

# Adaptive Internet Delivered Psychological Treatment Systems for Mental Health Problems



Suresh Kumar Mukhiya  
✉ skmu@hvl.no

**Supervisors:**

Prof. Yngve Lamo & Assoc. Prof. Violet Ka I Pun & Assoc. Prof. Fazle Rabbi

January 14, 2020

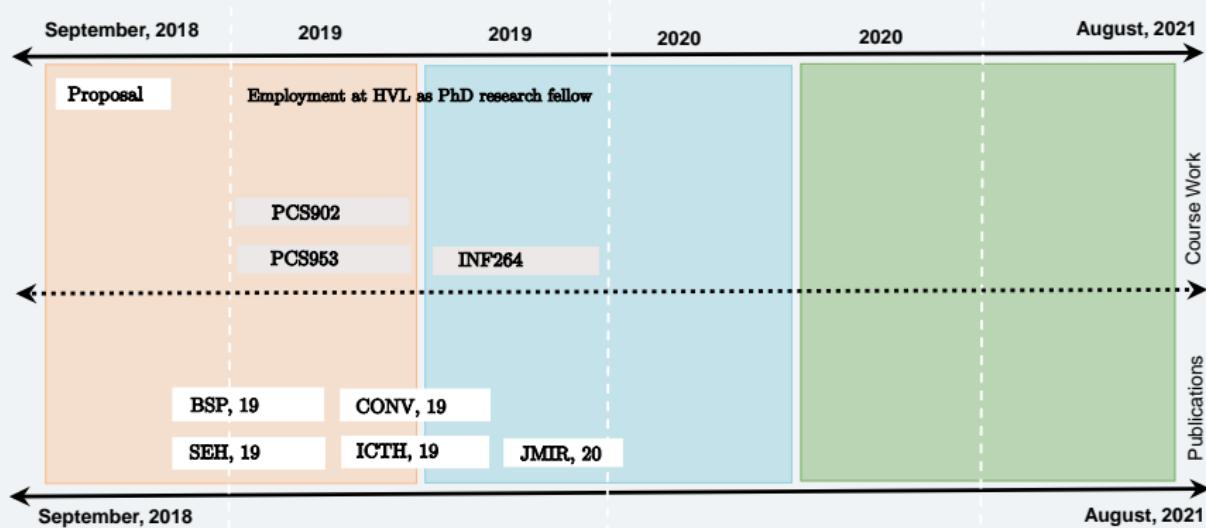
# Agenda

- 1 Introduction
- 2 Internet Delivered Psychological Treatments: approaches, tools
- 3 Research Questions
- 4 Artifacts developed
- 5 Publication
- 6 Future Plans

# Meta Information

- Associated with INTROMAT project.
- Assigned to Work package 3: modular and flexible ICT infrastructure with corresponding tools and supports for core clinical process.
- Three years *Ph.D.*
- Started last year in 1<sup>st</sup> September, 2018.
- Ends in 30<sup>th</sup> August 2021.

# Overall progress



Subject code	Subject title	Institution	Planned semester	Credits	Status
PCS953	Model Driven Software Engineering	HVL	2019 Spring	10	Completed
PCS902	Research Methodology, Ethics and Scientific Work Practice	HVL	2019 Spring	5	Completed
INF264	Introduction to Machine Learning	UIB	2019 Fall	10	Completed

5 ECTS based on PhD schools and presentations: Planned for next semester

## Problem Definition - Current statistics

1/4 people in the world will be affected by mental or neurological disorders at some point in their lives. 450 million people are suffering from mental or neurological disorders around the world. [1]

## Problem Definition - Current statistics

1/4 people in the world will be affected by mental or neurological disorders at some point in their lives. 450 million people are suffering from mental or neurological disorders around the world. [1]

Based on EU Green Papers 1/4 citizens is affected by mental health problems at some point during their lives and has often led to suicide [2, 3].

## Problem Definition - Current statistics

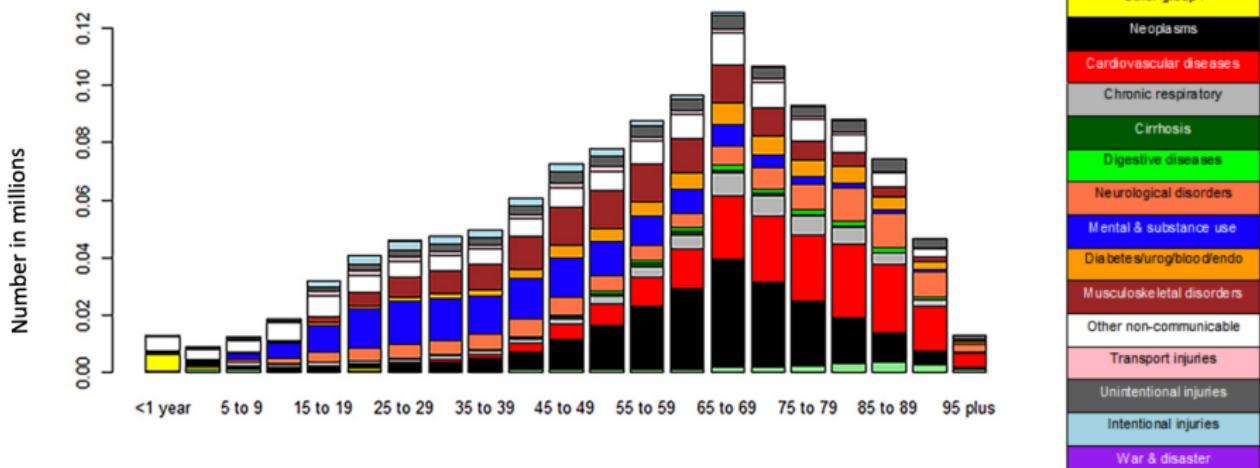
1/4 people in the world will be affected by mental or neurological disorders at some point in their lives. 450 million people are suffering from mental or neurological disorders around the world. [1]

Based on EU Green Papers 1/4 citizens is affected by mental health problems at some point during their lives and has often led to suicide [2, 3].

About half of the Norwegian population may have experience of mental health problems during their life, and about one-third during one year [4].

# Problem Definition - Burden of disease in Norway

The burden of disease in Norway. The number of years in different age groups in the population. Source: GBD2016 – healthdata.org.



# Problem Definition - Suicide in Norway



- Every year, between 550 and 600 deaths are suicides. Two in three suicides are men.
- It is a common assumption that there are ten times more attempted suicides than actual suicides.
- Mental disorders, including substance use disorders, are regarded as the leading risk factors for suicide, with comorbidities producing a particularly elevated risk

## Problem Definition - Future predictions

Depression is expected to run as the leading cause of the burden of disease both at an individual and at societal level in high-income countries by 2030 [5].

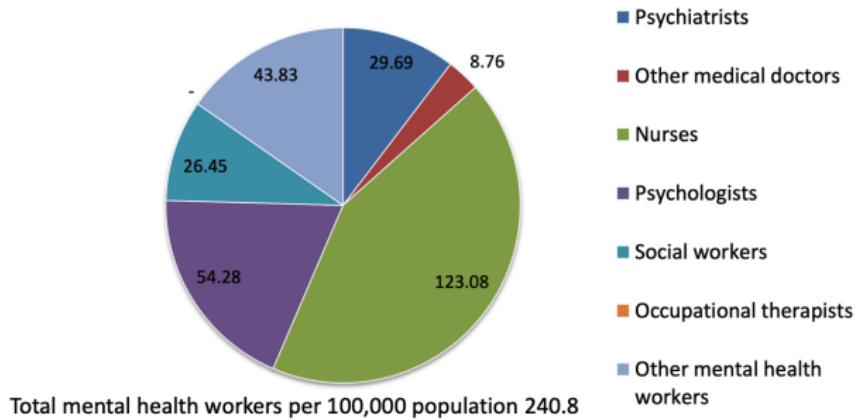
Source: Projections of global mortality and burden of disease from 2002 to 2030, Colin D. Mathers

## Problem Definition - Lack of resources

- According to WHO [1], Less than half of those affected in the world receive such procedures due to long waiting lists, high treatment costs and social stigma [6] associated with the mental disorder.
- Depression can lead to suicide, and close to 800 000 people die due to suicide every year [1].

# Problem Definition - Lack of resources - Norway

## Mental health workforce (rate per 100,000 population) in Norway



[Source: World Health Organization]

# Important question

How can we address the issues of growing mental health disorder and provide healthcare facilities to far-reaching population?

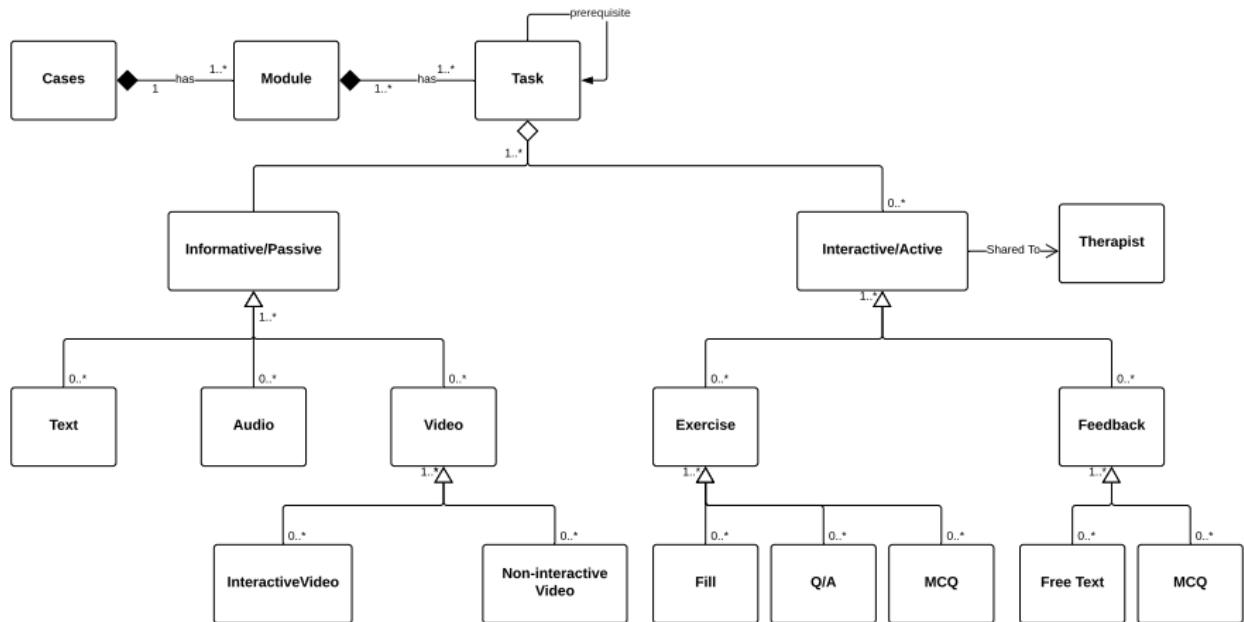
## Possible solution - Use ICT



# What is IDPT?

- Internet Delivered Psychological Treatments
- Developed in 1960s [7] and most commonly practiced and extensively researched forms of psychotherapy [8].
- Any form of treatments/therapy delivered through Internet.
- Usually involves web-applications, mobile based or the use of Augmented/Virtual reality environment.

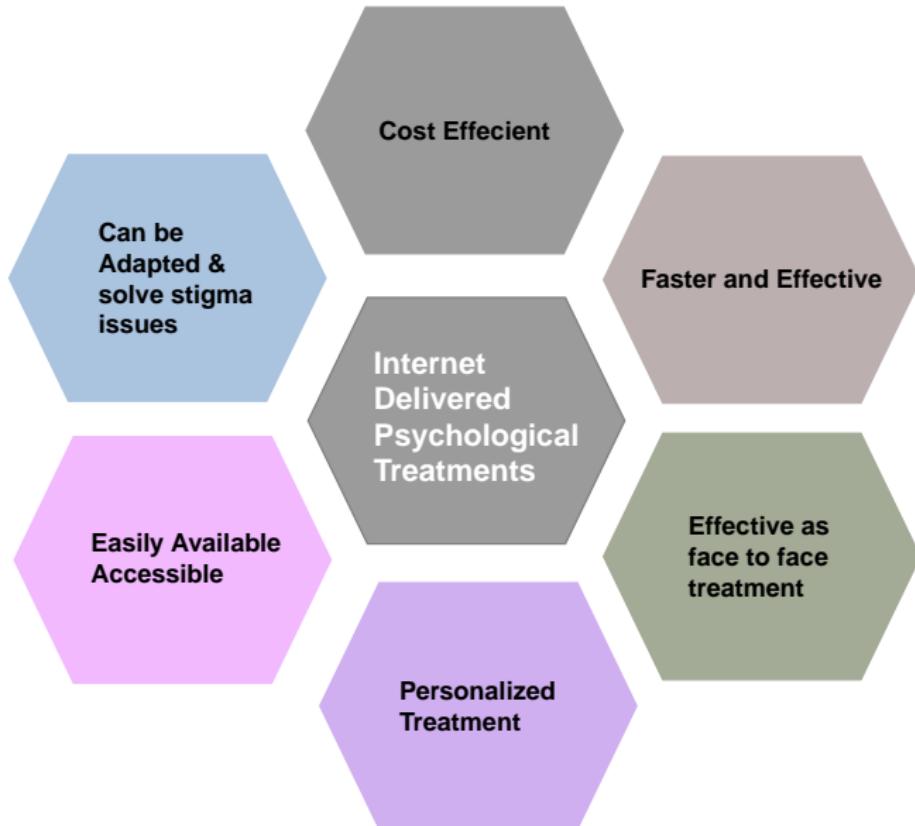
# Components of IDPT



# Components - ADHD case in INTROMAT

- **Case:** ADHD
- **Modules:** 7 Modules
  - ① Start - introduction, symptom description and goal setting
  - ② Breathe - inattention and breathing exercises
  - ③ Stop - awareness and stop exercise
  - ④ Emotions - description and characteristics of the basic emotions, emotion regulation techniques
  - ⑤ Problem solving - identifying problematic behavior and changing this
  - ⑥ Planning and organization - using a calendar to plan, to do lists, dividing tasks into subtasks, energy budgeting
  - ⑦ Acceptance - self acceptance and self care exercises
- **Tasks:**
  - ① Reading/Listening/Watching
  - ② Setting personal goal
  - ③ Self assessment through psychometric test (ASRS V1.1)
  - ④ Feedback after exercise.

# Why Internet Delivered Psychological Treatments?



# Several issues with Current IDPT systems 1/4

- **P1: User adherence** to such interventions are low i.e. higher dropout rates. *how can these IDPT be effective if the user adherence is sub-optimal?* Common causes of dropouts:
  - ① Sufficient progress.
  - ② Too much content without much flexibility/adaptive.
  - ③ Treatment being too difficult.
  - ④ Users expectations and trust.
  - ⑤ Lack of therapists feedback.

## Several issues with Current IDPT systems 2/4

- **P1: User adherence** to such interventions are low i.e. higher dropout rates. *how can these IDPT be effective if the user adherence is sub-optimal?*
- **P2: Lack of concrete architecture:** *why is Architecture Centric Development (ACD) important?*

# Why is Architecture Centric Development (ACD)?

## Software Failures

- FBI Virtual Case File System (2000-2005)
  - Replacement for the antique FBI's IT infrastructure
  - Cost: \$389 million - \$500 million
  - Never delivered. Continuous changing requirements. Lost: \$100-\$200 million
- U.S. Air Traffic Control System (1981-1994)
  - Never delivered. \$2.6 billion spent. Cumulative cost for U.S. airlines: \$50 billion
- London Stock Exchange (1986-1993)
  - Never delivered. Cost: \$600 million.
- Ariane 5 (1996)
  - Arithmetic overflow due to 64-bit to 16-bit conversion

**Only in U.S. yearly cost for failed or troubled software is about \$60-\$70 billion**



3 © 2005 Nokia Tampere Uni 23.10.2007 claudio.riva@nokia.com

Source: Claudio Riva, Principal Scientist, Nokia Research Center

# Why is Architecture Centric Development (ACD)?

## Why Software Fails?

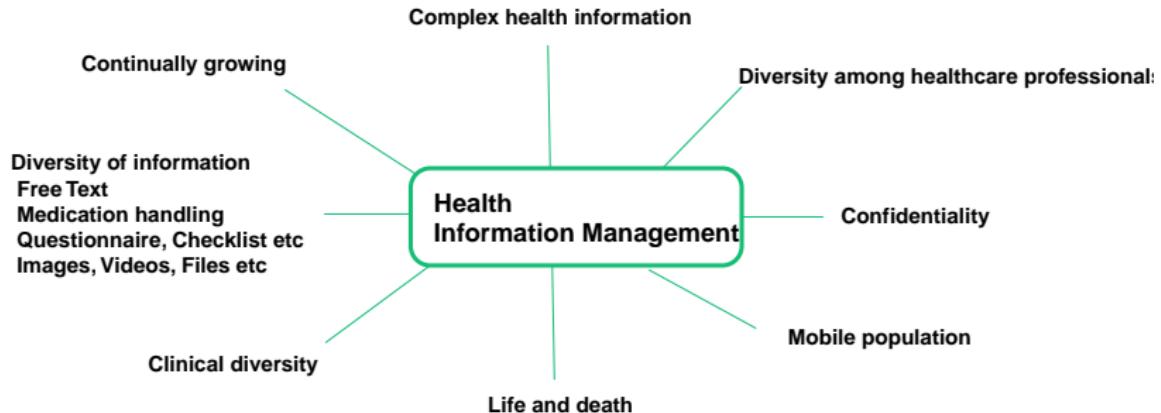
- Unclear and changing requirements
- Slipping deadlines
- Bad estimate of resources
- Misunderstood business needs
- Quality
- System goes out of date when delivered
- Cost and schedule overrun
- Use of immature technology
- Inability to handle the project complexity
- Poor project management
- Pressure because of time-to-market
- Poor communication among customers, developers and users

Software failures are caused by a combination of technical, management, business and human problems

## Several issues with Current IDPT systems 3/4

- **P1: User adherence** to such interventions are low i.e. higher dropout rates. *how can these IDPT be effective if the user adherence is sub-optimal?*
- **P2: Lack of concrete architecture:** *why is Architecture Centric Development (ACD) important?*
- **P3: Health Information Exchange: Interoperability**

# Why is Health Information(HI) management so hard?



*Why do we need to structure these Information?*

- For technical integration
- For information exchange

# Research Questions

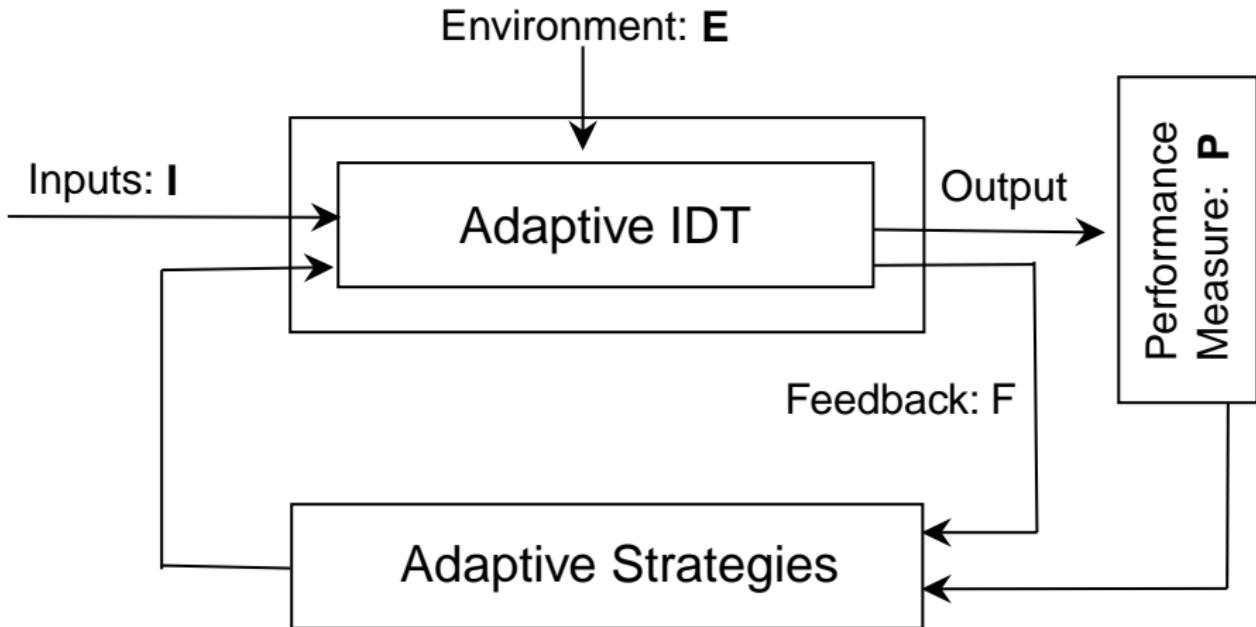
*How can we optimize pervasive Information Architecture chosen in Internet Delivered Psychological Treatment (IDPT) systems for adaptive and personalized treatments of mental health problems?*

# Adaptive Systems 1/2

The formal representation of the adaptive IDPT system constitutes following components:

- a set of E environments in which IDPT is working as a complex process,
- a set of controlled inputs I consumed by IDPT systems for changing the behavior of the process.
- a process to measure performance of the system P indicating performance of the IDPT in environment E when consuming I as input.
- a feedback function F which generates the adaptive strategy with dynamic information about the process being controlled,
- a set of strategies, which uses the knowledge learnt from information and performance of the system.

# Adaptive Systems 2/2



# Why do we need Adaptive IDPT?

## Psychotherapy perspective

Treatments administered to one patient is not the same as that given to another patient exhibiting similar symptoms.

## Software Engineering perspective

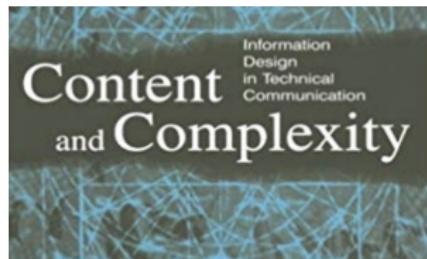
Explosion of information, integration of technology and continuous evolution in the software system. As a result of this continuous evolution, software system must be versatile, flexible, resilient, dependable, robust, energy-efficient, recoverable, configurable, customizable, and self-optimizing by adapting to operational changes contexts

# What can be adapted? 1/3

## Table of Content



## Content Presentation



## Content Complexity

A screenshot of a news website's sidebar. The heading 'YOU MAY ALSO LIKE:' is displayed above three recommended articles. Each article has a small thumbnail image and a brief description:

- Making New Friends on Vacation**  
"Locals know best" says Alex Simmons, lead blogger for TravellNow.com. Find out her secrets and real life tips. A trip to China and Italy yielded a bunch of new friends...
- 10 Road Trip Wonders & Tips**  
Car travel can be long and tiresome. Learn how to beat the boredom and skip the fast food from Martin Smith, sales advisor for RentItV's.com, who has traveled across the United States more than a dozen times since 1999...
- Choosing the Best International Itinerary**  
Picking where to go next, or where to go first can be difficult for both novice and veteran tourists. Sandy Wellington, Director of Customer Travel at D&D Insurance, explains how to make the

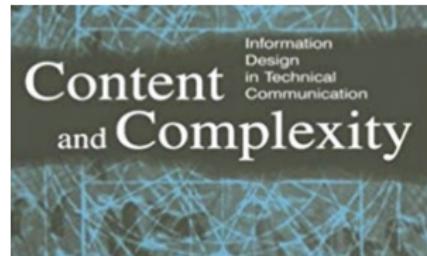
## Recommendation

# What can be adapted? 2/3

## Table of Content



## Content Presentation



## Content Complexity

YOU MAY ALSO LIKE:

- Making New Friends on Vacation**  
"Locals know best" says Alex Simmons, lead blogger for TravelWise.com. Find out her secrets and real-life tips. A trip to China and Italy yielded a bunch of new friends...
- 10 Road Trip Wonders & Tips**  
Car travel can be long and tiresome. Learn how to beat the boredom and skip the fast food from Martin Smith, sales advisor for RentAV.com, who has traveled across the United States more than a dozen times since 1999...
- Choosing the Best International Itinerary**  
Picking where to go next, or where to go first can be difficult for both novice and veteran tourists. Sandy Wellington, Director of Customer Travel at DOD Insurance, explains how to make the

## Recommendation



## Information Architecture



## User interface



## Reports

# What can be adapted? 3/3



Feedback



Notifications/Alerts

- Based on findings from the review paper, the definition of adaptation is confined to personalization of feedback and notifications.

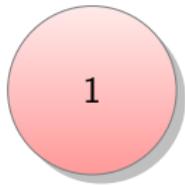
# Information Architecture

Information Architecture (IA) is associated with how people cognitively process information in any Information systems. (*IA, Peter Morville, Louis Rosenfeld, Jorge Arango*).

## Components

- ① Organization systems: (Alphabetical, Chronological, geographical, task-oriented, audience specific, hybrid schema)
- ② Labeling systems: (For example, “contact us” is a label that represent larger chunk of content including contact name, address, phone number, email address and message.)
- ③ Navigation systems: (Global navigation system, local navigation systems, contextual navigation systems, personalized navigation)

# Types of IA in current IDPT



# Types of IA in current IDPT

1

Tunnel Design : Like TV series

# Types of IA in current IDPT

1

Tunnel Design : Like TV series

2

# Types of IA in current IDPT

1

Tunnel Design : Like TV series

2

Matrix Design :  
Government websites

# Types of IA in current IDPT

1

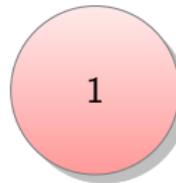
Tunnel Design : Like TV series

2

Matrix Design :  
Government websites

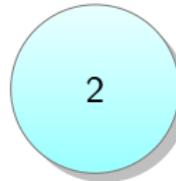
3

# Types of IA in current IDPT



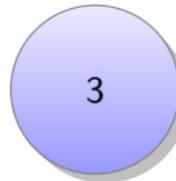
1

Tunnel Design : Like TV series



2

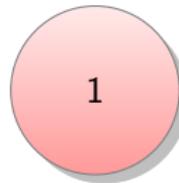
Matrix Design :  
Government websites



3

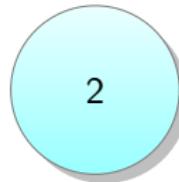
Hierarchical Design :  
Top down approaches

# Types of IA in current IDPT



1

Tunnel Design : Like TV series



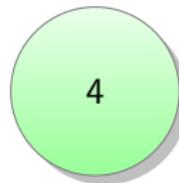
2

Matrix Design :  
Government websites



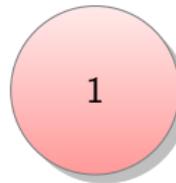
3

Hierarchical Design :  
Top down approaches



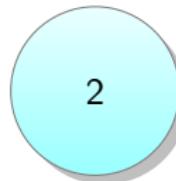
4

# Types of IA in current IDPT



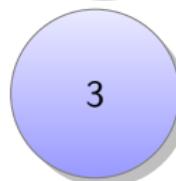
1

Tunnel Design : Like TV series



2

Matrix Design :  
Government websites



3

Hierarchical Design :  
Top down approaches



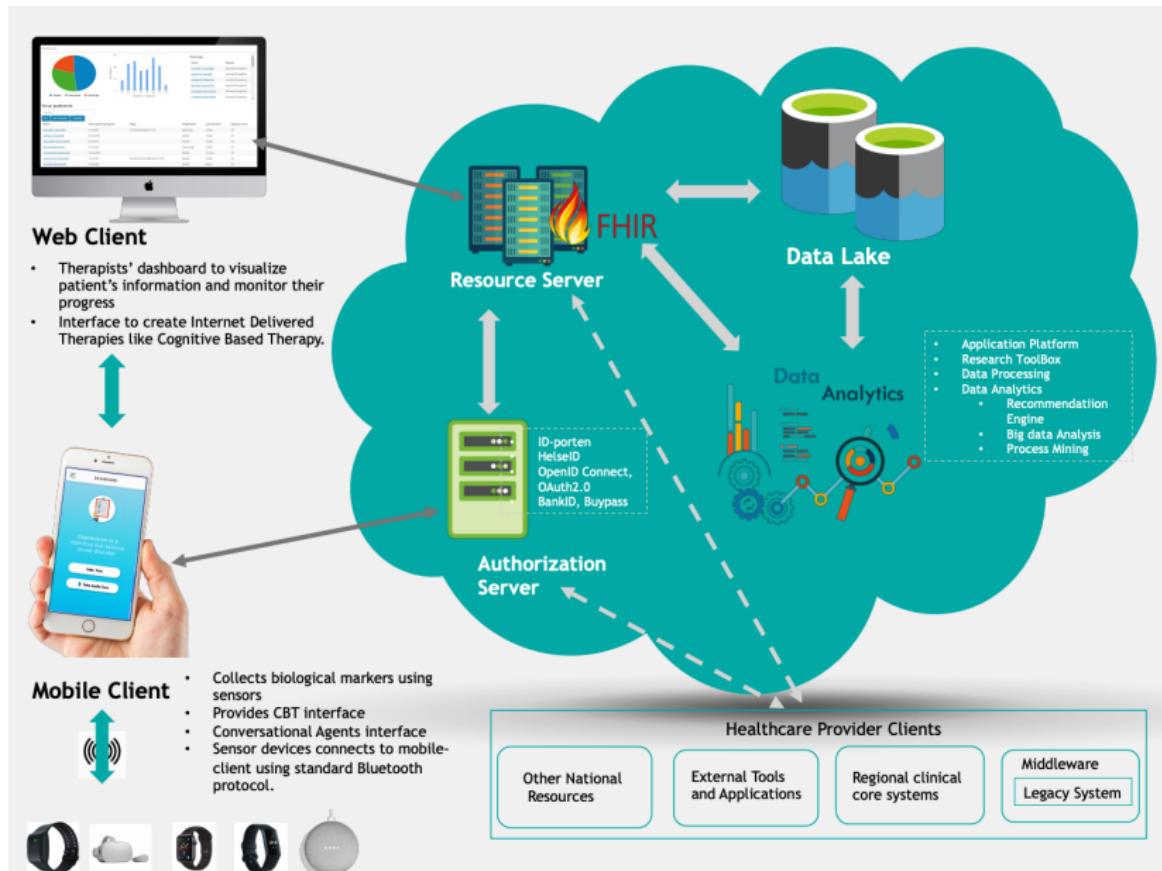
4

Hybrid Design

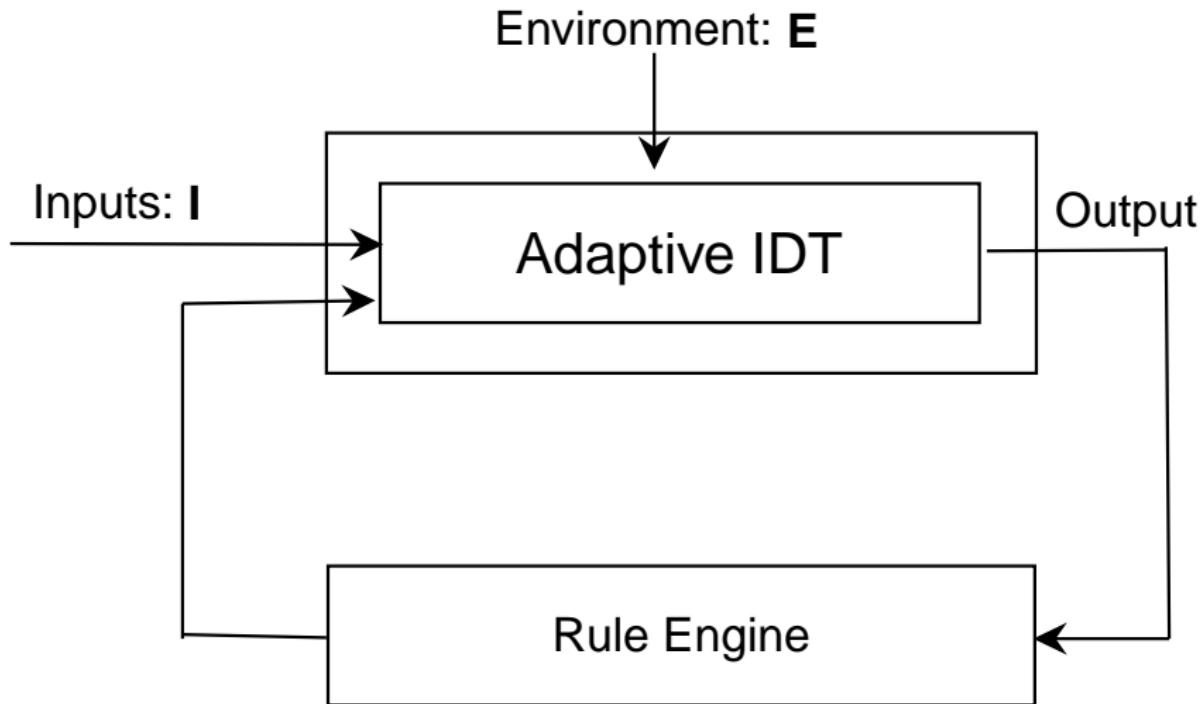
# Types of IA in current IDPT

- 
- The diagram illustrates four distinct types of Information Architecture (IA) designs, each represented by a numbered circle and a corresponding text box:
- 1** Tunnel Design : Like TV series
  - 2** Matrix Design : Government websites
  - 3** Hierarchical Design : Top down approaches
  - 4** Hybrid Design

# ACD- Proposed architecture



## Strategies for adaptation: Rule Based adaptation



# Rule Based Example: Anxiety - 2D adaptation - role

Select Psychometric Score

GAD (GAD7.)



Conditions

Equals to ( = )



Select Value

21

AND

User Activity

Last logged in



Conditions

Equals to ( = )



Select Value in Hour

72 hours ago

OR

Goals

User goal



Conditions

Equals to ( = )



Select goal

decrease anxiety

THEN

Create Alert

Email



Select Role

Therapist



Select Email Templater

Template Alert The.



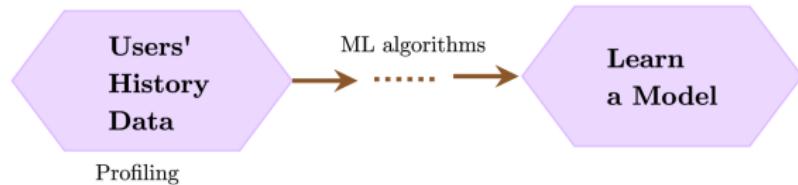
## Strategies for adaptation: Goal driven adaptation

- Two types of goals are managed - *patient goals, therapists or providers goals.*
- Goal driven adaptation involves *goal management, change management and control.*
- System changes the behavior of the system to maximize goal achievement.

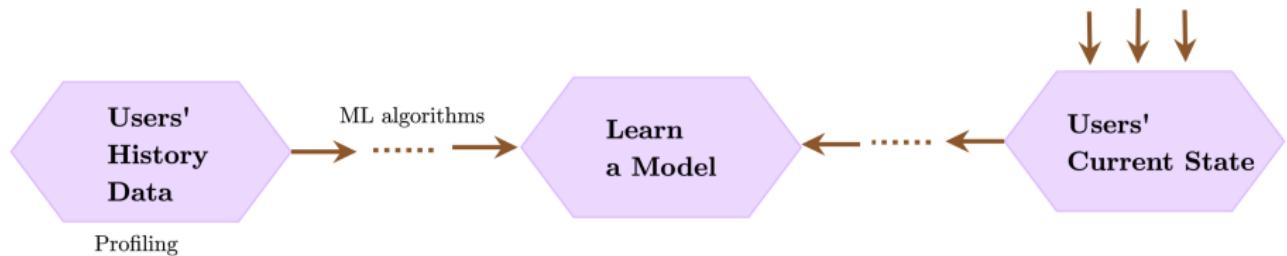
# Adaptation through predictive algorithms



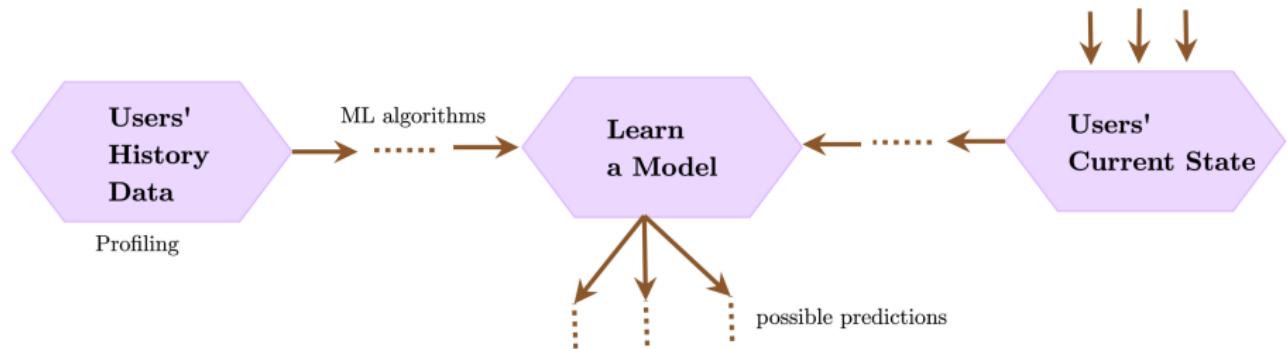
# Adaptation through predictive algorithms



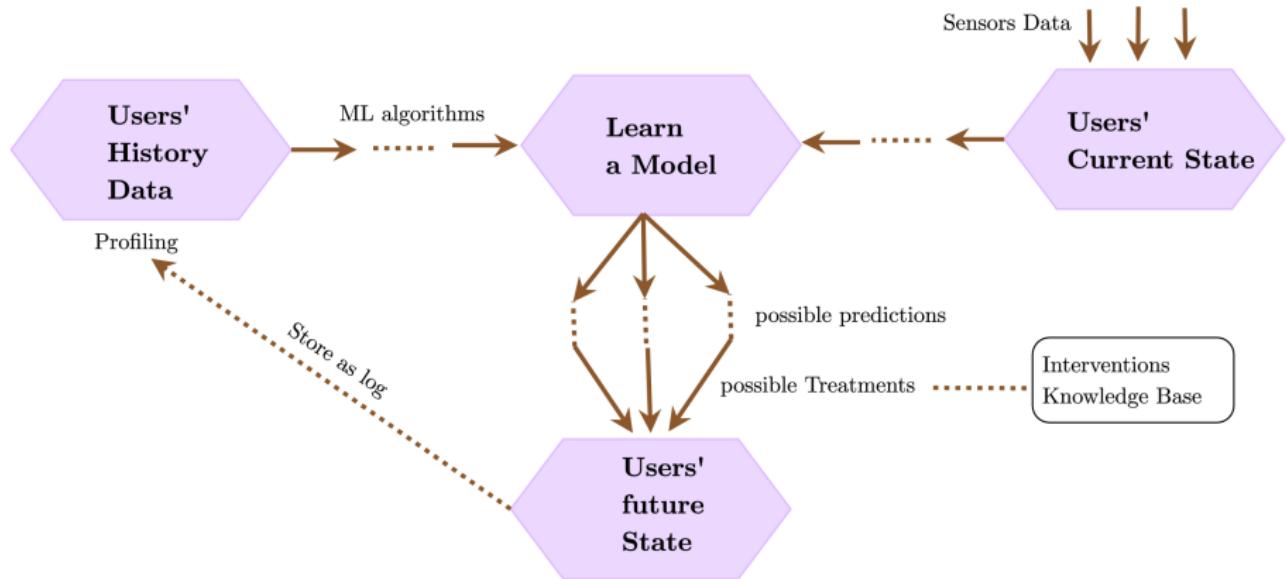
# Adaptation through predictive algorithms



# Adaptation through predictive algorithms



# Adaptation through predictive algorithms



# Revisiting Research Questions 1/3

RQ1: What are the state-of-the-art works done in creating adaptive IDPT?

- 1.1: What are the main choices of Information Architecture (IA) in IDPT? What are the main rationales behind choosing such IA? Does the choice of pervasive IA affect user adherence? Publication 5
- 1.2: What are the primary adaptive elements used in the architecture of the state-of-the-art IDPT systems? How do these adaptive elements contribute to enhancing user adherence and intervention outcomes? Publication 5
- 1.3: What are the main adaptive strategies used in state-of-art IDPT? Can these adaptive strategies increase the outcome of mental health interventions? What are the main dimensions of adaptive strategies used in IDPT systems?

Publication 5 Semester 4: Discussion paper

RQ2: **How can we utilize software engineering techniques to improve the architecture of adaptive IDPT?**

2.1: How can we utilize the MDSE technique to build a conceptual framework for adaptive IDPT?

Publication 1 Semester 4/5

2.2: Can we use Artificial Intelligence-based predictive algorithms to perform automated adaption on IDPT systems? What type of AI-based adaptive strategies can be used for IDPT systems?

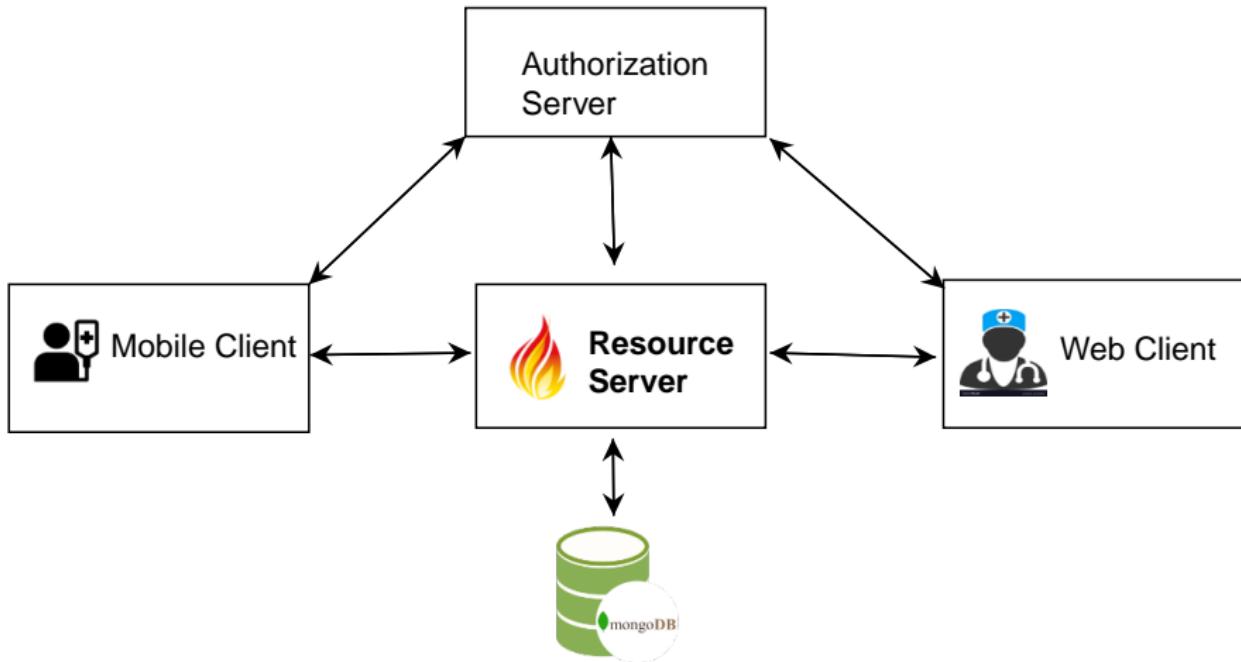
Publication 3

Semester 4/5

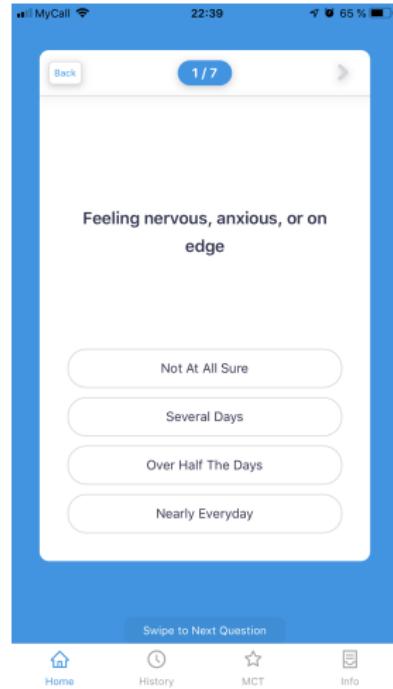
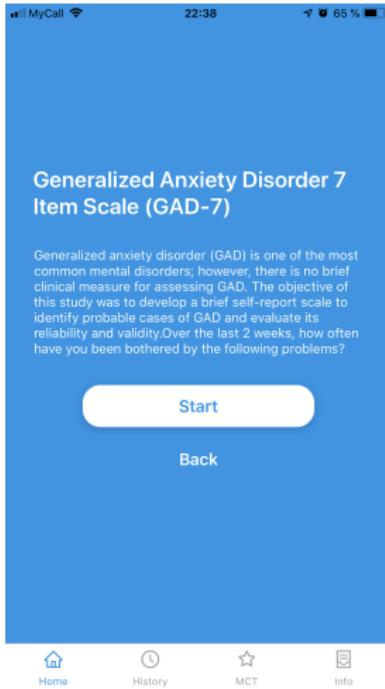
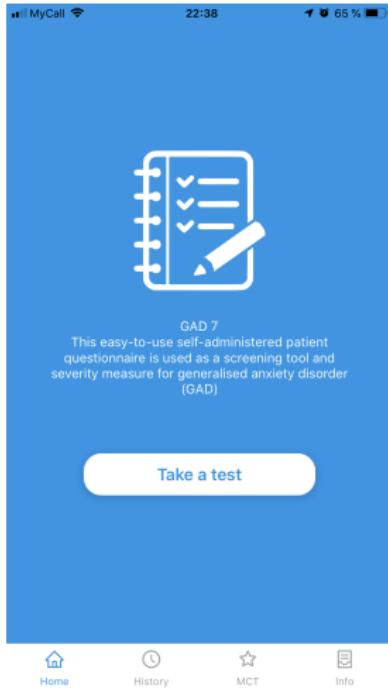
## RQ3: How can we evaluate IA of IDPT systems?

- 3.1: How can we use Design Science Research (DSR) principles for evaluating the developed architecture with respect to ISO/IEC 25000:2014 software quality evaluation metrics [9]? Publication 1, 2, 4
- 3.2: How can we use the adaptive IDPT systems in a clinical setup? How can we exploit these adaptive strategies in IDPT systems to enhance user adherence and treatment outcome? Publication 4 Semester 4/5

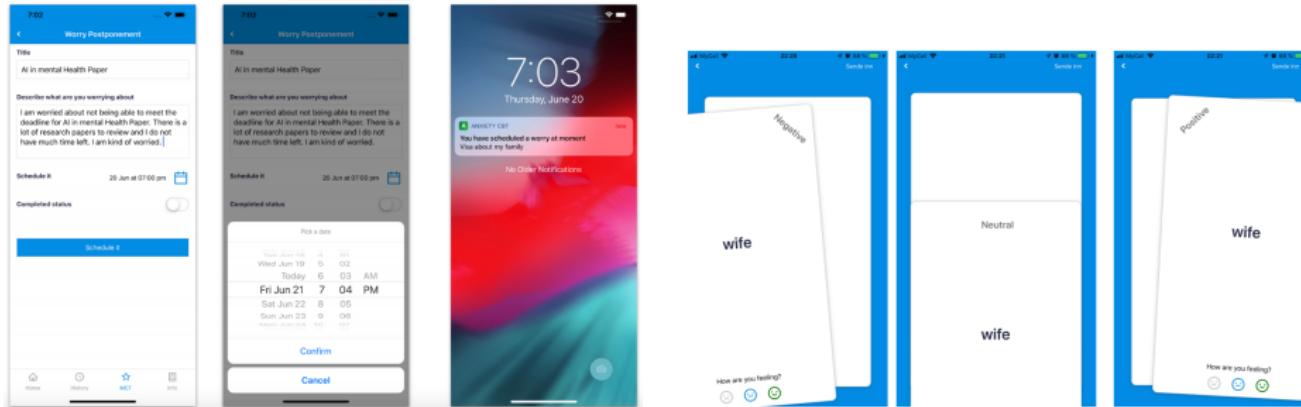
# Prototypes/Artifacts developed 1/3



# Prototypes/Artifacts developed: Self Assessment App 2/3



# Prototypes/Artifacts developed: Worry Tool for GAD 3/3



- ① **Self-assessment:** GAD-7 is available for self-assessment once a week.
- ② **Worry Postponement:** Take control of when you worry and what you worry about.
- ③ **Implicit Association Test:** Detect the strength of a person's subconscious association between mental representations of objects in memory.

# Can I get access to these prototypes?

sureshHARDIYA / phd-resources

Code Issues 4 Pull requests Actions Projects Wiki Security Insights Settings

Internet Delivered Treatment using Adaptive Technology <https://skmukhiya.netlify.com>

70 commits 1 branch 0 packages 0 releases 1 contributor

Create new file Upload files Find file Clone or download

Latest commit 12 days ago

File	Commit Message	Time Ago
Data	Add embase dataset	12 days ago
Papers	AI in mental health paper	4 months ago
Posters/Workshop at HRI	Best Poster Award 2019	6 months ago
presentations	Update meta data	last month
.gitignore	Update meta data	last month
README.md	Update paper	last month
README.md		

- ① <https://github.com/sureshHARDIYA/phd-resources>
- ② <https://github.com/sureshHARDIYA/intromat-fhir/>
- ③ <https://github.com/sureshHARDIYA/graphql-auth-server>

# Publications

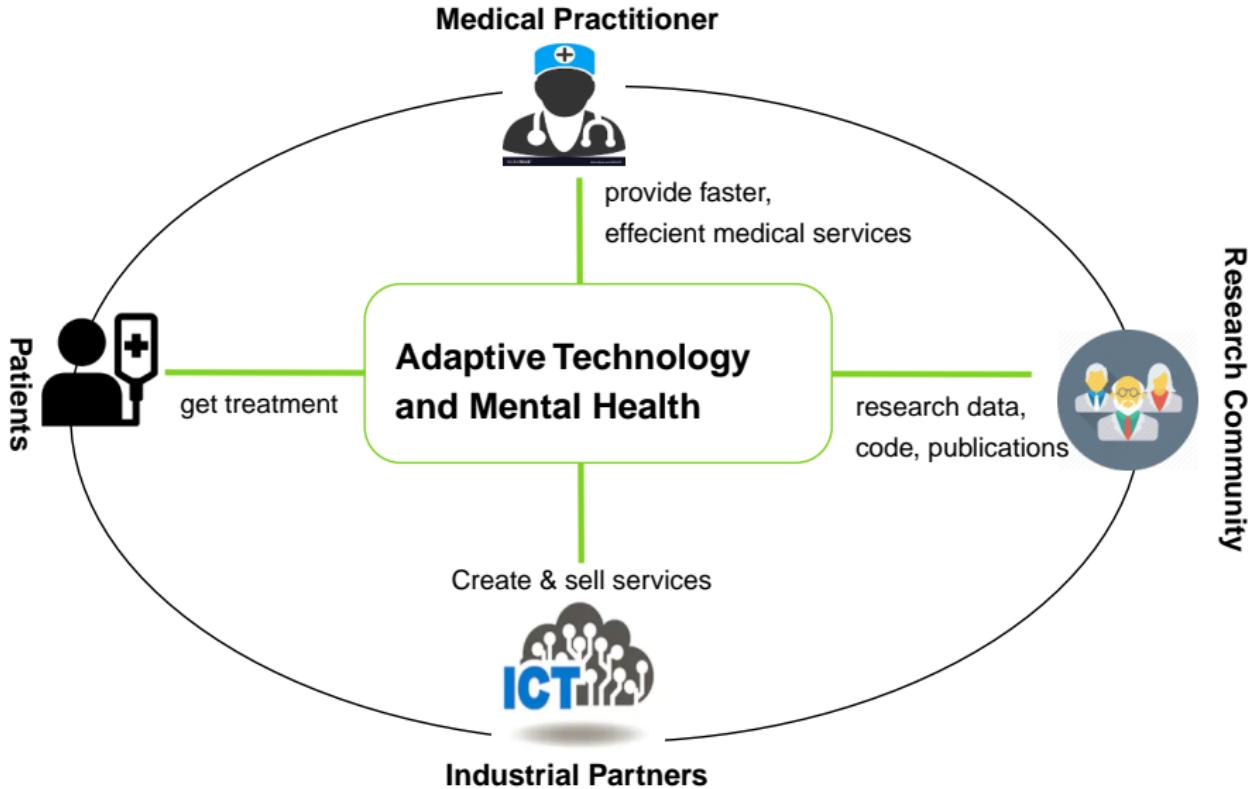
- ① Mukhiya, S., Rabbi, F., Pun, K. & Lamo, Y. *An Architectural Design for Self-reporting e-Health Systems.* (IEEE Press, 2019), url = <https://doi.org/10.1109/SEH.2019.00008>, doi = 10.1109/SEH.2019.00008)
- ② Mukhiya, S., Rabbi, F., Pun, K., Rutle, A., & Lamo, Y. *A GraphQL approach to Healthcare Information Exchange with HL7 FHIR.* (Proceedings published by Elsevier Science, 2019)
- ③ Mukhiya, S., Aminifar, A., Rabbi, F., Pun, K., & Lamo, Y. *Artificial Intelligence in Mental Health* (Frontiers in Artificial Intelligence: Models, Algorithms and Application Areas, 2019, Bentham Science Publishers )
- ④ Nordberg, O., Wake, J., Nordby, E., Flobak, E., Nordgreen, T., Mukhiya, S., & Guribye, F. *Designing chatbots for guiding online peer support conversations for adults with ADHD.* Conversation, 2019, Amsterdam, Netherland.
- ⑤ Mukhiya, S., Wake, J., Pun, K., Lillehaug, S., & Lamo, Y. *Adaptive Element in Architecture of Internet-Delivered Treatments systems to improve user adherence: Systematic Review.* (Planned for submission in JMIR publication, Journal of Medical Internet Research in the end of December, 2019)

# Main contribution areas

Table:

Problem Addressed	Publication	Type of publication
P1: Adaptive IDPT	5, 3, 4	- [5] Journal, Review paper - Discussion paper (In progress) - [3] Book Chapter - [4] Conference paper, conversation
p2: Architecture centric development	1	SEH, Workshop paper
p3: Interoperability	2	ICTH 2019, Conference Paper

# Beneficiary stakeholders from this research



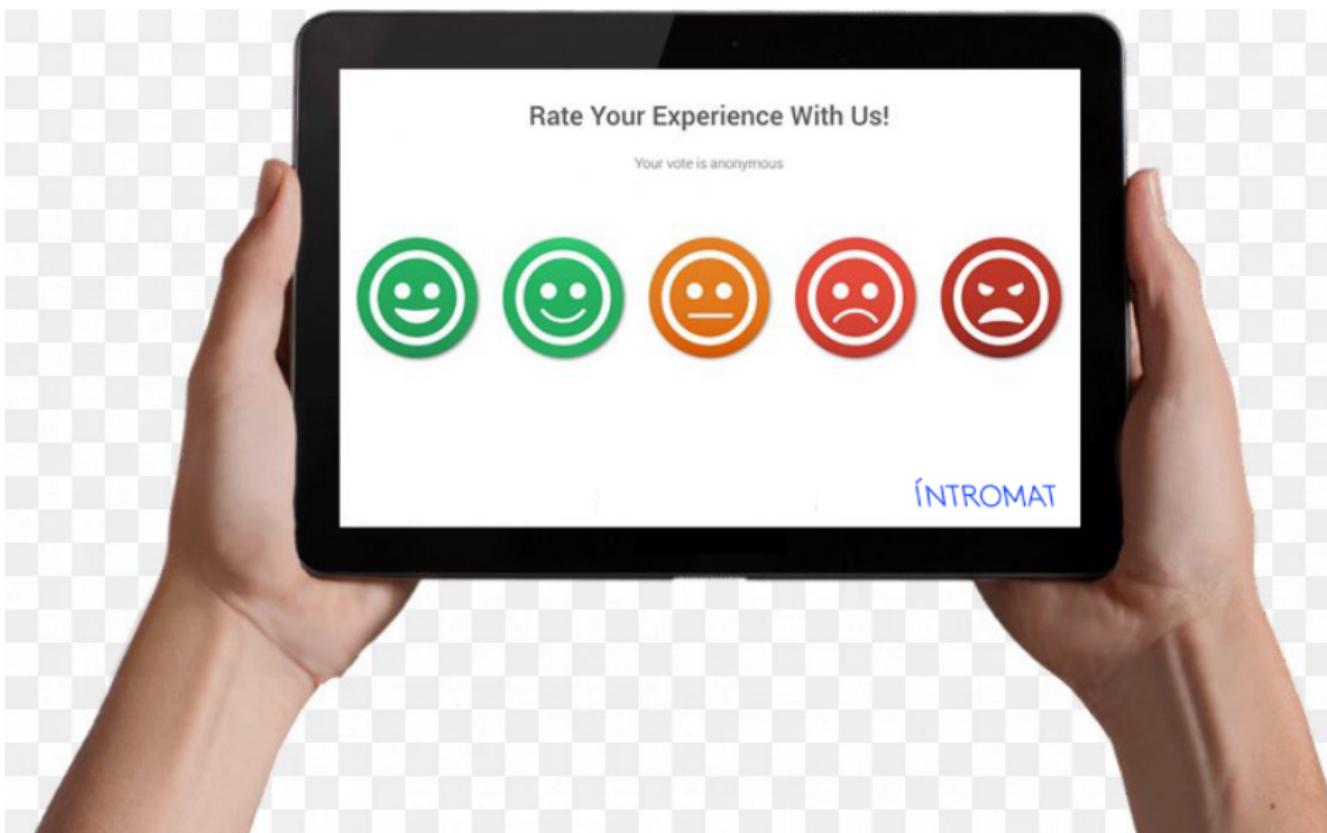
# Future plans

Semester	Work Item	Period
4	<ul style="list-style-type: none"><li>▪ Theory development and experimental evaluation</li></ul>	Jan- June, 2020
5	<ul style="list-style-type: none"><li>▪ Internal Research Stay</li><li>▪ Theory Development</li><li>▪ Theory development</li><li>▪ Experimental evaluation</li></ul>	Aug - Dec, 2020
6	<ul style="list-style-type: none"><li>▪ Thesis</li></ul>	Jan - Aug, 2021

- Development of conceptual framework for adaptive IDPT using MDSE techniques.
- Extend the prototypes for adaptive interventions.
- **Outcome:** At least 1/2 paper(s) describing a conceptual framework for adaptive IDPT. The main idea is to utilize the finding from the review paper submitted to JMIR Publication

- Continue theory development and evaluation.
- International research stay.
- Using AI assisted techniques for automated adaptation on IDPT systems.
- **Outcome:** 1-2 papers exploring how adaptation can be facilitated by using AI assisted predictive algorithms.

- Write manuscript constituting a Ph.D. thesis.
- Write an overview chapter.
- The collection of published papers.
- **Outcome:** Ph.D. Thesis.



# References I



WHO.

World health report, 2018.



European Union.

Improving the mental health of the population: Towards a strategy on mental health for european Union, Technical report.

*Health & Consumer Protection Directorate General*, 2005.



European Union.

Improving the mental health of the population: Towards a strategy on mental health for european Union, Technical report.

*Health & Consumer Protection Directorate General*, 2008.



Mona Sommer.

Mental health among youth in norway.

*Norden*, 69:7, 06 2016.



Colin D. Mathers and Dejan Loncar.

Projections of global mortality and burden of disease from 2002 to 2030.

*PLoS Medicine*, 2006.



Angela Sweeney, Steve Gillard, Til Wykes, and Diana Rose.

The role of fear in mental health service users' experiences: a qualitative exploration.

*Social Psychiatry and Psychiatric Epidemiology*, 2015.



Aaron T. Beck and Brad A. Alford.

Depression causes and treatment.

*University of Pennsylvania*, 1967.

# References II



Keith S. Dobson.

*HANDBOOK OF COGNITIVE-BEHAVIORAL THERAPIES THIRD EDITION.*

The Guilford Press, London, 2010.



ISO/IEC 25000, ISO/IEC JTC 1/SC 7.

ISO/IEC 25000:2014 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE, 2014.



et al Goss, Stephen.

*Technology in Mental Health.*

Charles C. Thomas, Publisher, Ltd, 2016.



National Health Expenditure Accounts (NHEA).

National health expenditure data, 2017.



David Bloom and et. al.

The global economic burden of noncommunicable diseases.

Pgda working papers, Program on the Global Demography of Aging, 2012.