

# AI Planning in Medicine

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# About me



- PhD in Computer Science, 2011
  - University of Granada
  - Development of Knowledge Engineering techniques for AI HTN Planning & Scheduling (e-learning, healthcare and business process management)
- Postdoc in University of Haifa, Israel
  - MobiGuide Project [www.mobiguide-project.eu](http://www.mobiguide-project.eu)
    - Clinical Decision Support System for Physicians and Patients to manage the care process of Gestational Diabetes and Atrial Fibrillation “anytime and everywhere”



# scheduling patient - hospital beds



# conducting clinical trials protocols





# Intensive Care Units



# Risk and consequences assessment



# Treatment Planning



People may think:

**AI applied to Medicine?!**

I don't trust computers that much





# Some impressive numbers...

- A 2000 *Institute of Medicine* report estimated that medical errors are estimated to result in about between **44,000 and 98,000** deaths and **1,000,000** excess injuries each year in U.S. hospitals.
- A 2006 follow-up study found that **medication errors** are among the most common medical mistakes, harming at least **1.5 million people every year**.
  - According to the study, 400,000 preventable drug-related injuries occur each year in hospitals, 800,000 in long-term care settings.



# Evidence-based Medicine and Clinical Guidelines

- Clinical Guidelines and Protocols are used for
  - ✓ improving quality assurance
  - ✓ reducing variation in clinical practice
  - ✓ guiding data collection
  - ✓ better interpretation and management of the patient's status
  - ✓ improving decision support
  - ✓ activating alerts and reminders



# Therapy Planning

Traditional AI Planning approaches are based on assumptions like deterministic behavior, which do not always hold in medical domains

**Requirements in Medicine are higher than in typical toy-problems!**

**Unpredictable nature** of the domain

- Context-sensitive +
- Task-specific sub-processes:
  - plan generation,
  - plan verification,
  - plan visualization,
  - plan execution,
  - plan modification,
  - plan critiquing
- Challenges:
  - Knowledge Engineering
    - Acquisition
    - Verification and Validation
  - Temporal representation and management
  - Data Integration
  - Exception handling
    - mixed initiative planning needed in many cases



# Temporal Monitoring

- States, events, actions, plans, goals, and effects are durative
  - This makes monitoring of the states and events during execution of durative actions necessary
- The states model of a plan engine may need to consider more than plan generation
  - E.g. Plan suspension, completion, abortion.
- The domain is not static, many unpredictable events can occur
  - Depends on the domain (low/high frequency domains)





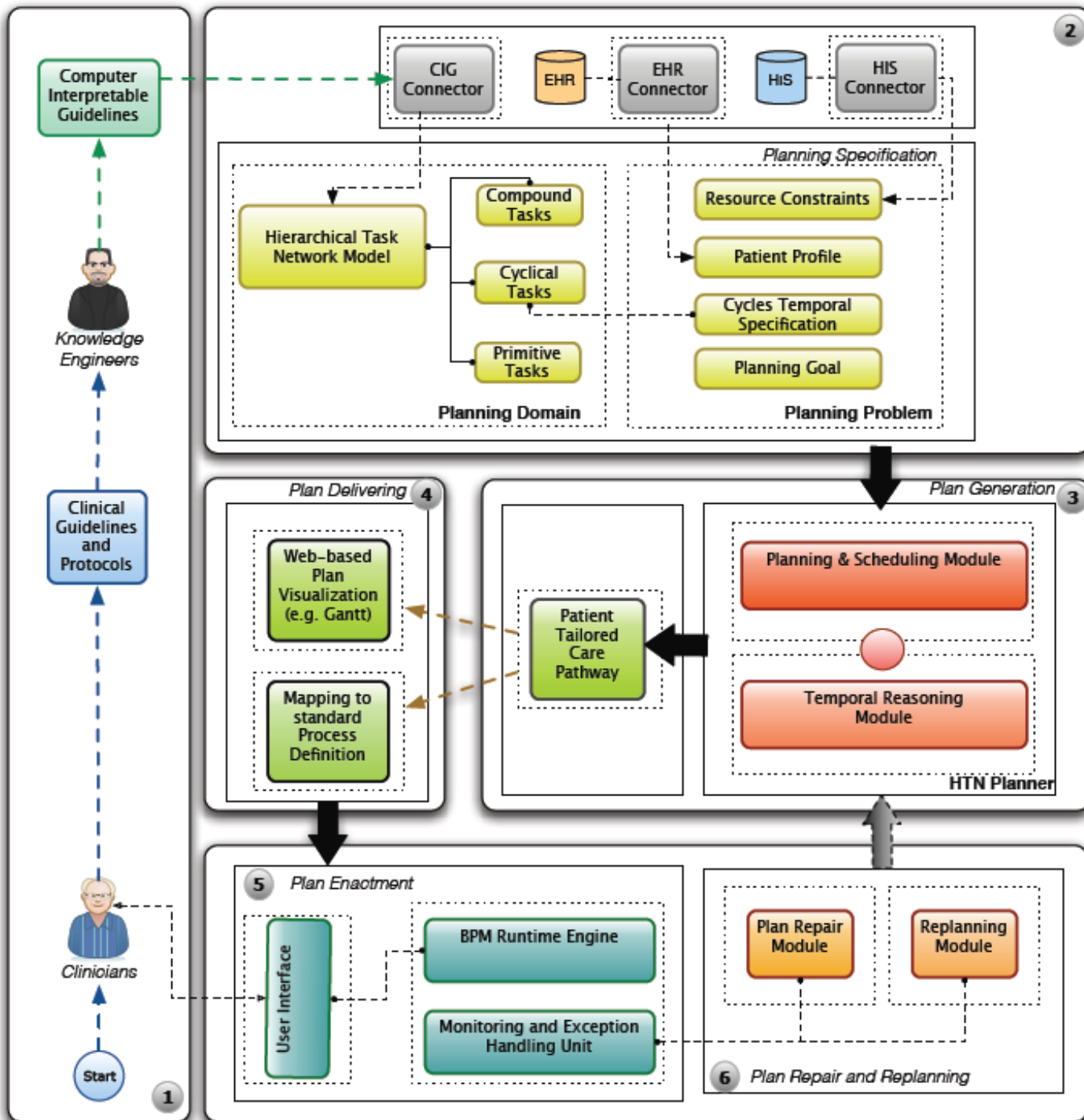
# Care Team Management

- Medicine is applied by a team of physicians, nurses, etc. (**roles**), and they use a number of **resources** (e.g. x-ray machines)
- The plans to be generated from clinical protocols may need to consider these institutional constraints and deliver a **personalized plan for patients and physicians**



# Oncotheraper Project

- 7 hospitals in Spain, area of Pediatric Oncology
- Oncologists are required to apply **Clinical Guidelines** for treating sick patients
  - complex **temporal constraints**
- They want to have **personalized** care process for
  - patient
  - medical staff + institutional requirements
- They want to reduce the **time** spent on preparing treatments



# What do we get?

A fragment of the generated care pathway:

Planner text output showing part of an automatically generated care pathway.

| Start date | End date   | Duration | Part of | Oncologist | Action         | Patient | Dose  |
|------------|------------|----------|---------|------------|----------------|---------|-------|
| 08/11/2011 | 23/11/2011 | 360.0    | OPPA    | John       | Administer PRD | Job     | 60.0  |
| 08/11/2011 | 09/11/2011 | 24.0     | OPPA    | John       | Administer VCR | Job     | 1.5   |
| 15/11/2011 | 16/11/2011 | 24.0     | OPPA    | John       | Administer VCR | Job     | 1.5   |
| 22/11/2011 | 23/11/2011 | 24.0     | OPPA    | John       | Administer VCR | Job     | 1.5   |
| 08/11/2011 | 23/11/2011 | 360.0    | OPPA    | John       | Administer PRC | Job     | 100.0 |
| 08/11/2011 | 09/11/2011 | 24.0     | OPPA    | John       | Administer ADR | Job     | 40.0  |
| 23/11/2011 | 24/11/2011 | 24.0     | OPPA    | Paul       | Administer ADR | Job     | 40.0  |

Deployed into a BPM engine (ubiquitous execution)





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