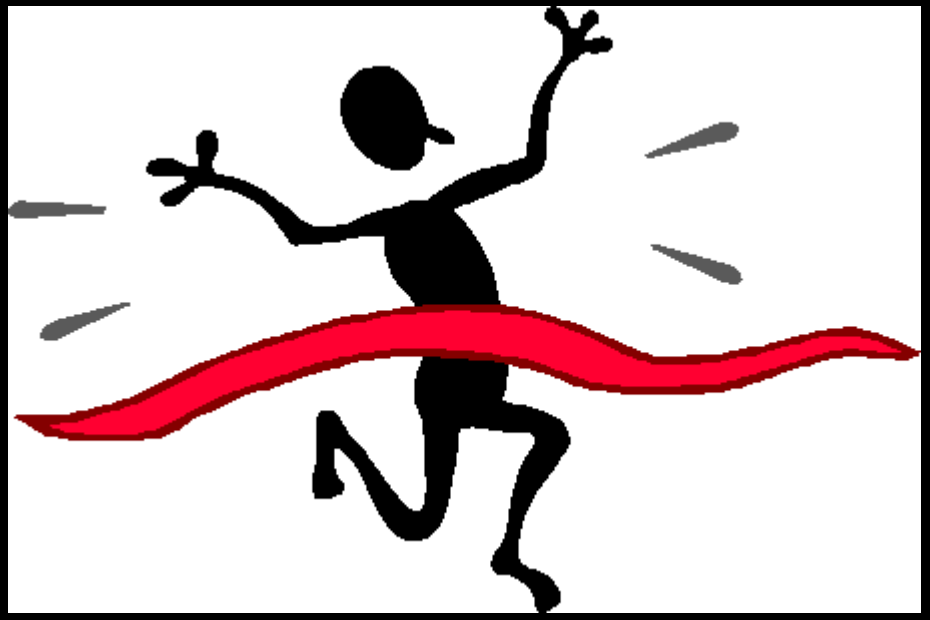
Relevant Practical Factors

- Ethics, Regulatory and Integration in Medical Workflow
  - Ethics
  - Regulations
  - Integration in Medical Workflow
  - Medical Trials

Several Risks handling Multidisciplinary Clinical Research



Conclusions

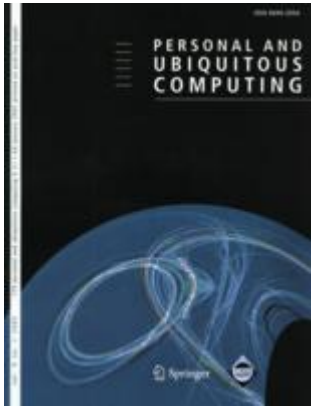


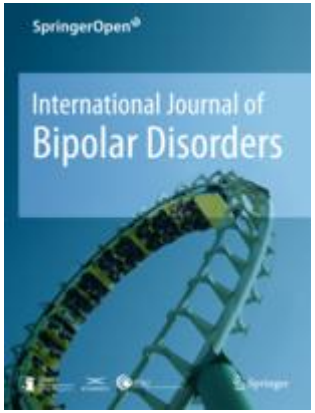
MONARCA Main Achievements

- Involvement of near 120 patients overall in diffferent phases of the project including system design and trials implementation
- Development of a flexible platform adaptable to different requirements
- Integration of MONARCA in real-life clinical environment with high adherence from patients
- Use of multiparametric heterogeneous sensors generating objective data from everyday activities and from devices used on daily life (mobile phone)

Dissemination Activity in a Snapshot

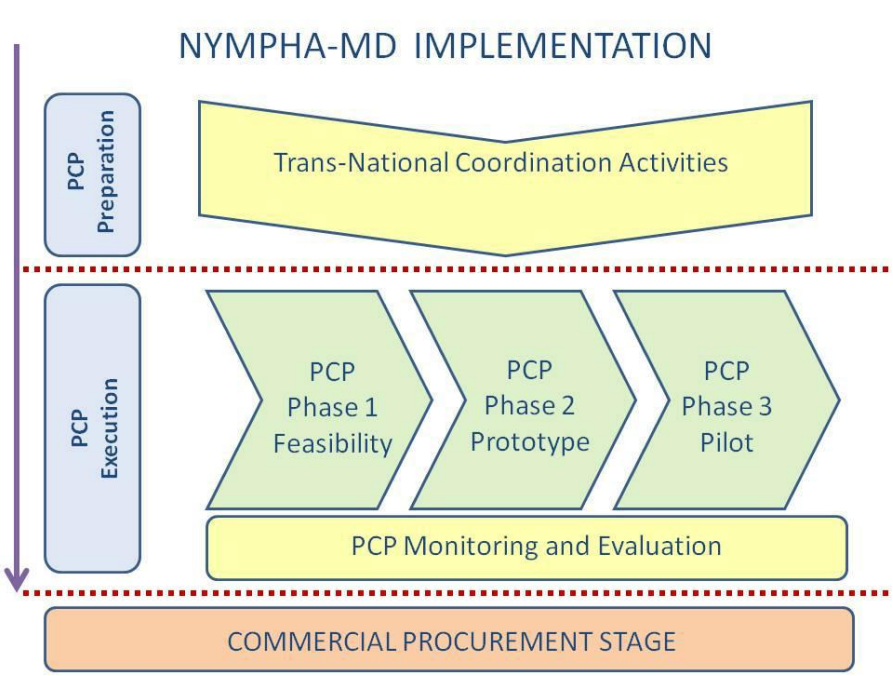
- Production and presentation of over thirty Scientific papers in Conferences and Workshops
- over Ten invited presentations in technical/clinical events
- Production of over Ten Journal papers (target=6, several papers upcoming)

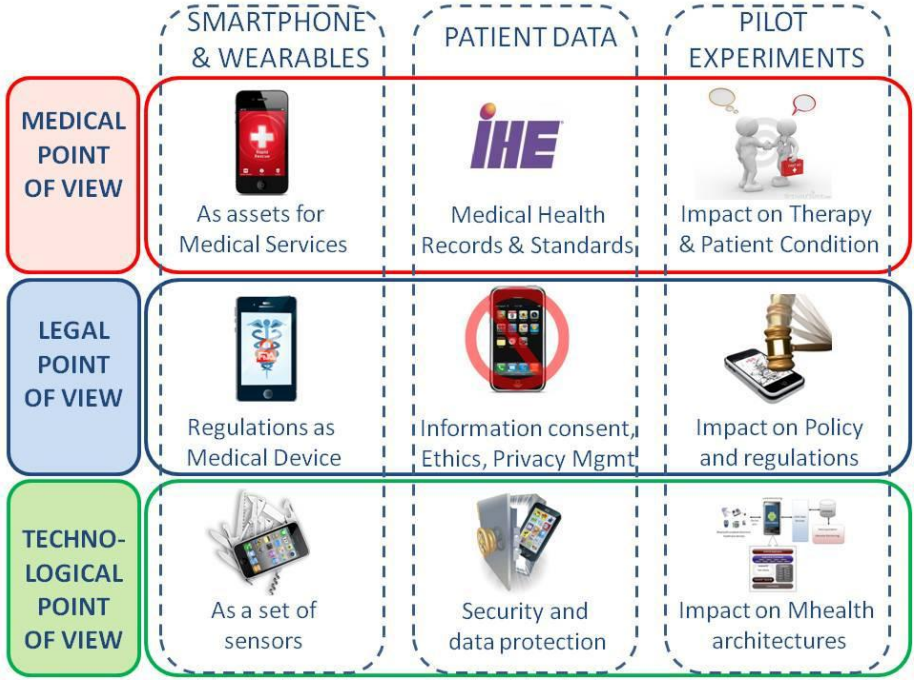




MONARCA Exploitation into PCP

NYMPHA-MD -- Next generation Mobile Platforms for HeAlth, in Mental Disorders.





MONARCA Project

Thank You!

Oscar Mayora – Project Coordinator

CREATE-NET

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