SUPPORT FOR INTERDISCIPLINARY HEALTHCARE TEAMS

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Acknowledgements

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- Prof. Krzysztof Słowiński
  Klinika Chirurgii Urazowej, Leczenia Oparzeń i Chirurgii Plastycznej, Uniwersytet Medyczny, Poznań

- Dr. Michael Fung Kee Fung
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Outline

1. Introduction and research goals
2. Related work
3. Research plan and results
   - Empirical model of a team
   - Conceptual model of a team
   - Design and implementation of MET4
4. Case study: obesity in children
5. Conclusions and future work

Introduction and Research Goals

Introduction

- Increasing complexity of relatively frequent patient cases
- New patient management techniques – management workflows derived from clinical practice guidelines (CPGs)
- Typically a workflow needs to/should be executed by a team of healthcare (and other) practitioners

> *Teams have been reported to reduce hospitalization time and costs, improve service provision and enhance patient satisfaction, staff motivation and team innovation*

- Successful execution of a workflow (⇨provision of comprehensive care) requires collaboration and coordination

Understood also as associating specific tasks to appropriate team members

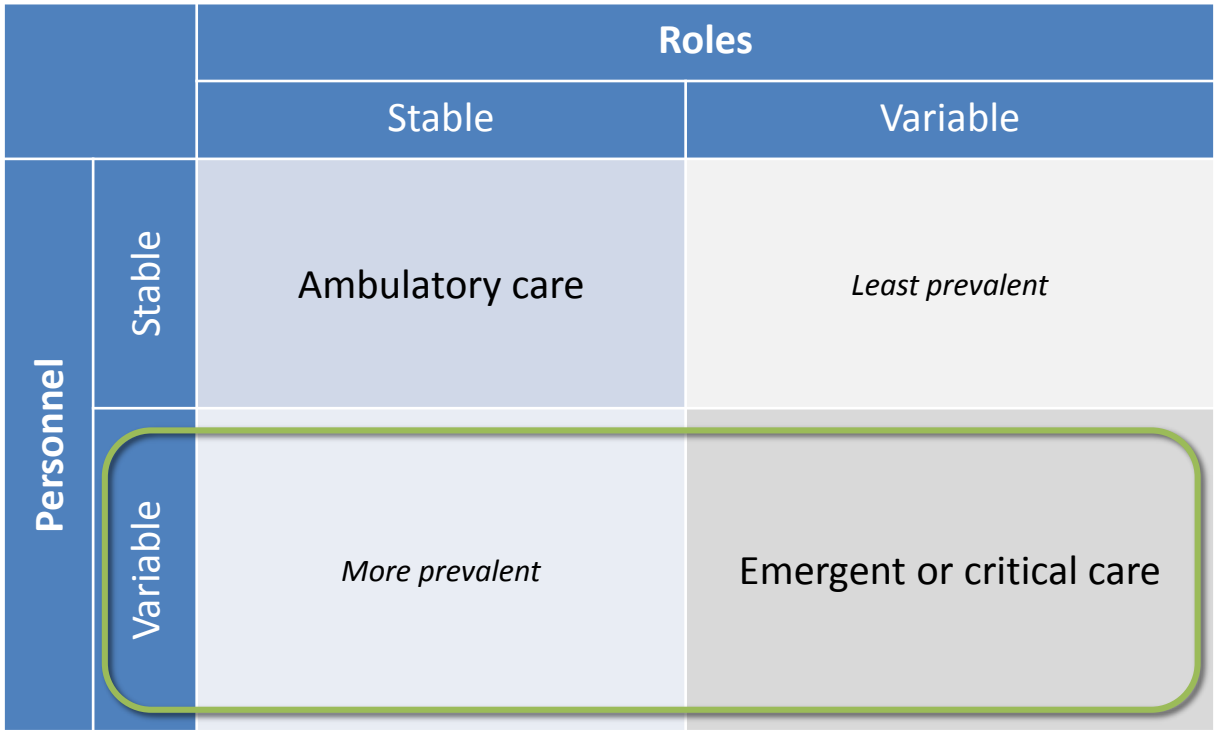
C.S. Borill, J. Carleta, A.J. Cater, et al.: *The Effectiveness of Health Cate Teams in the National Health Service. Final Report for Department of Health*. University of Aston, 2001.

Models of Team Practice

Extensive research on collaboration in healthcare teams and multiple categorizations of team practice

I. Oandasan, D. D'Amour, M. Zwarenstein, et al.: *Interdisciplinary Education for Collaborative, Patient-Centered Practice. Research and Findings Report*. Health Canada, 2006.
B.C. Choi, A.W. Pak: Multidisciplinarity, Interdisciplinarity and Transdisciplinarity in Health Research, Services, Education and Policy: 1. Definitions, Objectives, and Evidence of Effectiveness. *Clinical and Investigative Medicine*, 2006, 29 (6), 351-364.

Variability in IHT



P.B. Andreatta: A Typology for Health Care Teams. *Health Care Management Review,* 2010, 35 (4), 345-354.

Research Goals

Overall goal

To provide ***methodological foundations*** and ***practical tools*** to support IHT in providing care according to a workflow

Specific goals

To propose sufficiently expressive **models** of workflows and IHT

To propose **strategies** and **algorithms** for handling (creating, maintaining, distributing tasks) IHT when executing a workflow

To develop a **CDSS** that employs proposed models and implements proposed algorithms

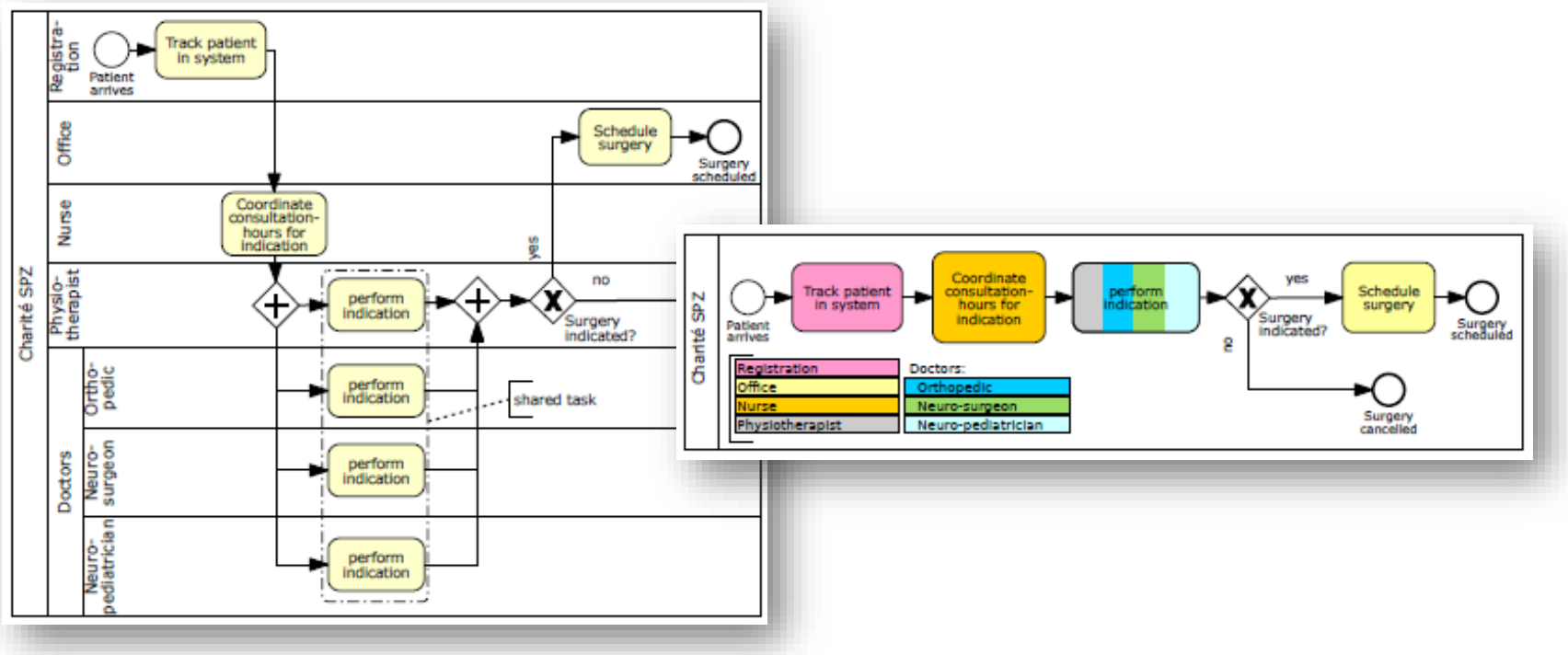
Related Work

Related Work

“Colored” BPMN

Extension of BPMN (Business Process Model and Notation)

- Multiple roles and shared tasks
- Colors (instead of lanes) associated with individual and shared tasks

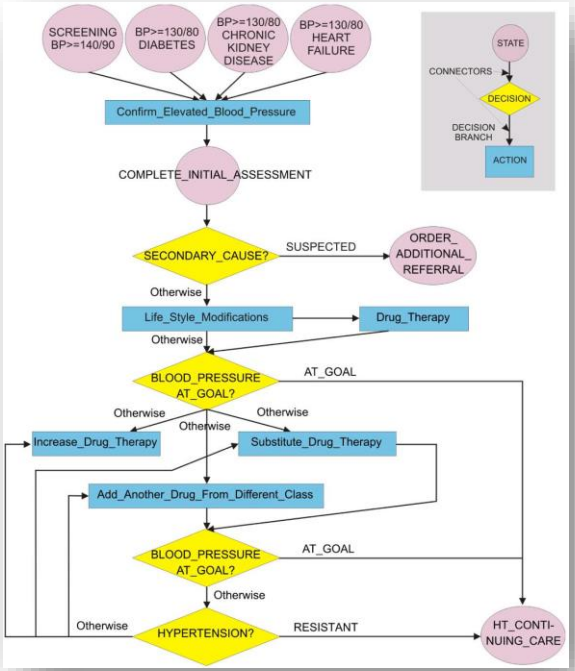


R. Müller, A. Rogge-Solti: BMPN for Healthcare Processes. *CEUR Workshop Proceedings,* 2011, 705, 65-72.

Related Work

K4CARE

- European project (FP6) aimed at providing knowledge-based e-services for managing elderly patients
  - SDA* representation for workflows
  - Ontological models of workflows, processed data and documents and practitioners (limited characteristics in terms of their abilities)
  - Multi-agent system to support execution of workflows by an IHT
- Limited evaluation in Pollenza, Italy
  - 23 volunteer elderly patients, 10 practitioners
  - Highly evaluated by physicians and head nurse for (semi-automatizing) administrative work

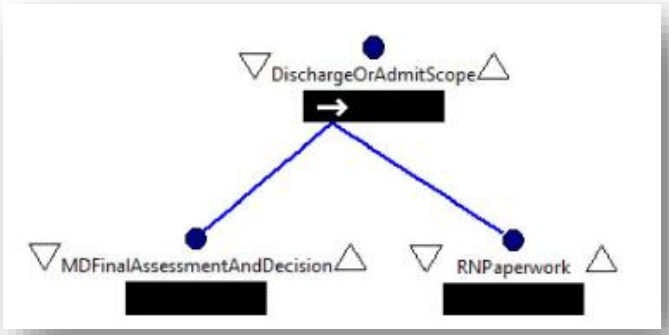


M. Batet, D. Isern, L. Martin, et al.: Knowledge-driven Delivery of Home Care Services. *Journal of Intelligent Information Systems*, 2012, 38 (1), 95-130.

Related Work

Resource Management Framework

- Formal resource management framework
  - Extensive description of resources required to execute processes, customized to a specific problem
  - Simplified (e.g., in comparison to BMPN) description of processes
- A prototype system simulation system
  - Experiments involving several ED scenarios
  - Minimization of the time spent in ED



M.S. Raunak, L.J. Osterweil: Resource Management for Complex, Dynamic Environments. *IEEE Transactions on Software Engineering*, 2013, 39 (3), 384-402.

Related Work

Patterns of Collaboration in Healthcare

- Goal-based workflow representation based on PROforma
- State-based exceptions for detecting obstacles and hazards and associated plans for handling them
- Formal description of two collaboration patterns
  - *Assignment* ⇨ provider is accountable for outcome and responsible for handling exceptions
  - *Delegation* ⇨ client is responsible for outcome and responsible for managing any exceptions that provider cannot handle
- Extensive description of practitioners (to ensure valid assignment/delegation), but no notion of a team

M.A. Grando, M. Peleg, M. Cuggia, D. Glasspool: Patterns for Collaborative Work in Health Care Teams. *Artificial Intelligence in Medicine*, 2011, 53 (3), 139-160.

Related Work

Patterns of Collaboration in Healthcare

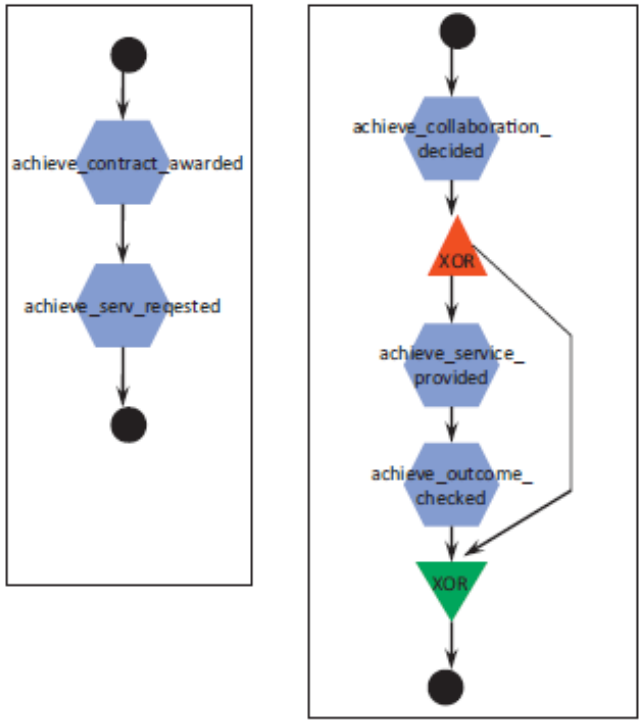


Fig. 2. (1) Client_assignment_pattern, (2) Provider_assignment_pattern. The hexagons represent goals, the triangles corresponds to split points and the inverted triangles to join points.

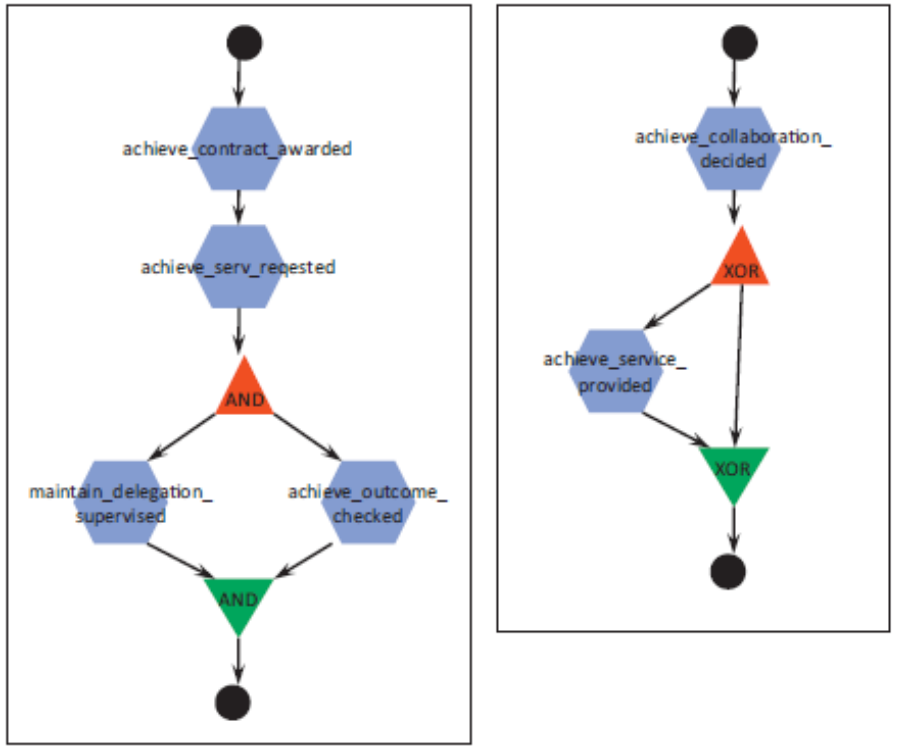


Fig. 6. (1) Client_delegation_pattern and (2) Provider_delegation_pattern.

Research Plan

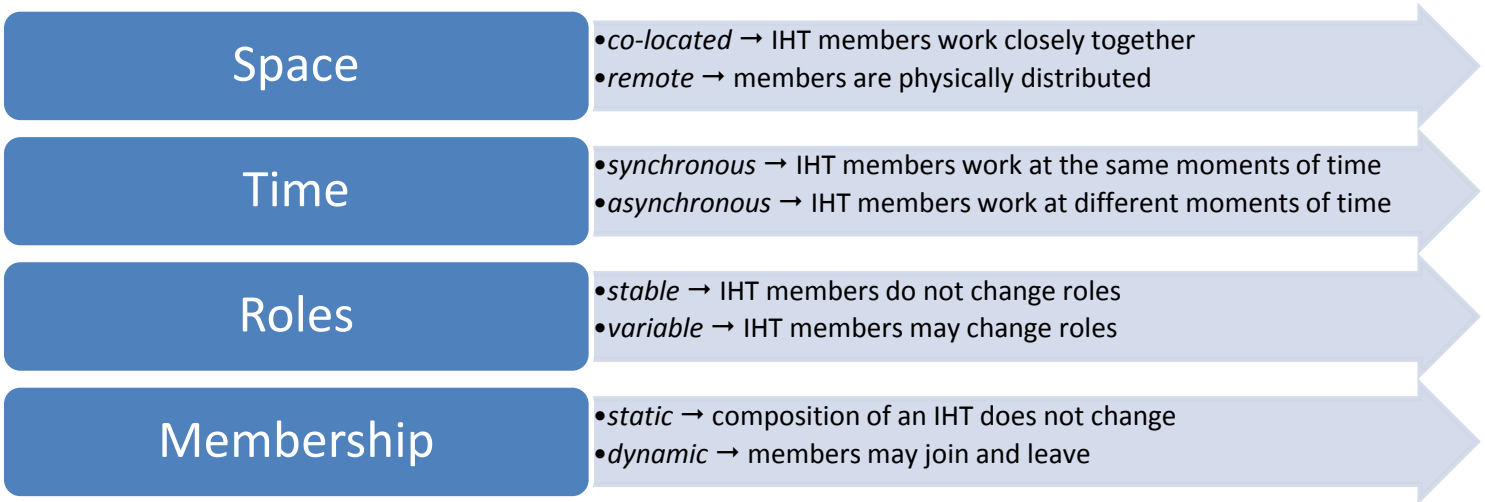
Research Plan

1. To define the **empirical model** (⇨ practice-based model) of an IHT
2. To derive the **conceptual model** (⇨ system-based model) of an IHT executing a management workflow
3. To propose **strategies** and **algorithms** to handle an IHT when executing a workflow
4. To design and implement **MET4** – a multiagent system to support workflow execution by an IHT
5. To implement several workflows (**pediatric obesity,** abdominal trauma, palliative care) within MET4
6. To perform clinical trial of MET4 with a selected workflow

Empirical Model of IHT

Empirical Model of an IHT

- General assumptions
  - IHT is created to handle a specific patient (*team-on-demand*?) and dissolved when management is finished
  - IHT has a **leader** that controls its operations – identifies tasks, delegates them to team members and makes relevant decisions
- Features (dimensions) characterizing an IHT



Team Formation

- Two-phase formation of a team
  1. Identification of the leader by some “external” administrative entity
  2. Identification of remaining team members by the leader (based on knowledge about skills and availability of potential team members, this can be supported by some administrative entity as well)

- Two types of team members
  - *Core* members – in direct and continuous contact with a patient
  - *Non-core* members – required on ad hoc basis

Decision about the type of a specific members is made by the leader taking into account patient management needs (workflow as a reference point)

Empirical Model of an IHT

Leadership

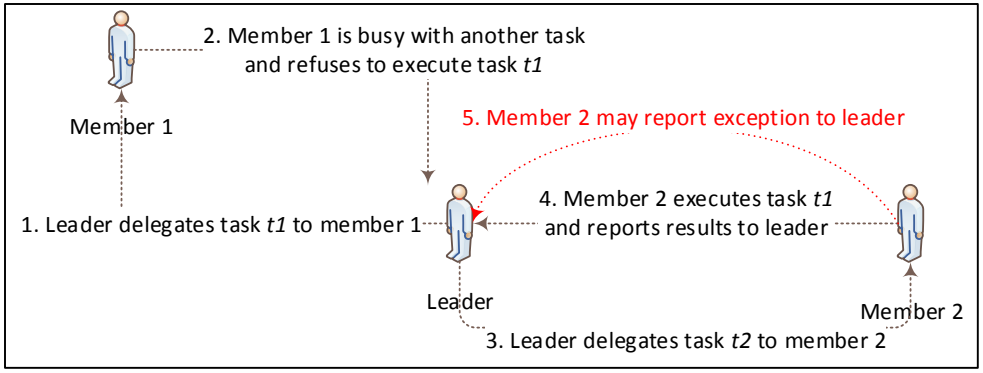
- Goals of the leader
  - To maintain a team (recruit new members and dismiss existing members)
  - To coordinate activities of team members and to solve conflicts
  - To make relevant decisions related to management
- Leadership may be static throughout the management process (acute condition) or it may change (chronic disease)

Task Delegation and Exceptions

- The leader delegates tasks to most appropriate team members (based on the required and possessed skills)
- If the selected member is not able to accept the task, the leader needs to find a replacement

> Exception is defined as an inability to complete a task because of some external circumstances (i.e., drastically changing patient condition).

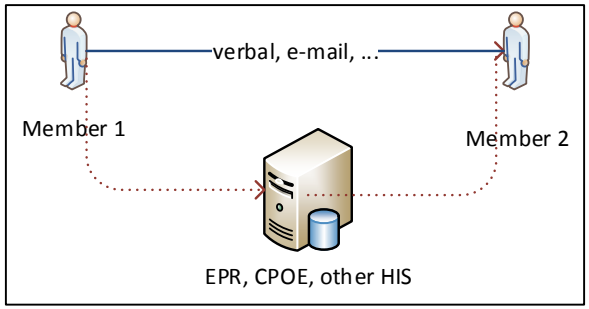
- Exceptions are handled by the leader



Empirical Model of an IHT

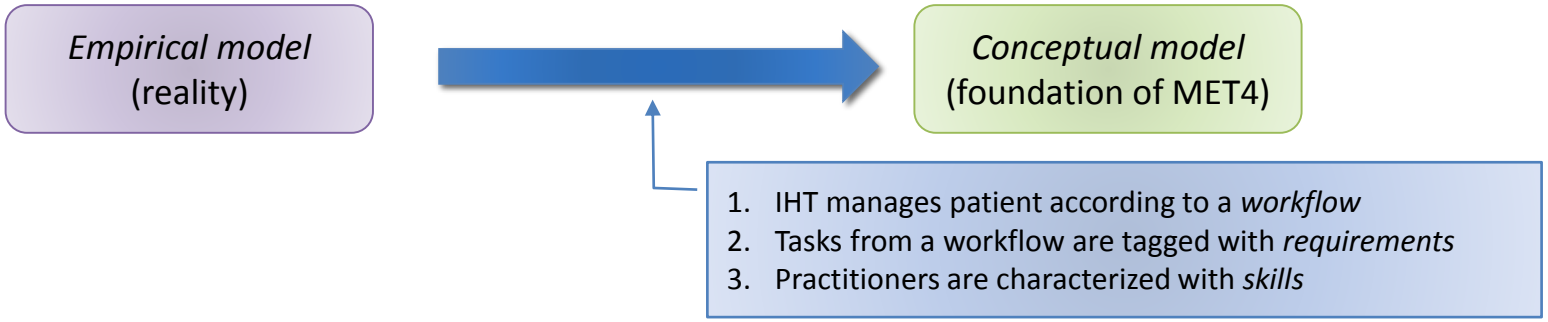
Communication

- Peer to peer with several explicit/direct (verbal, e-mail, notes) and implicit (CPOE, EPR) channels



- Explicit communication used to ensure proper delegation and coordination of activities

From Empirical to Conceptual Model



Issue	Empirical Model	Conceptual Model
Formation	Leader Administrative entity	Workflow-driven (matching requirements with skills)
Leadership	Team maintenance, task matching, decision making, exceptions	Decision making, exceptions; Workflow-driven otherwise
Task delegation	Leader	Workflow-driven (matching requirements with skills)
Exception	Leader	Leader
Communication	Direct and indirect channels	Selected direct channels

(Semi-) automatic execution of administrative activities

Conceptual Model of IHT

Conceptual Model

- Requirements and skills given in terms of *capabilities*

> *Capability* = ability to perform a certain clinical task

- Capabilities associated with practitioners (*possessed capabilities*), workflow tasks and arcs (*required capabilities*)
- Capabilities additionally characterized by *competency score*
  - *Competency level* for possessed capabilities
  - *Competency threshold* for required capabilities

A. Gardner, S. Hase, G. Gardner, et al..: From Competence to Capability: a Study of Nurse Practitioners in Clinical Practice. *Journal of Clinical Nursing*, 2008, 17 (2), 250-258.

Conceptual Model

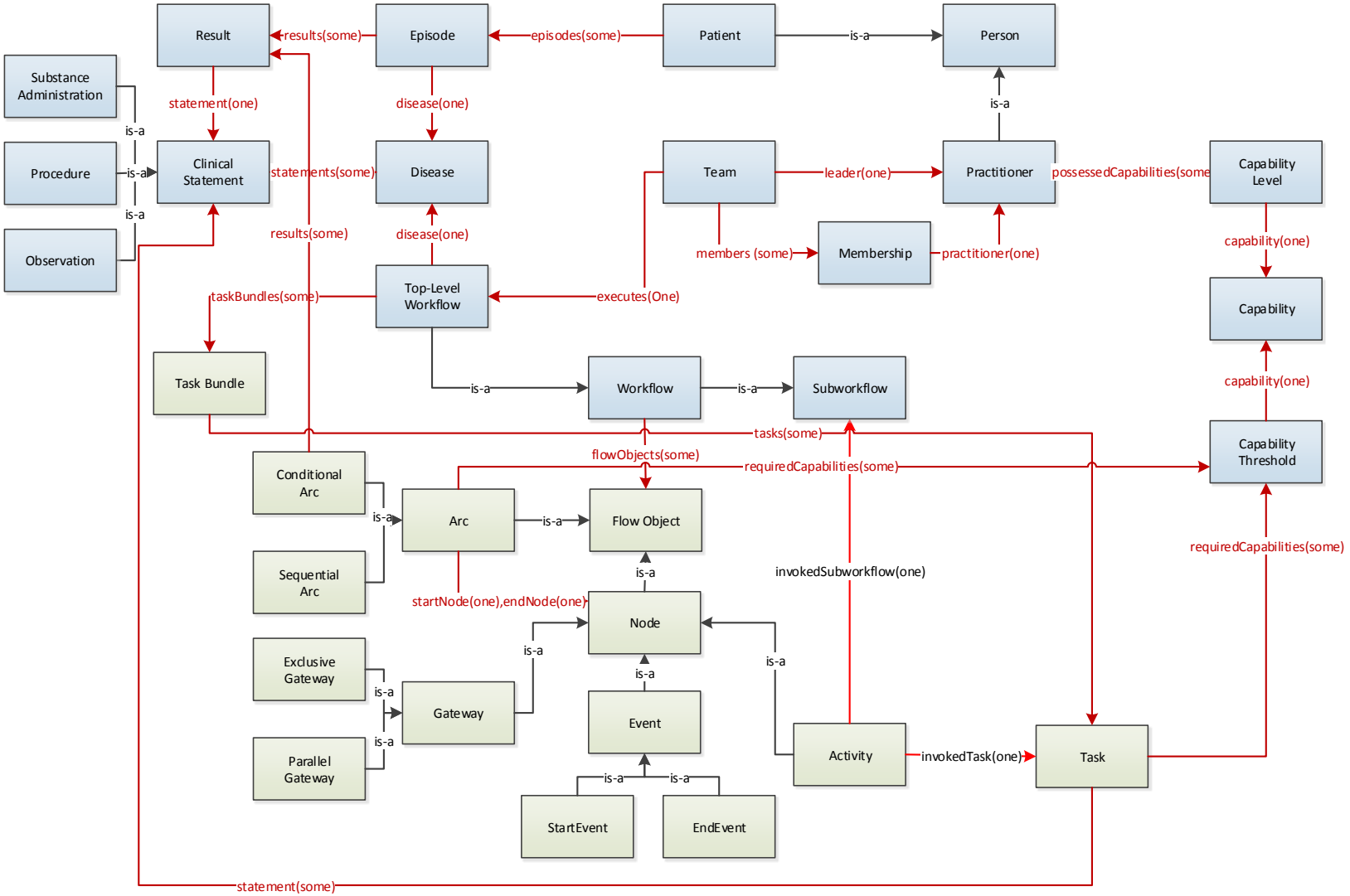
- Competency level established according to
  - Expert knowledge, e.g., corresponding to the seniority level
  - Objective tests, evaluating capabilities in evidence-based practice

- Practitioner may be delegated a specific workflow task if
  1. She possesses all capabilities required by the task
  2. For all the required capabilities competency value ≥ threshold
- Analogous approach for appointing the leader → possessed capabilities matched against the required ones

D. Ilic: Assessing Competency in Evidence Based Practice: Strengths and Limitations of Current Tools in Practice. *BMC Medical Education*, 2009, 9, 53.

Conceptual Model

Ontology



IHT Handling Strategy

- A hybrid strategy that combines static and dynamic approaches to team creation and maintenance

1. Initially IHT includes the leader
2. Before executing a specific task check if IHT contains appropriate member
   - If yes, select the existing member
   - Otherwise, recruit a new member and select it
3. Delegate the task to the selected member
4. After executing the task check if the selected member possesses capabilities required by subsequent tasks
   - If yes, retain the selected member in IHT
   - Otherwise, dismiss the selected member
5. Members may leave the IHT on their own

- Limited “idleness” of IHT members at the cost of pausing the workflow execution if no appropriate member can be recruited

Design and Implementation of MET4

Design of the MET4 System

- MET4 – a multiagent system to support workflow execution by IHT (team maintenance, task delegation, decision support)
- Builds on our experience with MET3 and significantly expands it to support a team and handle diversified workflows

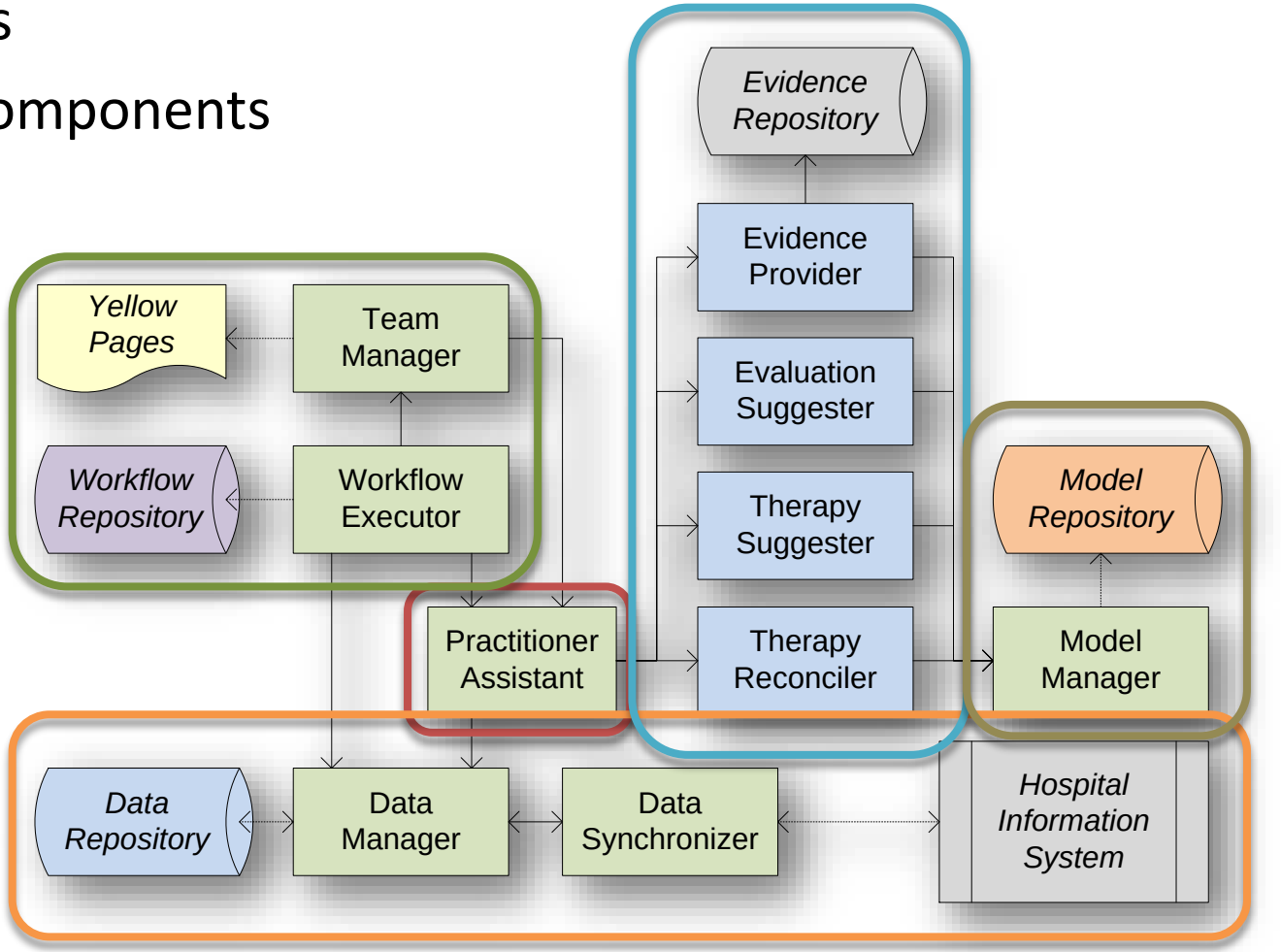
- Designed using the O-MaSE method
  - Flexible method for analyzing and designing multi-agent systems
  - Strongly rooted in software engineering (modified UML)
  - Constructs a sequence of models that translate requirements into detailed design specifications
  - Available toolset (*agentTool 3* – a plugin for Eclipse)

O-MaSE
Organization-based Multiagent Systems Engineering

agentTool

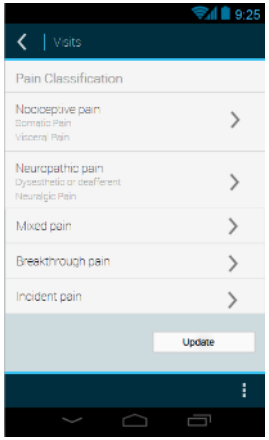
Agent Model for MET4

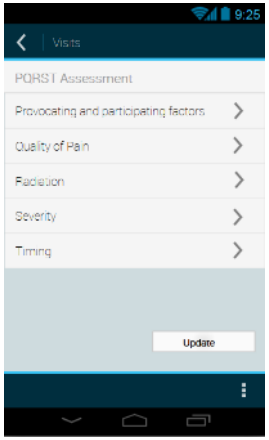
- Agent classes
- Non-agent components

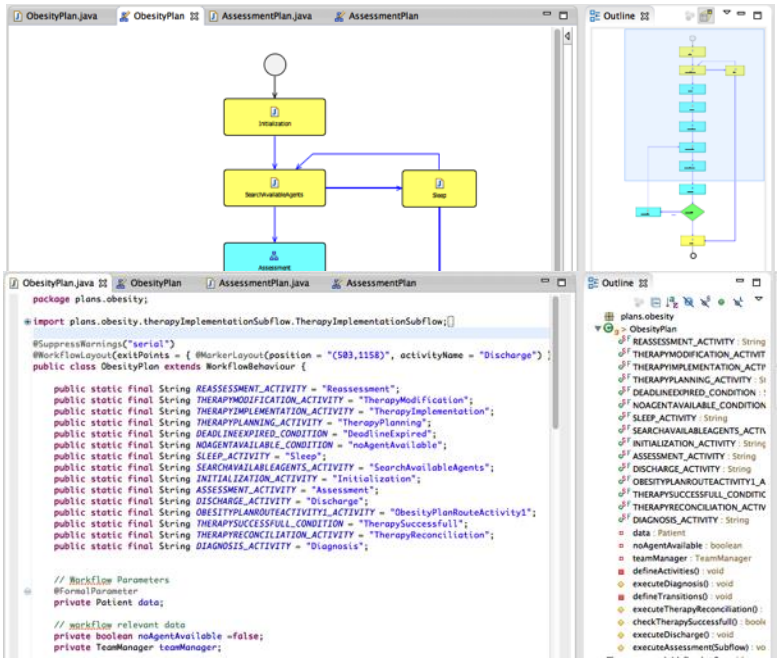


Implementation of MET4

- Functionality related to agents and workflows implemented using WADE (extension of JADE)
- Domain models and data repositories implemented using Protégé
- Touch-based interfaces for mobile devices (Android, iOS?)



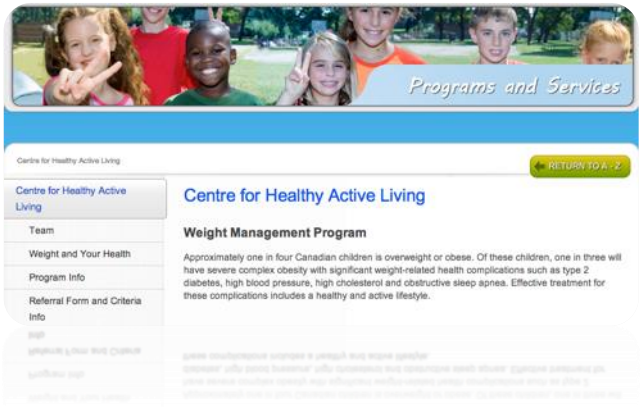




Case Study: Obesity in Children

Obesity in Children

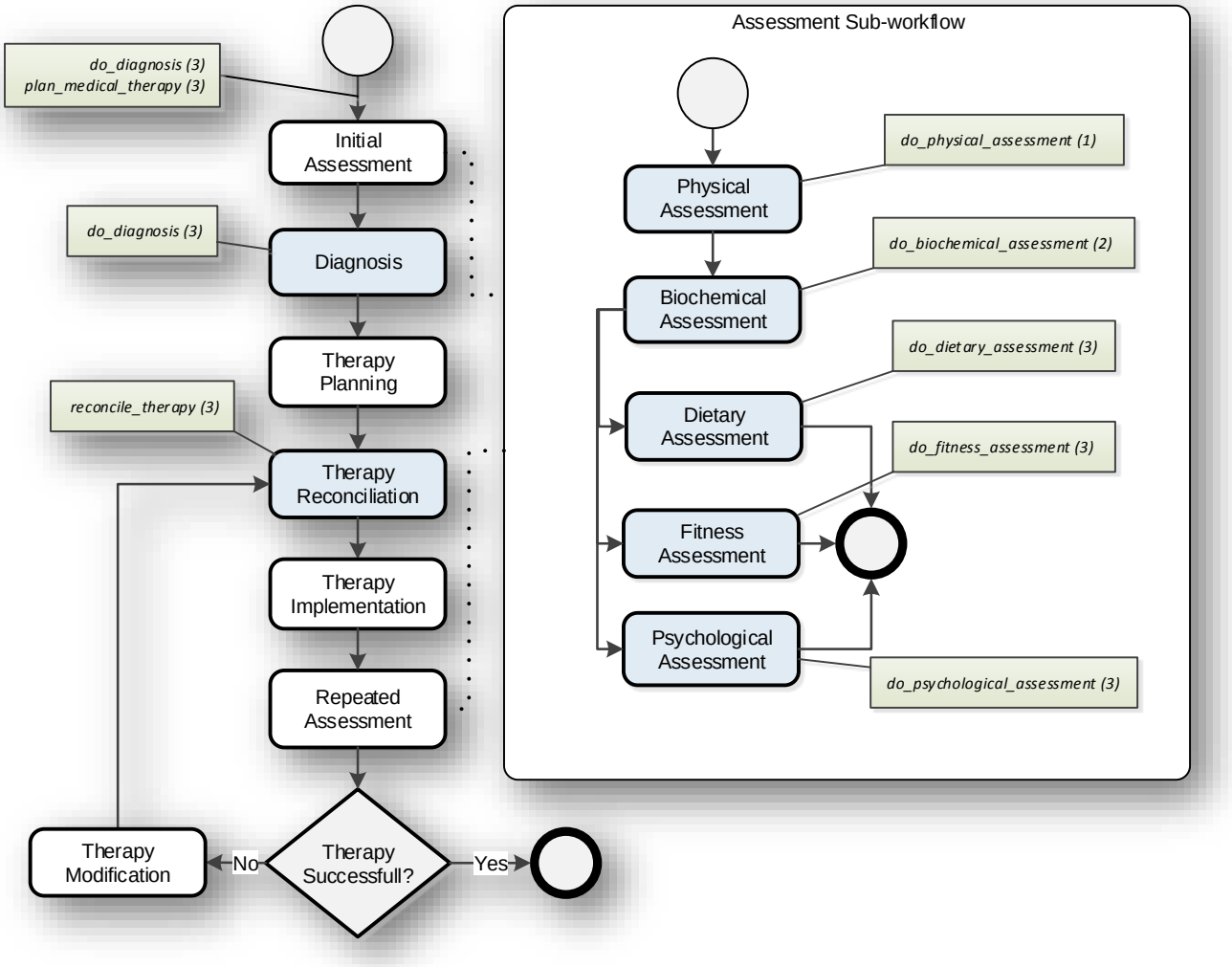
- Problem of increasing prevalence and importance
  - 29% of adolescents in Canada with unhealthy weight (2007)
  - 70% of adults obese or overweight in 2040
- Management in dedicated facilities, e.g., Centre for Healthy Active Living at CHEO



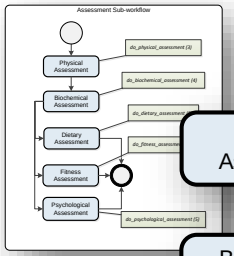
- An organizational workflow used at CHEO requires a team composed of multiple specialists

Pediatric endocrinologist
Registered nurse
Psychologist
Child and youth worker
Social worker
Exercise specialist
Dietitian

Obesity Management Workflow



Operations of MET4



Physical Assessment

Biochemical Assessment

do_physical_assessment (1)

do_biochemical_assessment (2)

RN1

RN2

pa-rn1 : Practitioner Assistant

pa-rn2 : Practitioner Assistant

do_physical_ assessment (3)
do_biochemical_ assessment (1)

do_physical_ assessment (2)
do_biochemical_ assessment (3)

Yellow Pages

Workflow Repository

dm : Data Manager

Data Repository

tm : Team Manager

we : Workflow Executor

pa-md1 : Practitioner Assistant

ds : Data Synchronizer

IHT = {*pa-md1, pa-rn1*}

do_physical_ assessment (2)
reconcile_therapy (3)
do_diagnosis (3)
plan_medical_therapy (3)

MD1

HIS

Conclusions and Future Work

Conclusions

- Empirical model of an IHT representing reality
- Conceptual model of an IHT built around the concept of capability
- Hybrid strategy for IHT creation and maintenance
- Design and implementation of MET4 (O-MaSE, WADE, Protégé)
- Workflow for pediatric obesity

Support for coordination

Support for IHT variability

Ongoing and Future Work

- Extensions of the conceptual model and the handling strategy
  - Emergency/high-priority tasks
  - “Bundles” of tasks executed by the same IHT member
  - Tasks executed simultaneously by several IHT members
  - Patient-centered care and patient preferences
- Improved implementation of the MET4 system
- Simulation experiments to verify the handling strategy
- Implementation of other management workflows (e.g., ovarian cancer) within MET4
- Clinical tests of the MET4 system

Thank you for your attention

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