PMR 5020

Modelagem do Projeto de Sistemas

Aula 5: Métodos modernos de modelagem de requisitos

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reinaldo@usp.br

A fase de requisitos e a ER

Como vimos até aqui:

i) a fase de requisitos é muito importante para os projetos;
ii) o sucesso do projeto depende de uma boa ER;
iii) para o design de sistemas esta fase é primordial;
iv) a ER é composta da: eliciação, modelagem e análise, validação/ verificação de requisitos;

The key problems

- The priority of requirements from different viewpoints changes during the development process.
- System customers may specify requirements from a business perspective that conflict with end-user requirements.
- The business and technical environment of the system changes during its development.

Good req's X Bad req's

- Enduring requirements. Stable requirements derived from the core activity of the customer organisation. E.g. a hospital will always have doctors, nurses, etc. May be derived from domain models
- Volatile requirements. Requirements which change during development or when the system is in use. In a hospital, requirements derived from health-care policy

The traceability concept

- Traceability is concerned with the relationships between requirements, their sources and the system design
- Source traceability
  - Links from requirements to stakeholders who proposed these requirements;
- Requirements traceability
  - Links between dependent requirements;
- Design traceability
  - Links from the requirements to the design;

Traceability

"The requirements traceability is the ability to describe and follow the life of a requirement, in both a forward and backward direction, i.e. from its origins, through its development and specification, to its subsequent deployment and use, and through periods of ongoing refinement and iteration in any of these phases."

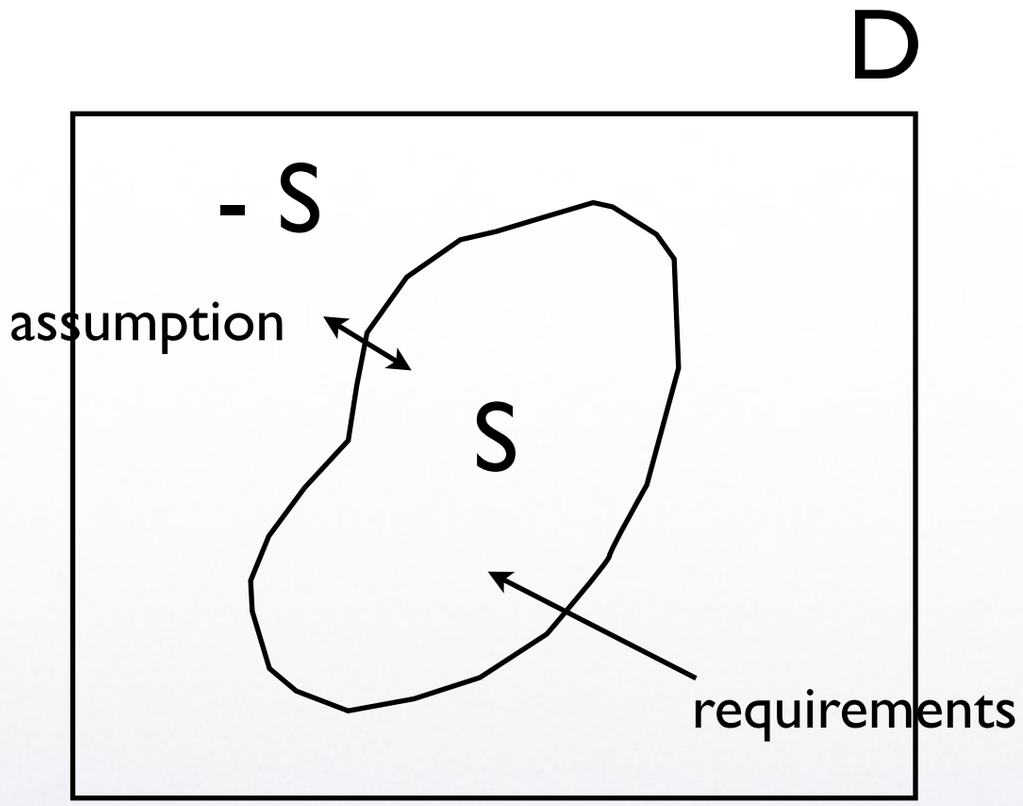
Gotel, O., Filkenstein, A.; An Analysis of the Requirements Traceability Problem, in Proc. of the First Int. Conf. on Requirements Engineering, pp 94-101, Colorado Springs, USA, 1994.

Design features

A base para a formulação de requisitos deve ser um conjunto genérico de features (objetivos) abstratos que definem o projeto. Esta definição genérica pode ser refinada em requisitos funcionais e não-funcionais até chegar em funções específicas de mais baixo nível.

Silva, J.R.; Uma formalização do processo de design baseado em metáforas: sua aplicação na automatização de Sistemas de Eventos Discretos, tese de doutorado, Escola Politécnica da USP, 1992.

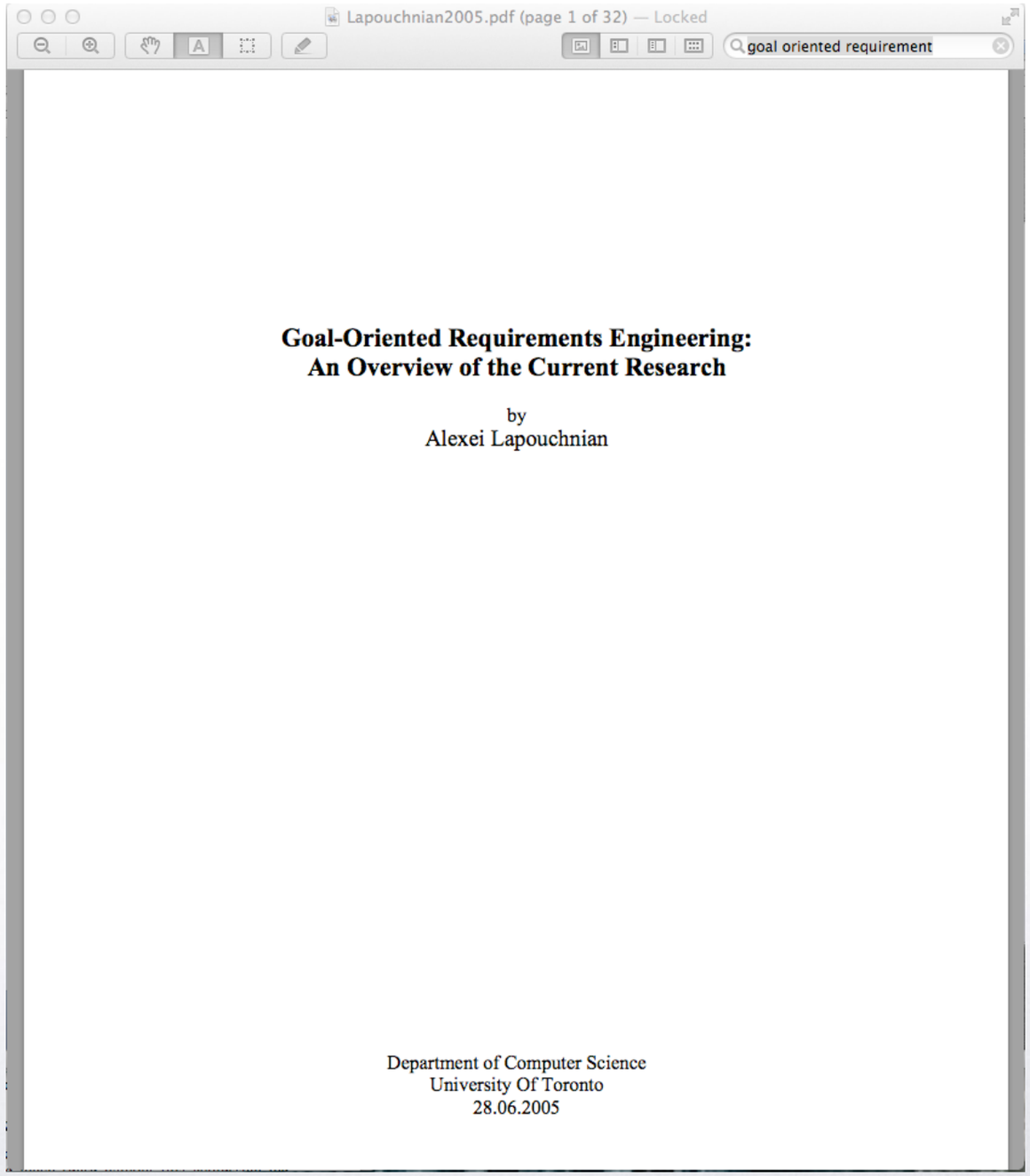
Contexto



Dominio de aplicação

Leitura da semana

To be funcional or not to be funcional, that is the question

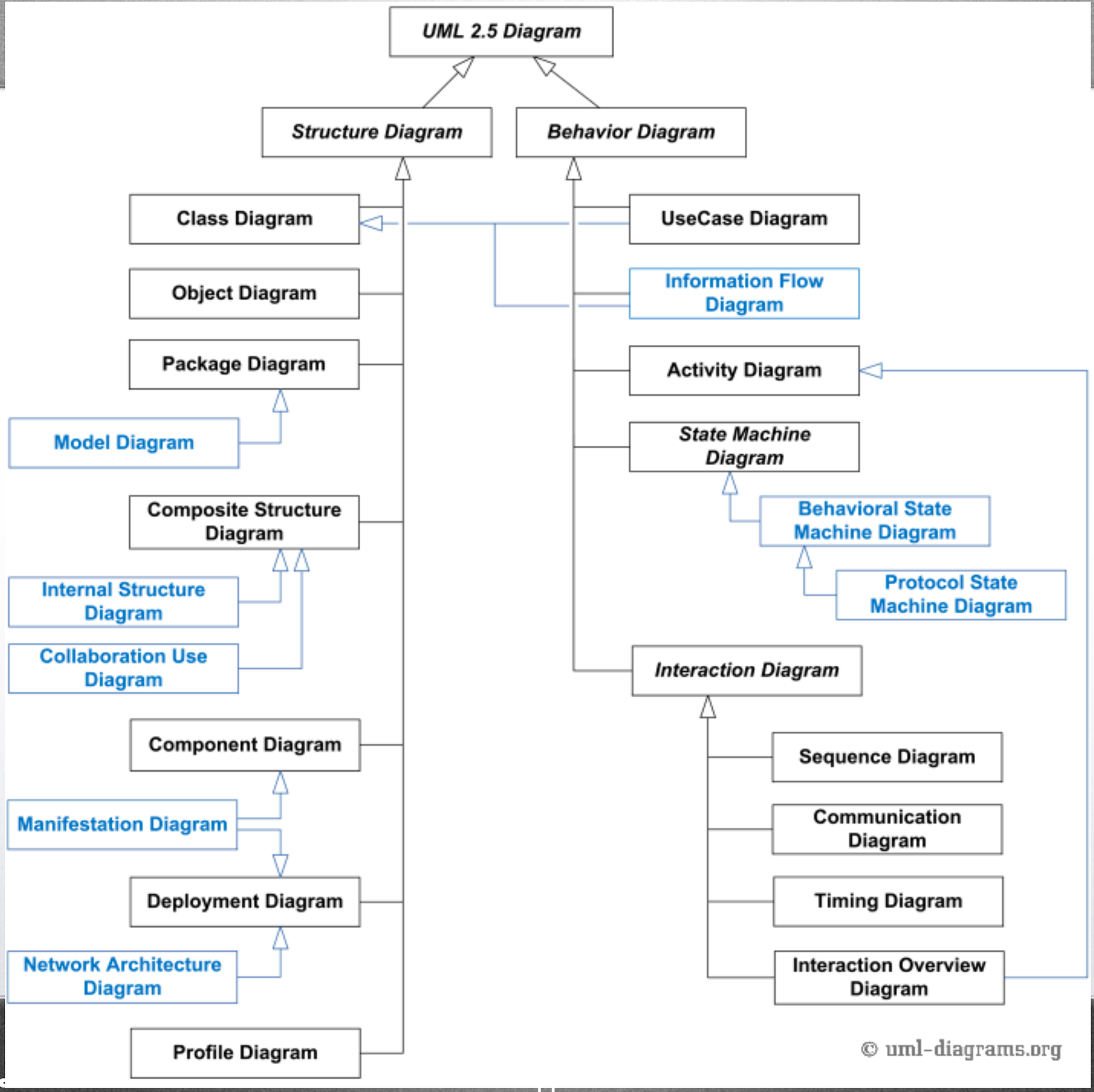


Os perigos da eliciação de requisitos

funcional

não-funcional

Um dos perigos da eliciação (e portanto da análise) de requisitos é privilegiar a análise funcional e a funcionalidade como alvo central.
Normalmente se diz que os requisitos devem refletir o que o sistema é e o que faz mas NUNCA "o como" este deve fazer as coisas (que seria alvo de etapas posteriores).
O perigo do "funcional" como antecipação do design está no stakeholder (especialmente em domínios disjuntos) ou no próprio designer (no caso de domínios próximos), ou em ambos quando não se trata de casos extremos.


UML 2.5 Diagram
Structure Diagram
Behavior Diagram
Class Diagram
Object Diagram
Package Diagram
Model Diagram
Composite Structure Diagram
Internal Structure Diagram
Collaboration Use Diagram
Component Diagram
Manifestation Diagram
Deployment Diagram
Network Architecture Diagram
Profile Diagram
UseCase Diagram
Information Flow Diagram
Activity Diagram
State Machine Diagram
Behavioral State Machine Diagram
Protocol State Machine Diagram
Interaction Diagram
Sequence Diagram
Communication Diagram
Timing Diagram
Interaction Overview Diagram
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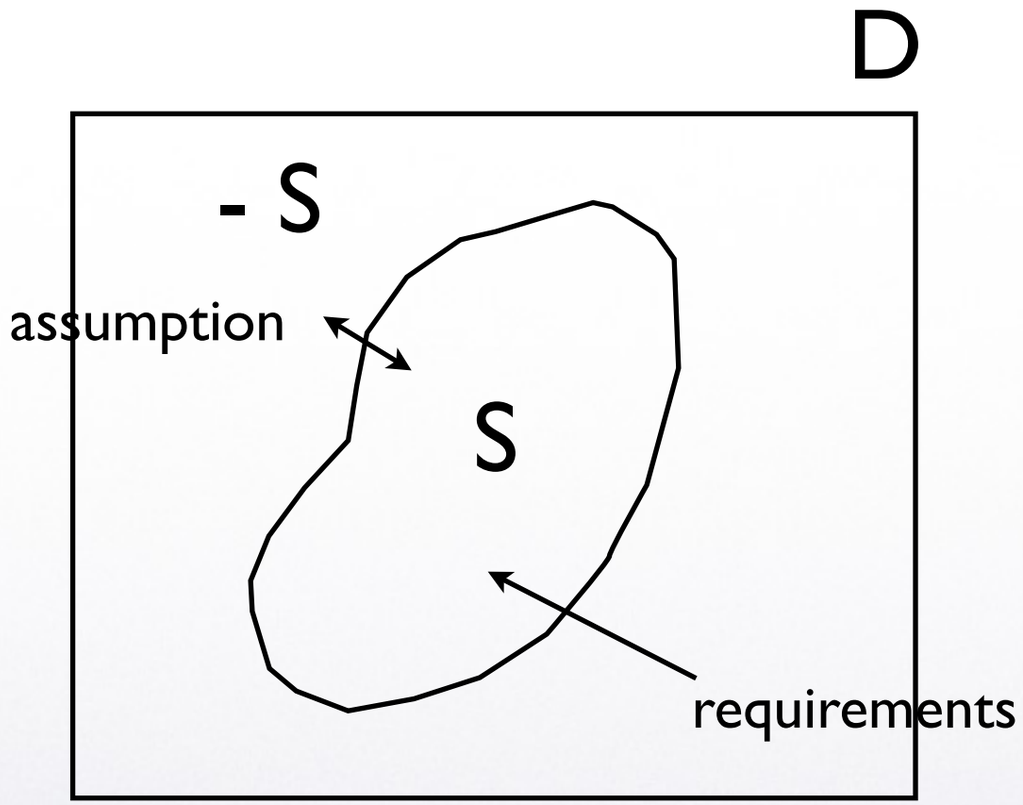
Contexto



Dominio de aplicação

functional

Goals

non-funcional

Requisitos orientados a objetivos (goals)

What are goals?
A *goal* is an objective the system under consideration should achieve. Goal formulations thus refer to intended properties to be ensured; they are optative statements as opposed to indicative ones, and bounded by the subject matter

Axel van Lamsweerde, Goal Oriented Requirement Engineering: a Guided Tour, RE 2001, Toronto

Exemplos

Atender mais passageiros

Agilizar e personalizar o atendimento

garantir a circulação com segurança e rapidez

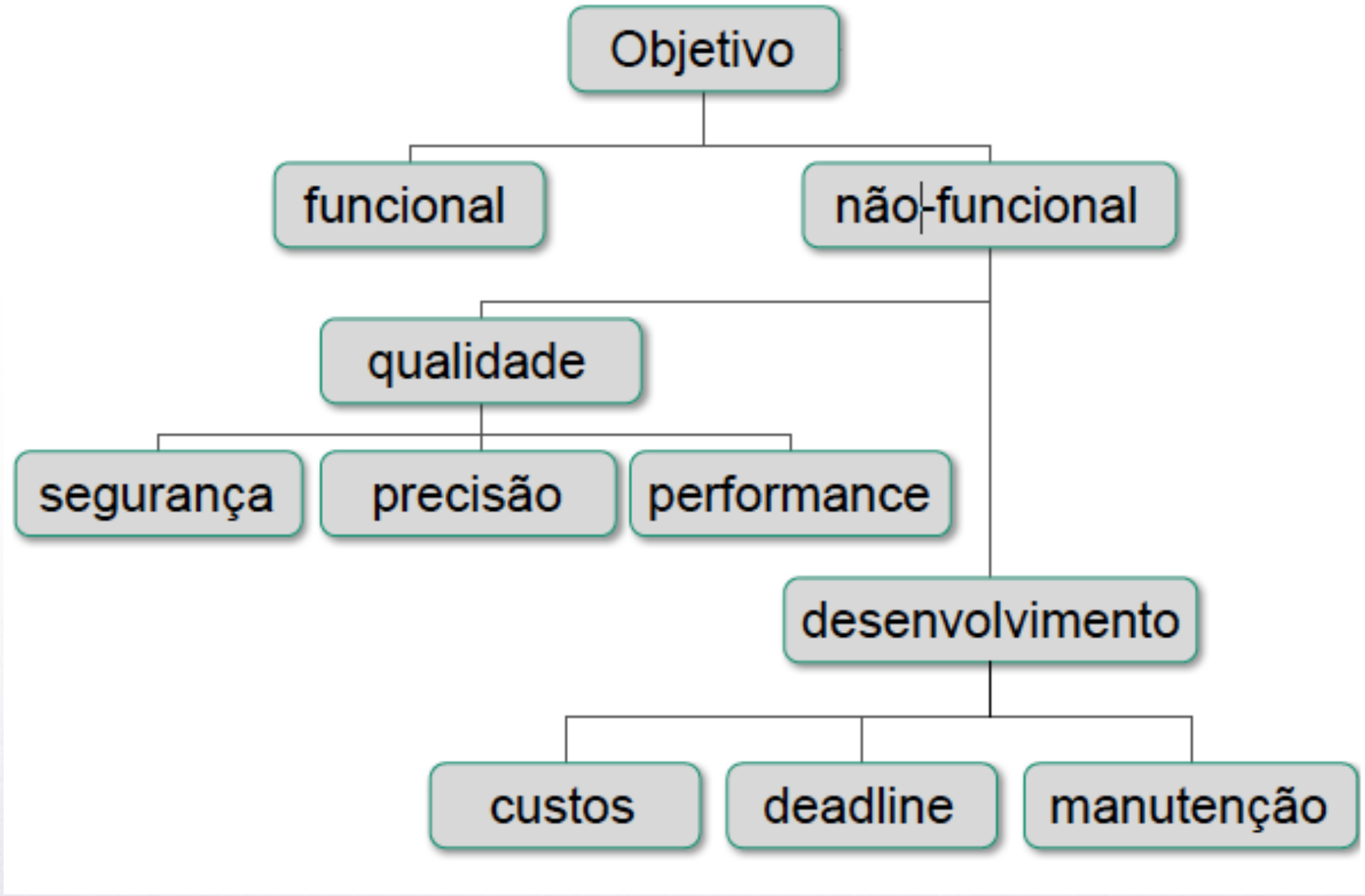
Goals (objetivos) integram o funcional e o não funcional

funcional

não-funcional

Goals also cover different types of concerns: functional concerns associated with the services to be provided, and non- functional concerns associated with quality of service such as safety, security, accuracy, performance, and so forth.

Uma estratégia mais inteligente seria basear a busca pelos requisitos em conceitos que integrem o funcional e o não-funcional evitando o dilema da escolha ou da prioridade.


Objetivo
funcional
não-funcional
qualidade
segurança
precisão
performance
desenvolvimento
custos
deadline
manutenção

Porque goals (objetivos)?

Why are goals needed?
There are many reasons why goals are so important in the RE process.
• Achieving requirements completeness is a major RE concern.. Goals provide a precise criterion for *sufficient completeness* of a requirements specification; the specification is complete with respect to a set of goals if all the goals can be proved to be achieved from the specification and the properties known about the domain considered.

O stakeholder é o "único" que pode encerrar/validar um ciclo de requisitos

É difícil distinguir quando um requisito que se refere a algum aspecto do sistema foi plenamente eliciado. Por isso a preocupação com a fase inicial dado que esta primeira visão sobre o sistema, nesta representação abstrata, pode se propagar por todo o processo de eliciação e talvez para as próximas fases.

• Avoiding irrelevant requirements is another major RE concern. Goals provide a precise criterion for requirements *pertinence*; a requirement is pertinent with respect to a set of goals in the domain considered if its specification is used in the proof of one goal at least.

• Explaining requirements to stakeholders is another important issue. Goals provide the rationale for requirements, in a way similar to design goals in design processes [Mos85, Lee91]. A requirement appears because of some underlying goal which provides a base for it [Ros77, Dar91, Som97]. More explicitly, a goal refinement tree provides traceability links from high-level strategic objectives to low-level technical requirements. In particular, for business application systems, goals may be used to relate the software-to-be to organizational and business contexts

Objetividade é outro aspecto importante. É preciso ter um conjunto minimal de requisitos válidos.

facilita o reuso

Validação e traceability (discutido na aula passada) são outros aspectos importantes para uma boa fase de eliciação e análise de requisitos.

facilita a manutenção

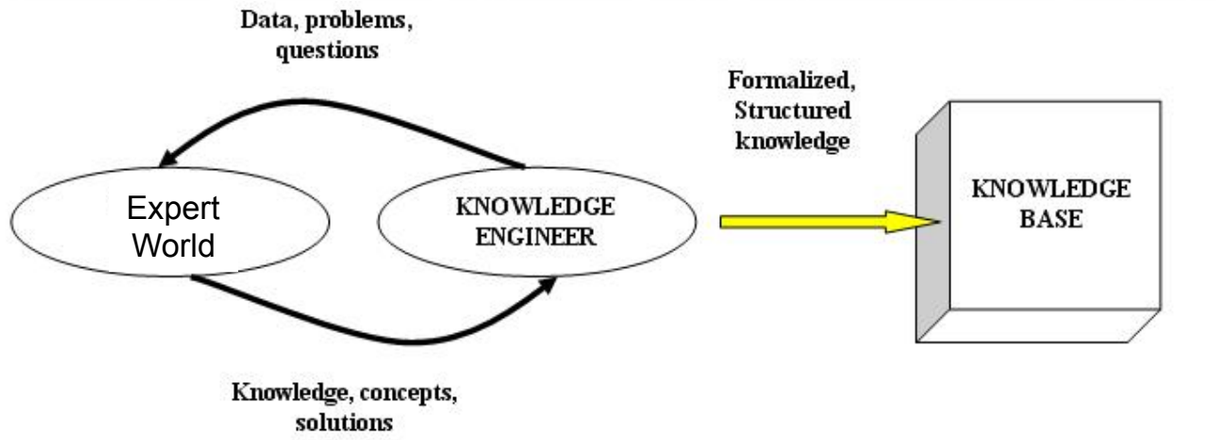
KAOS: Knowledge Acquisition in Automated Specification

KAOS is one method for formalising goals into requirements

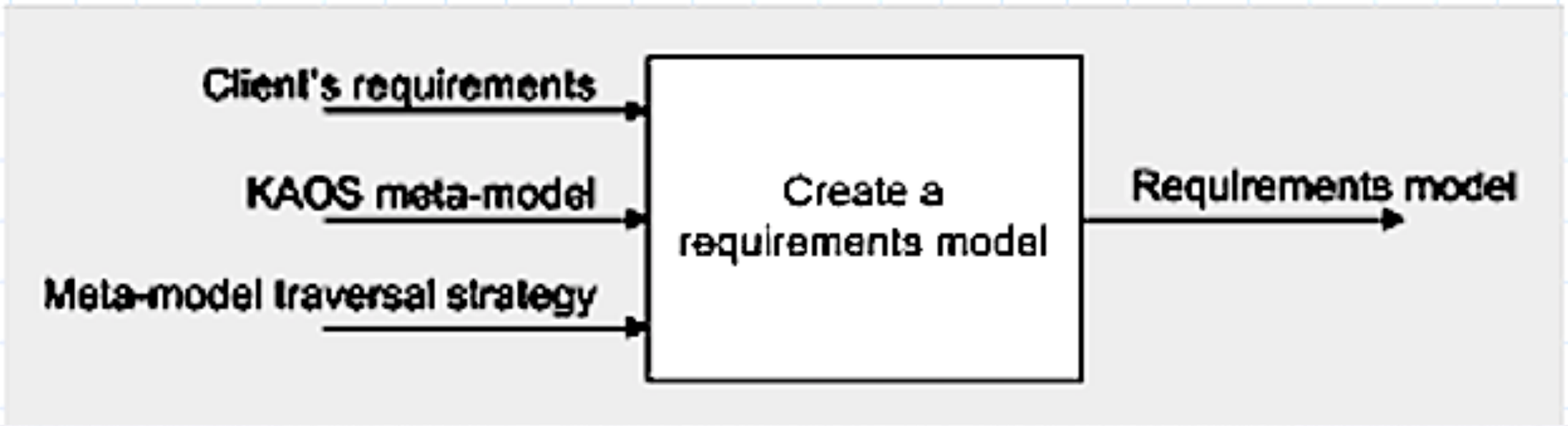
KAOS is a research project, but it is well documented, and has tool support from a tool called GRAIL

The aim of the ***KAOS approach*** is to derive a description of a system's behaviour and an initial analysis of its structure through acquiring and formalising functional and non-functional goals for a composite system

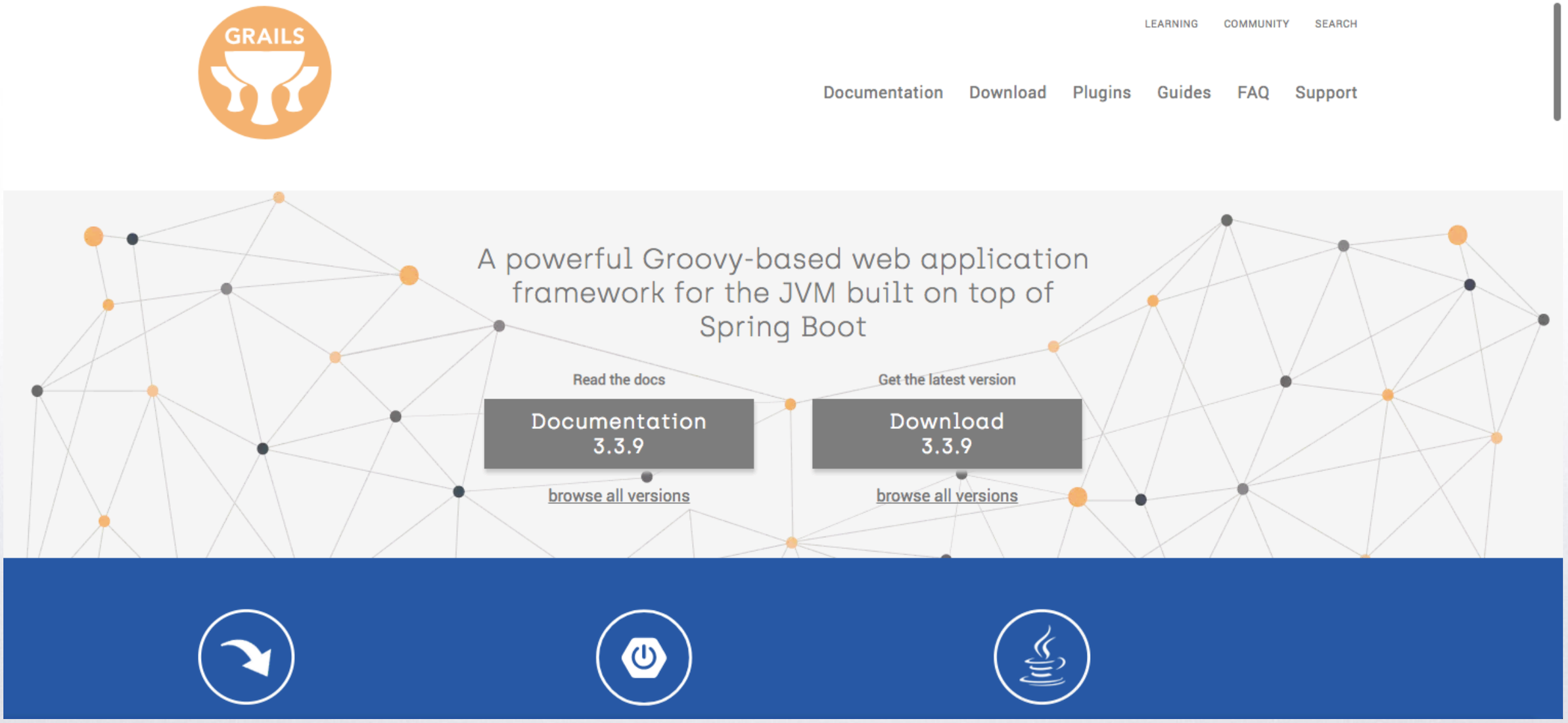
Stewart Green



KAOS estruturado



grails.org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A powerful Groovy-based web application framework for the JVM built on top of Spring Boot
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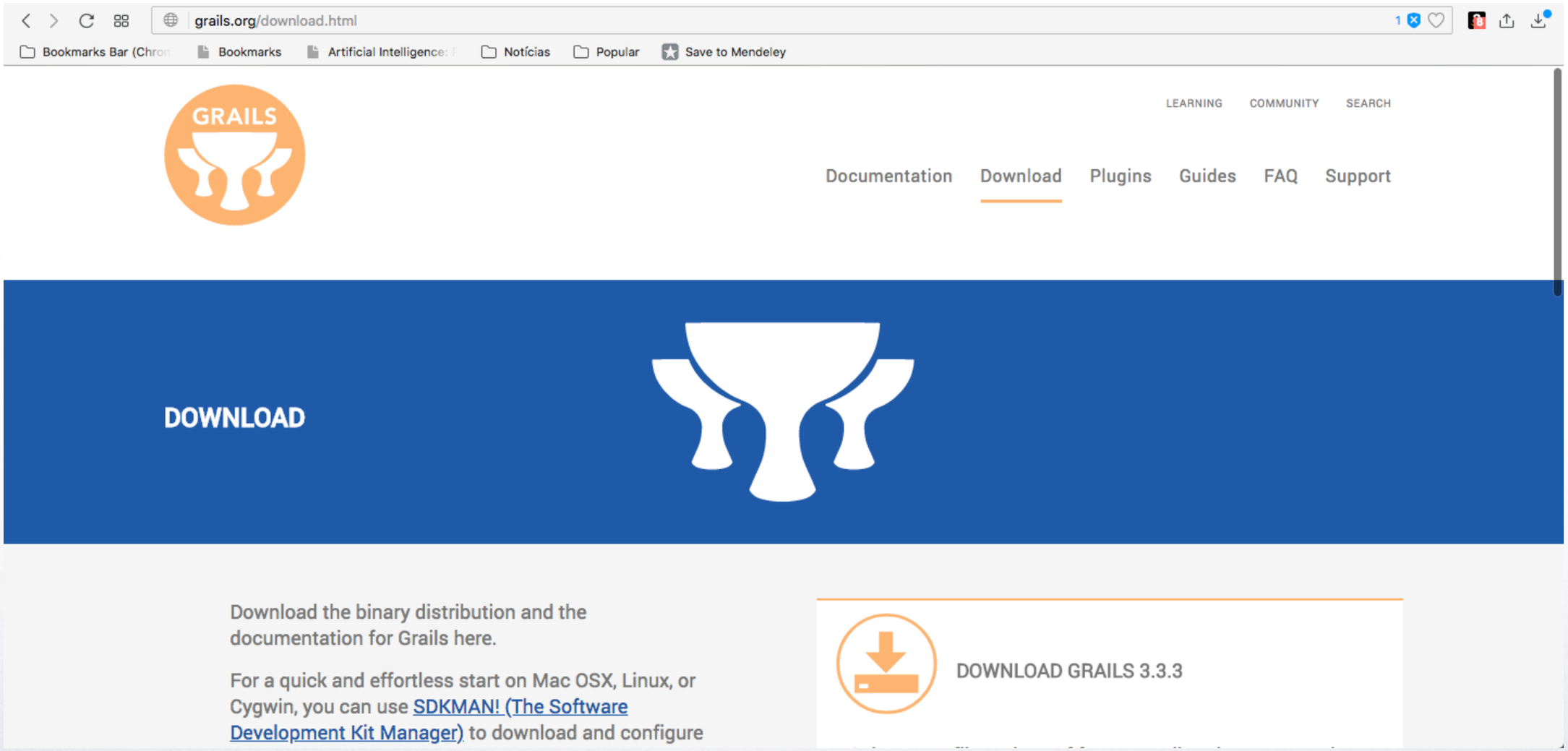
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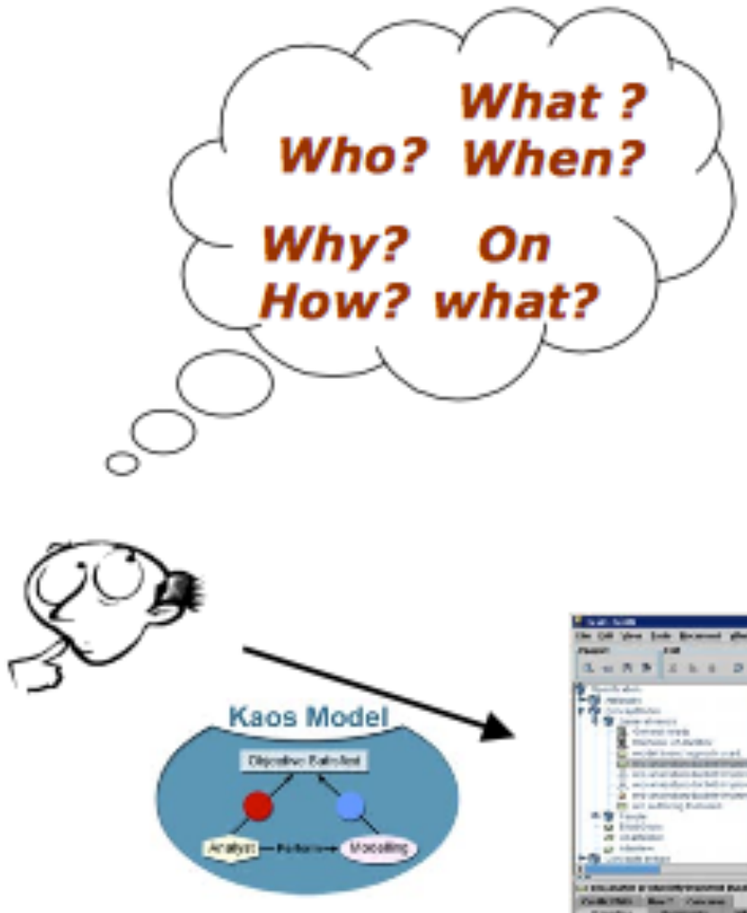
Support
DOWNLOAD
Download the binary distribution and the documentation for Grails here.
For a quick and effortless start on Mac OSX, Linux, or Cygwin, you can use SDKMAN! (The Software Development Kit Manager) to download and configure
DOWNLOAD GRAILS 3.3.3

GRAIL

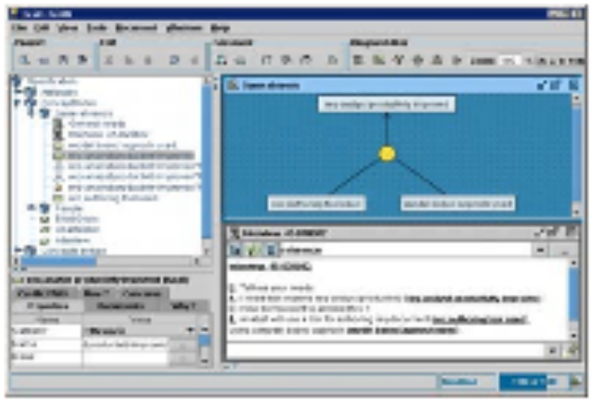
GRAIL[1] is a tool designed by RE practionners for RE practionners, to help them really **engineer requirements.** The tool relies on **KAOS**[2], the **goal-driven** requirements methodology. It helps industrial projects to succeed by **effectively** and **systematically eliciting** the requirements, defining system's agents and artefacts along with their expected behaviours. These elements are gathered, and linked together in a unique coherent model. GRAIL automates authoring process by **deriving** the requirements documents directly from the model.

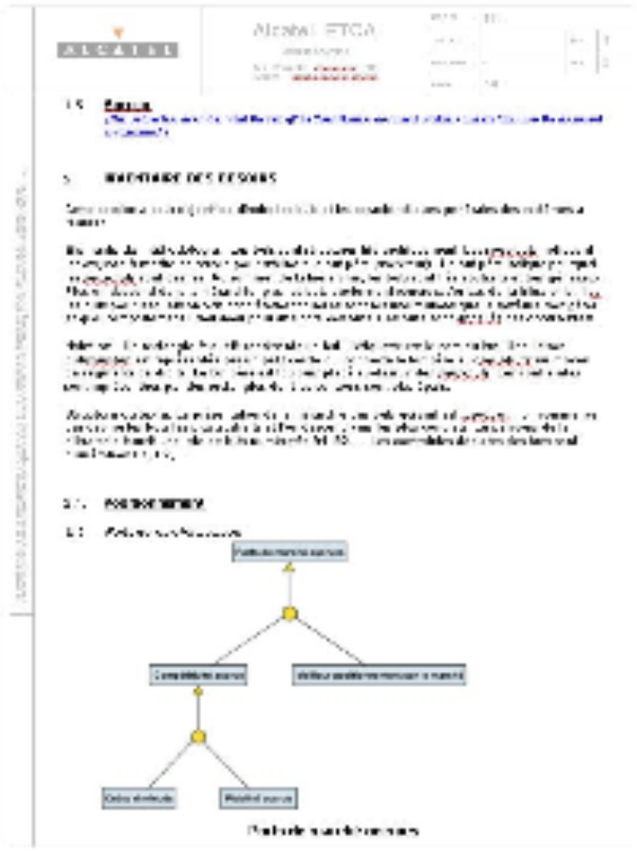
[1] More information on GRAIL at Cediti can be found at URL http://www.cediti.be/EN/Solutions_Services/requirements/

[2] More information on KAOS at UCL can be found at URL http://www.info.ucl.ac.be/research/projects/AVL//ReqEng.html

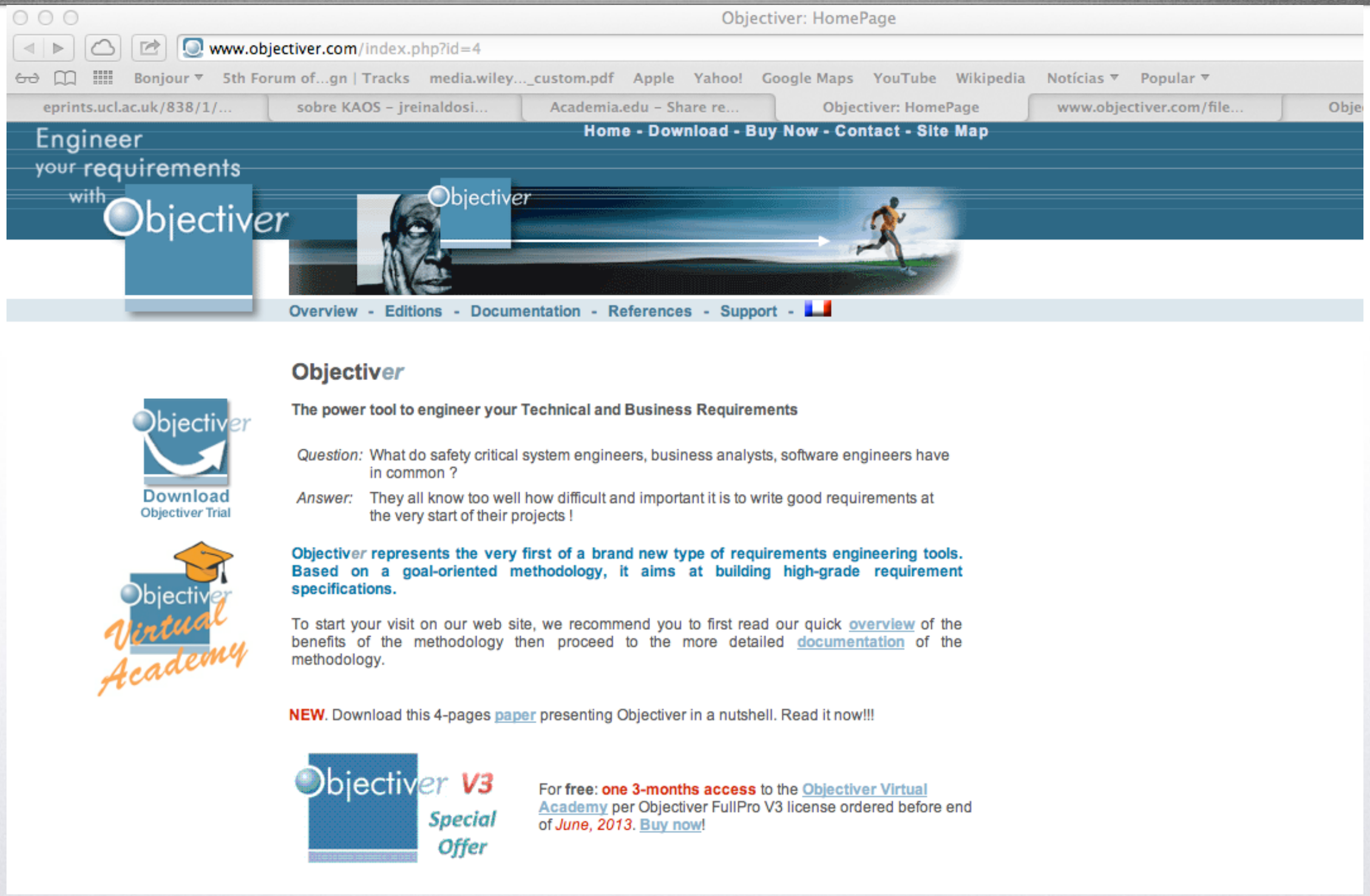

What ?
Who? When?
Why? On
How? what?
Kaos Model
Objective Refined
Analyst
Refine
Modelling


Corporate
Standard





Grail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New Paradigm for requirements analysis

Axel Van Lamsweerde

	Todos	Desde 2009
Citações	10431	4872
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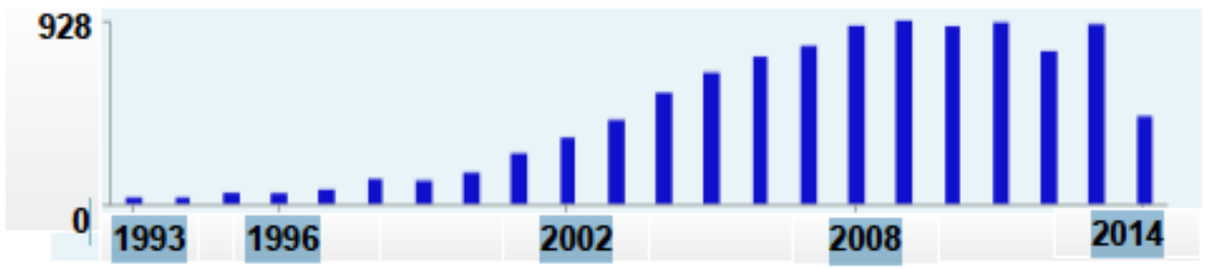
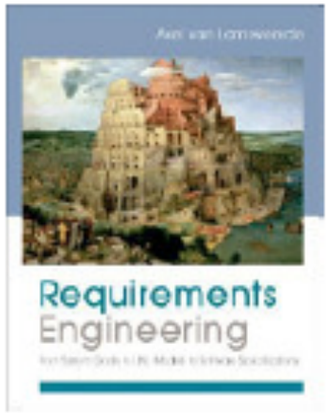




Requirements Engineering: From System Goals to UML Models to Software Specifications

REquirements & **SPEC**ification **T**echniques for **I**nformation **T**echnology

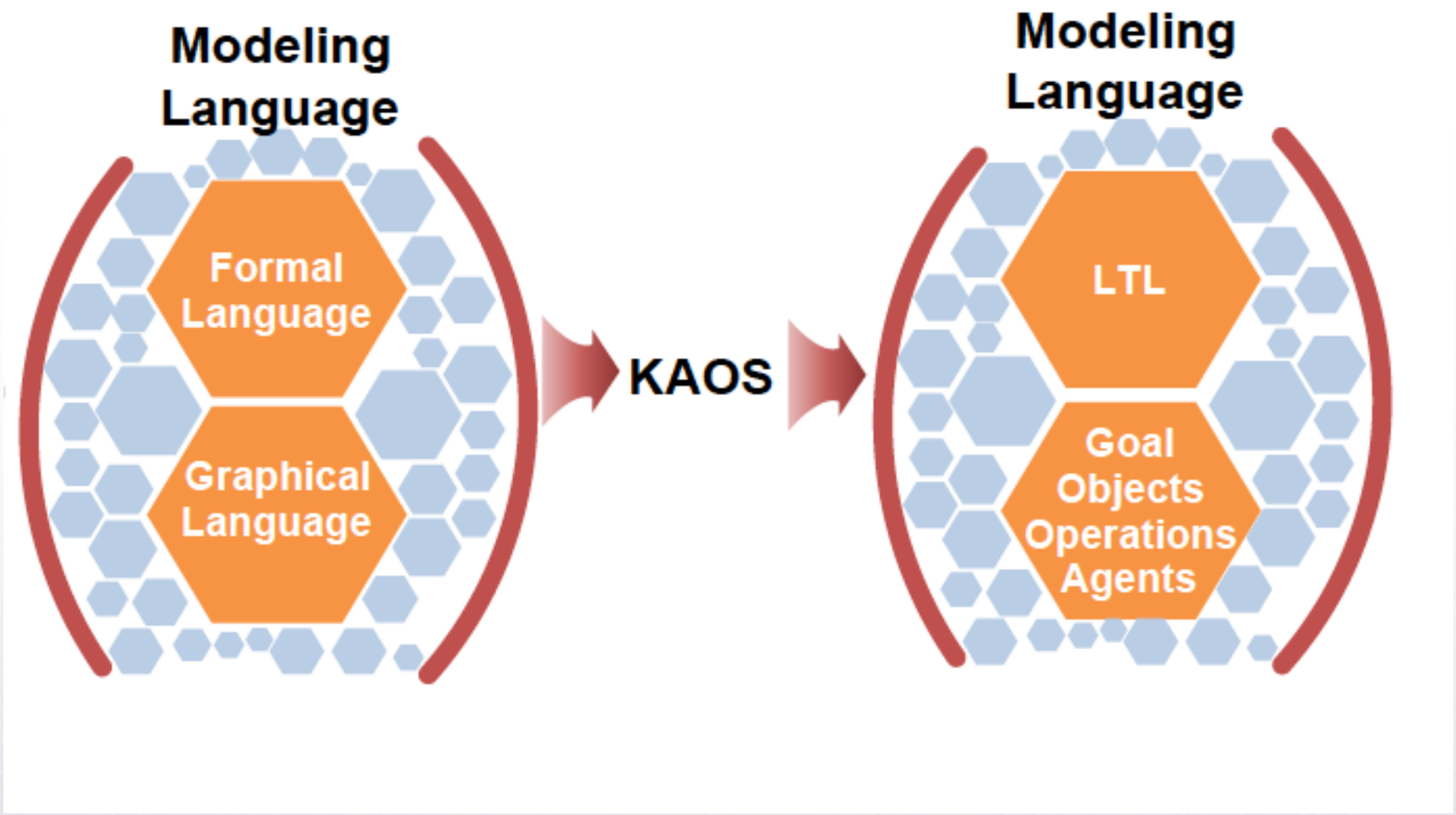
Spin out of UCL (University of Louvain-Belgium).

Scientific Advisor: Prof. Axel Van Lamswerde.

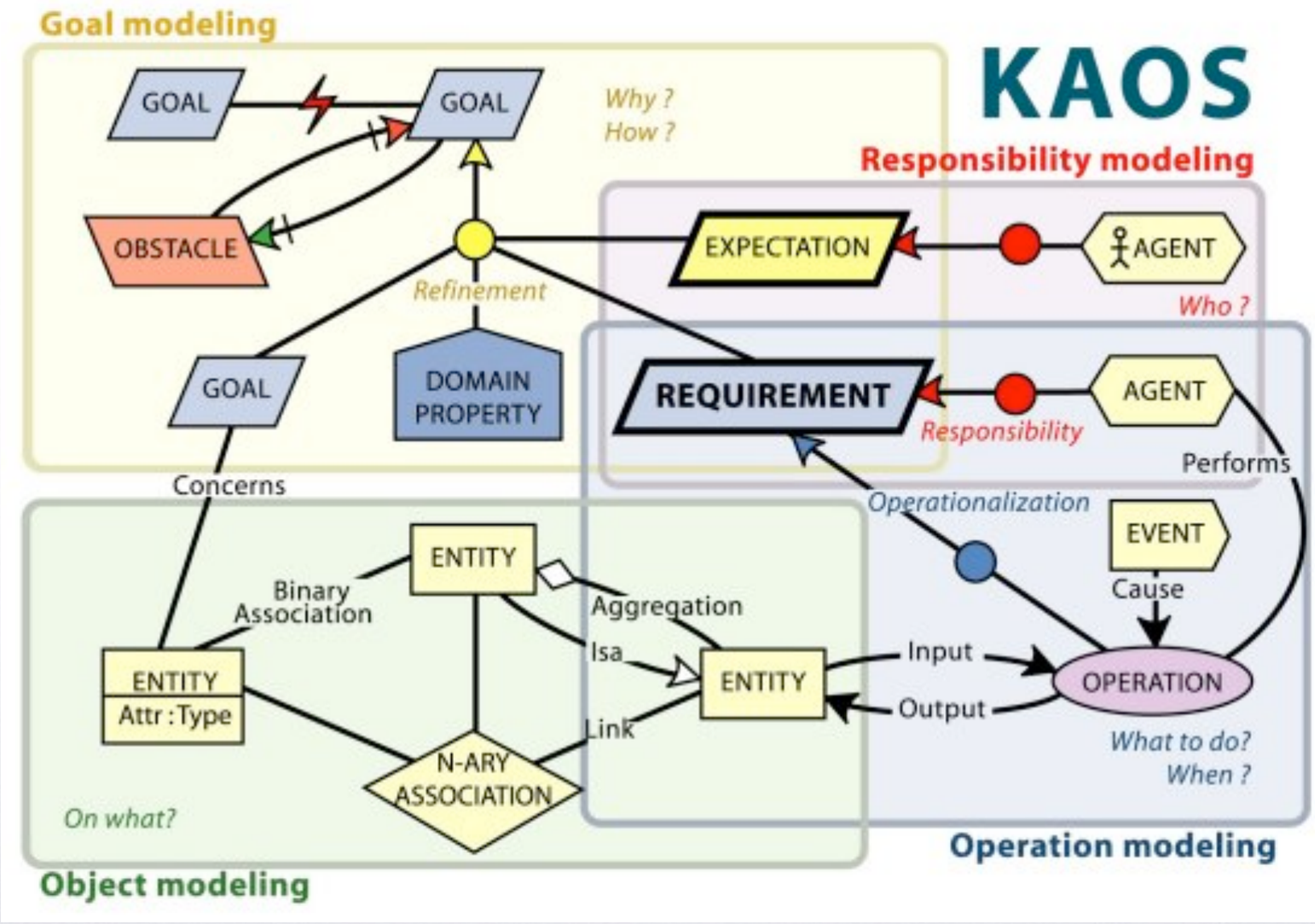
Main activities:

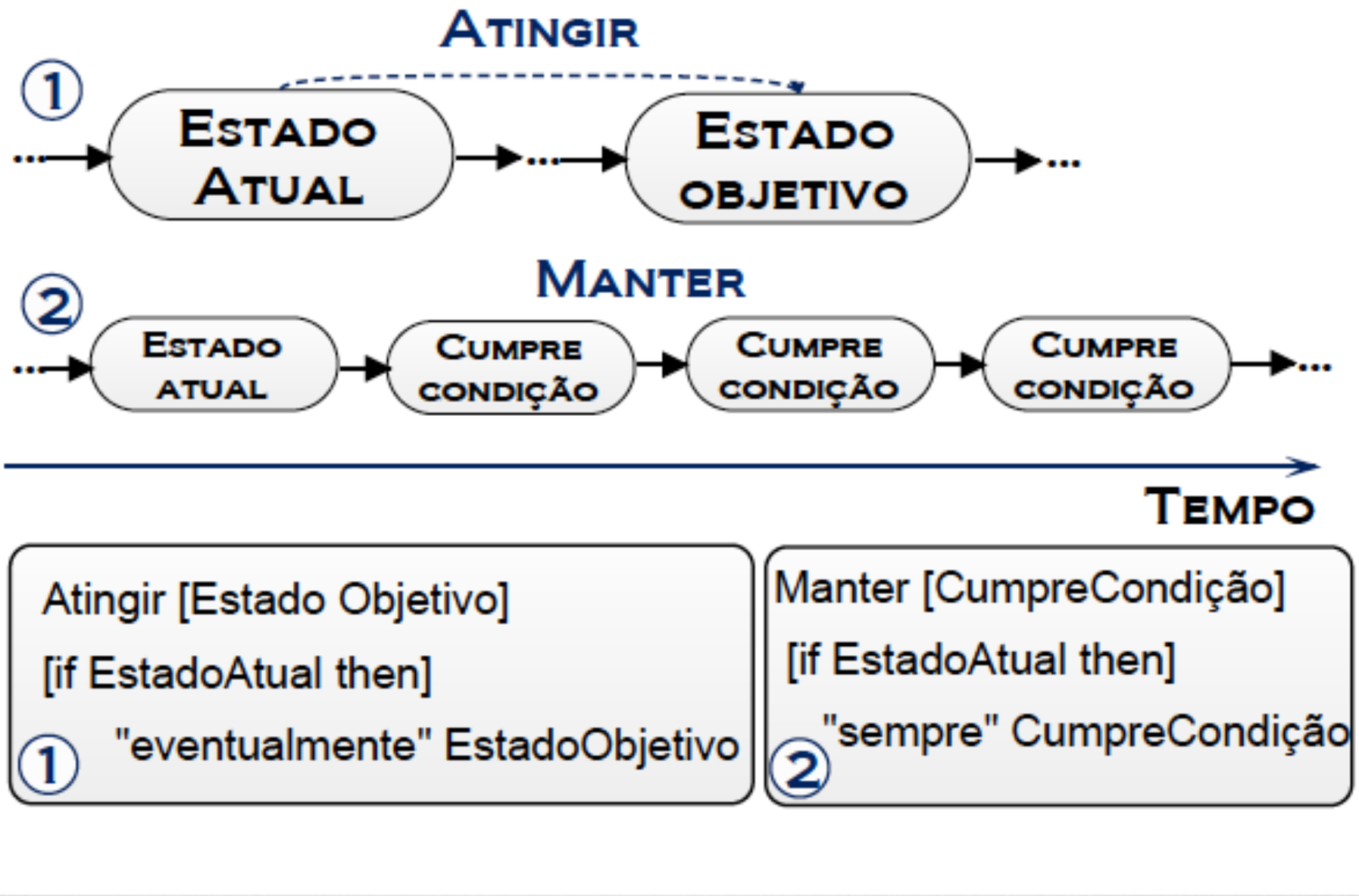
- Consultancy service in GORE.
- Tool Editor

Requirements modeling with KAOS



KAOS metamodel




ATINGIR
1
ESTADO ATUAL
ESTADO OBJETIVO
MANTER
2
ESTADO ATUAL
CUMPRE CONDIÇÃO
CUMPRE CONDIÇÃO
CUMPRE CONDIÇÃO
TEMPO
Atingir [Estado Objetivo]
[if EstadoAtual then]
1 "eventualmente" EstadoObjetivo
Manter [CumpreCondição]
[if EstadoAtual then]
2 "sempre" CumpreCondição

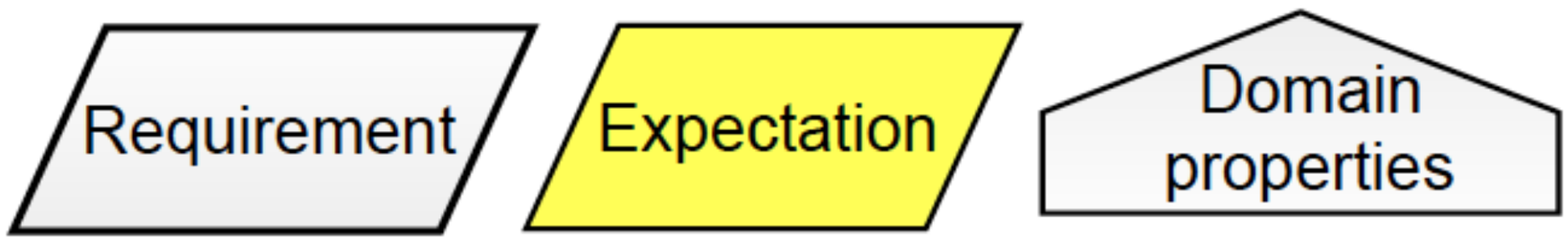
$$R, E, D \vdash G$$

"In view of properties D of the domain, the requirements R will achieve goals G under expectations E"

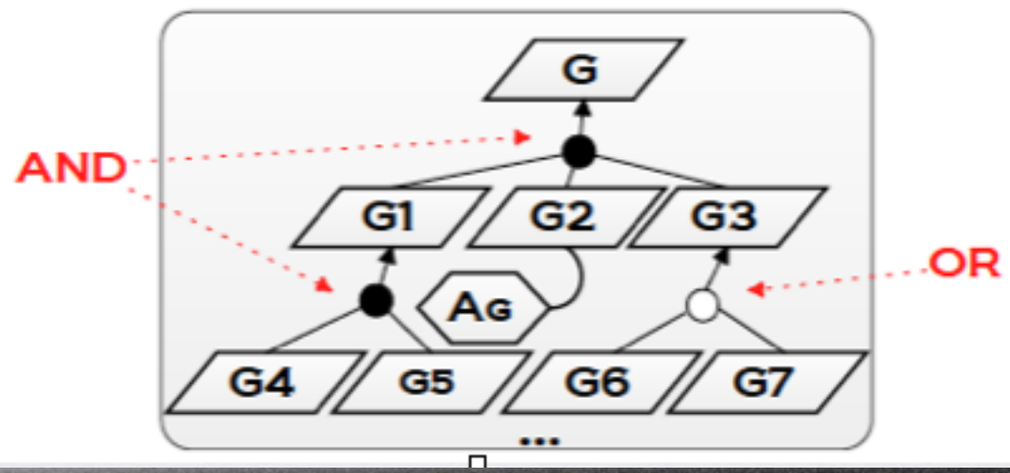
Requirement: Goal assigned to single agente in software-to-be.

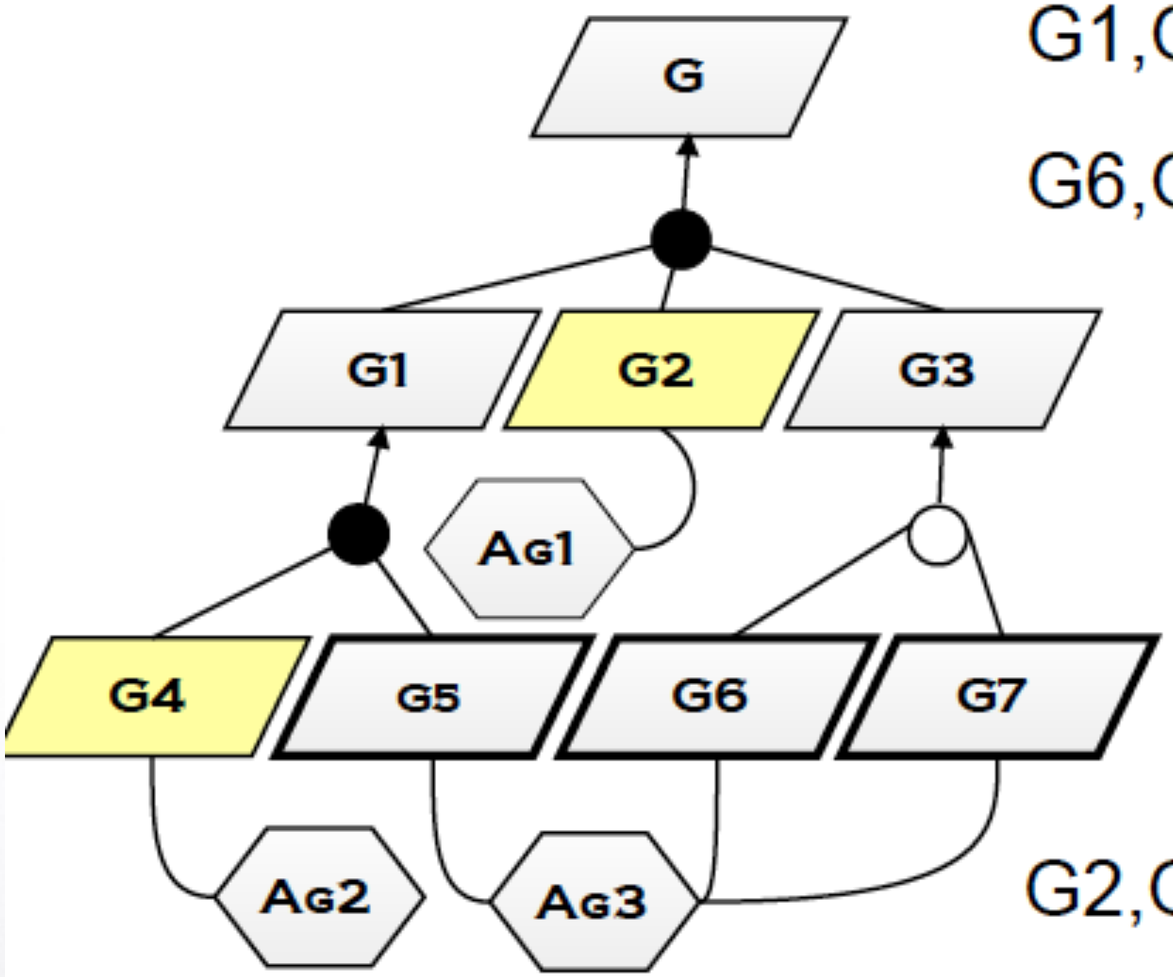
Expectation: Goal assigned to single agente in environment.

Domain properties: Descriptive statements about environment(physical laws, organizational policies)



- O refinamento AND do objetivo G nos sub-objetivos $G_1, ..., G_n$ expressa que G se cumpre, satisfazendo os sub-objetivos $G_1, ..., G_n$.
  - O conjunto é chamado de refinamento de G.
  - O sub-objetivo G_i é é uma contribuição positiva para G.
- O refinamento OR do objetivo G nos sub-objetivos $R_1, ..., R_m$ expressa que G se cumpre, satisfazendo pelo menos um sub-objetivo R_i do refinamento.
  - O(s) sub-objetivo(s) são chamados de alternativa(s) do refinamento.





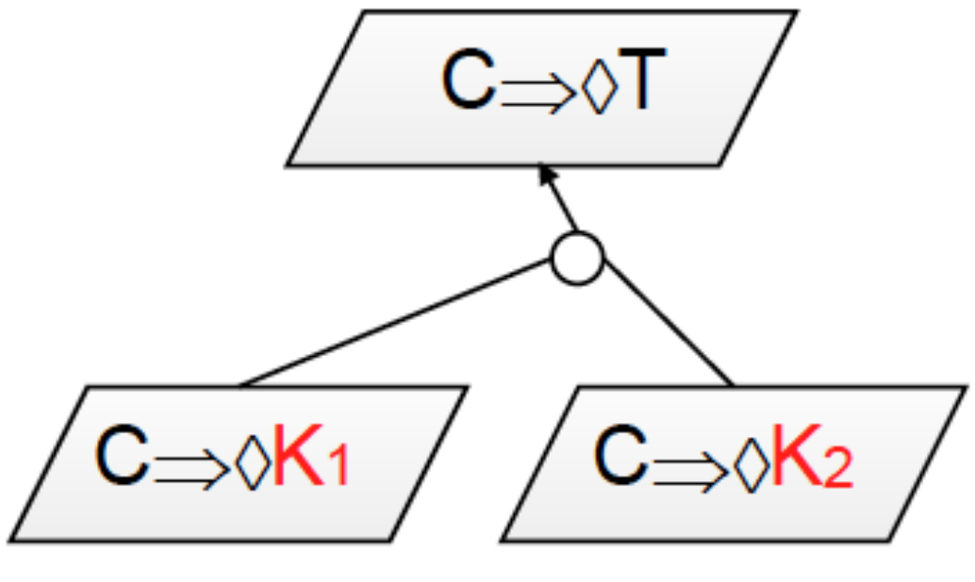
G1,G2,G3 **refinement** of G.

G6,G7 **alternatives** of G3.

G2,G4 **expectations** of agents Ag1 and Ag2.

G5,G6,G7 **requirements** of agents Ag3.

CASE-DRIVEN



$K_1 \vee K_2 \Rightarrow \Diamond C$: $K_1 \Rightarrow \Diamond C$, $\vee K_2 \Rightarrow \Diamond C$. Then:

$K_1 \Rightarrow \Diamond T$, $K_2 \Rightarrow \Diamond T$.

Rule generalization

$K_1 \vee K_2 \vee \ldots \vee K_n \Rightarrow \Diamond C$:

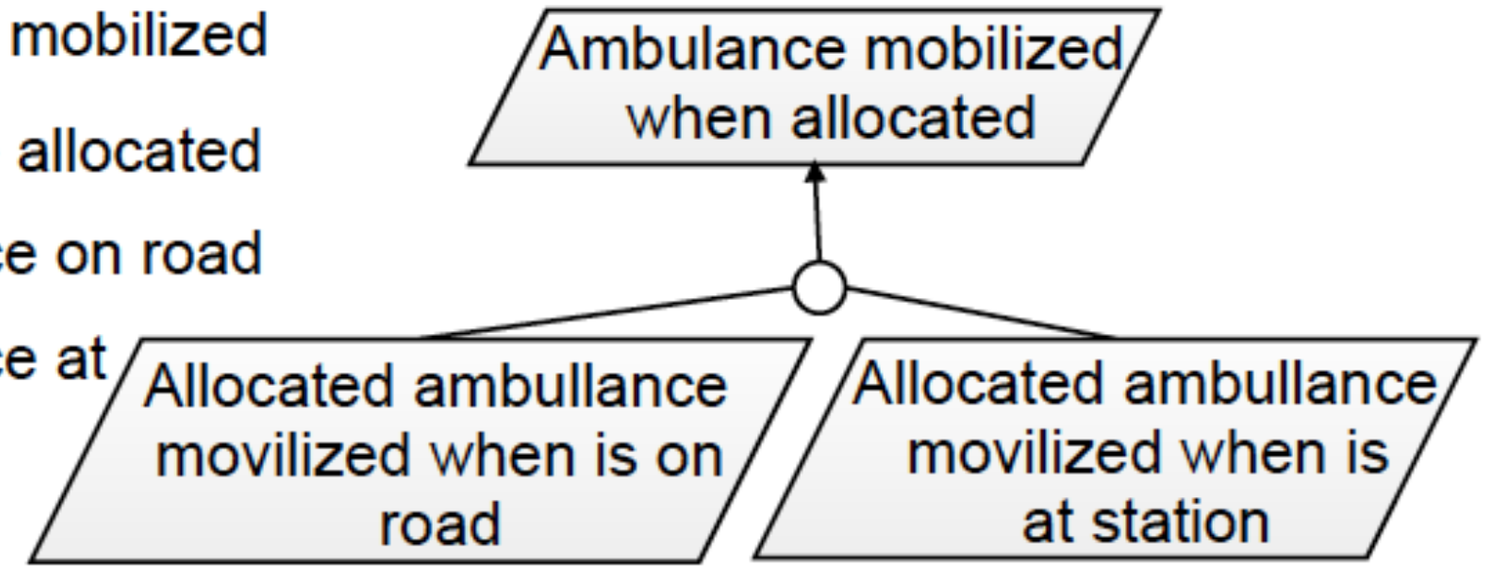
$K_1 \vee K_2 \vee \ldots \vee K_n \Rightarrow \Diamond T$.

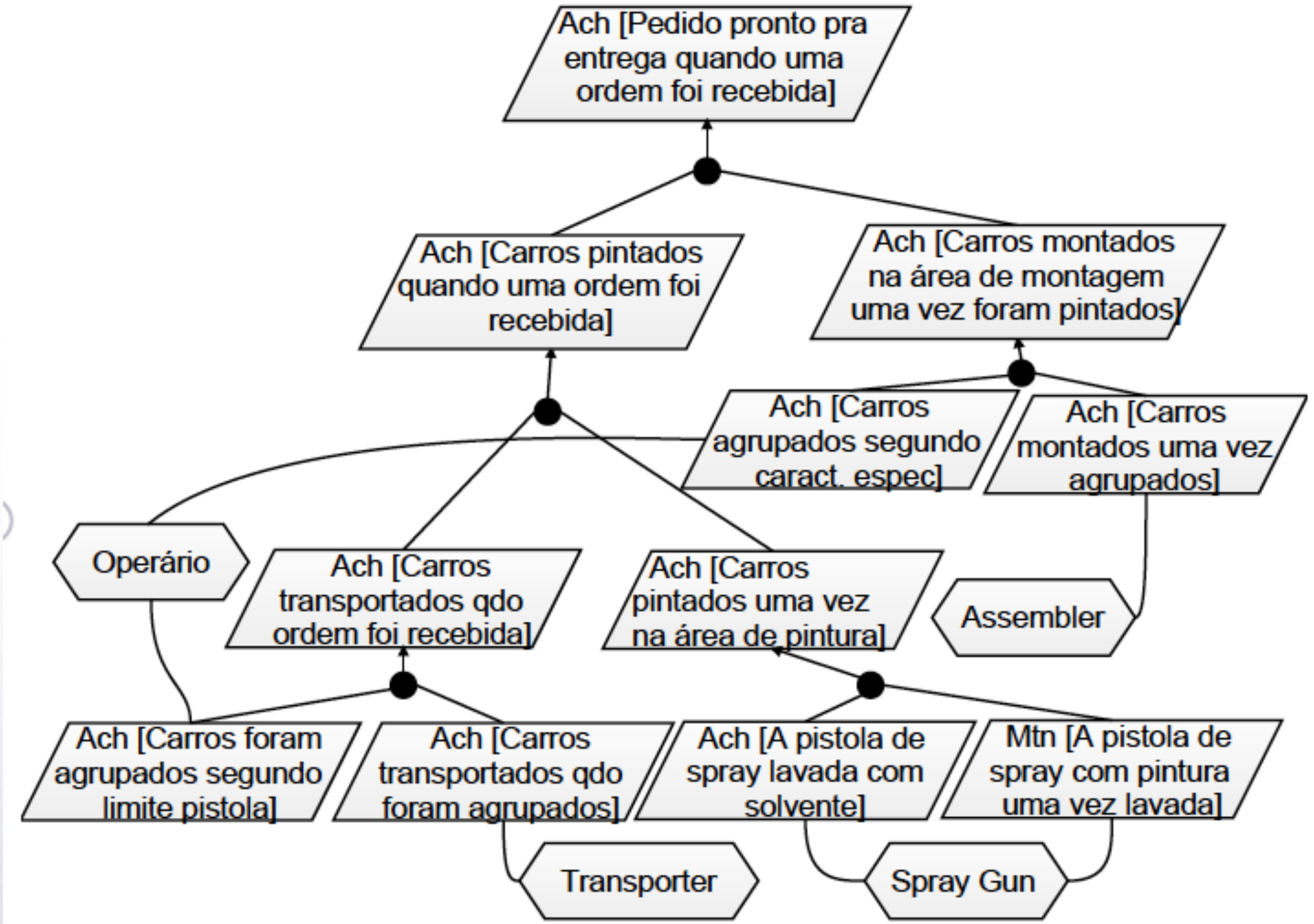
T:Ambullance mobilized

C:Ambullance allocated

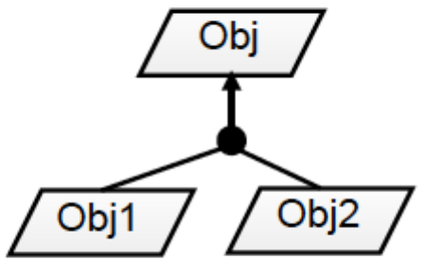
K_1: Ambullance on road

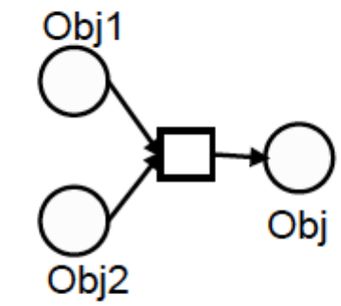
K_2: Ambullance at station.



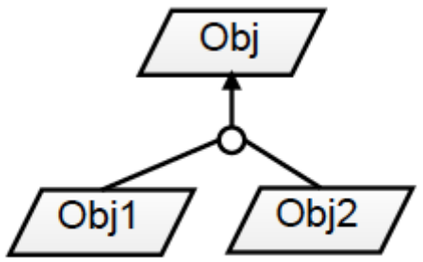

Ach [Pedido pronto pra entrega quando uma ordem foi recebida]
Ach [Carros pintados quando uma ordem foi recebida]
Ach [Carros montados na área de montagem uma vez foram pintados]
Ach [Carros agrupados segundo caract. espec]
Ach [Carros montados uma vez agrupados]
Operário
Ach [Carros transportados qdo ordem foi recebida]
Ach [Carros pintados uma vez na área de pintura]
Assembler
Ach [Carros foram agrupados segundo limite pistola]
Ach [Carros transportados qdo foram agrupados]
Ach [A pistola de spray lavada com solvente]
Mtn [A pistola de spray com pintura uma vez lavada]
Transporter
Spray Gun

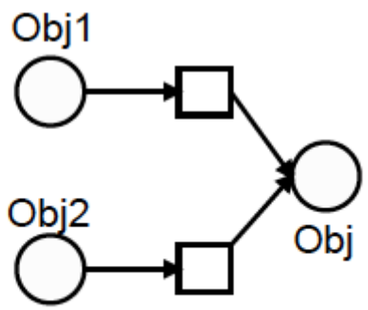
Refinamento-and



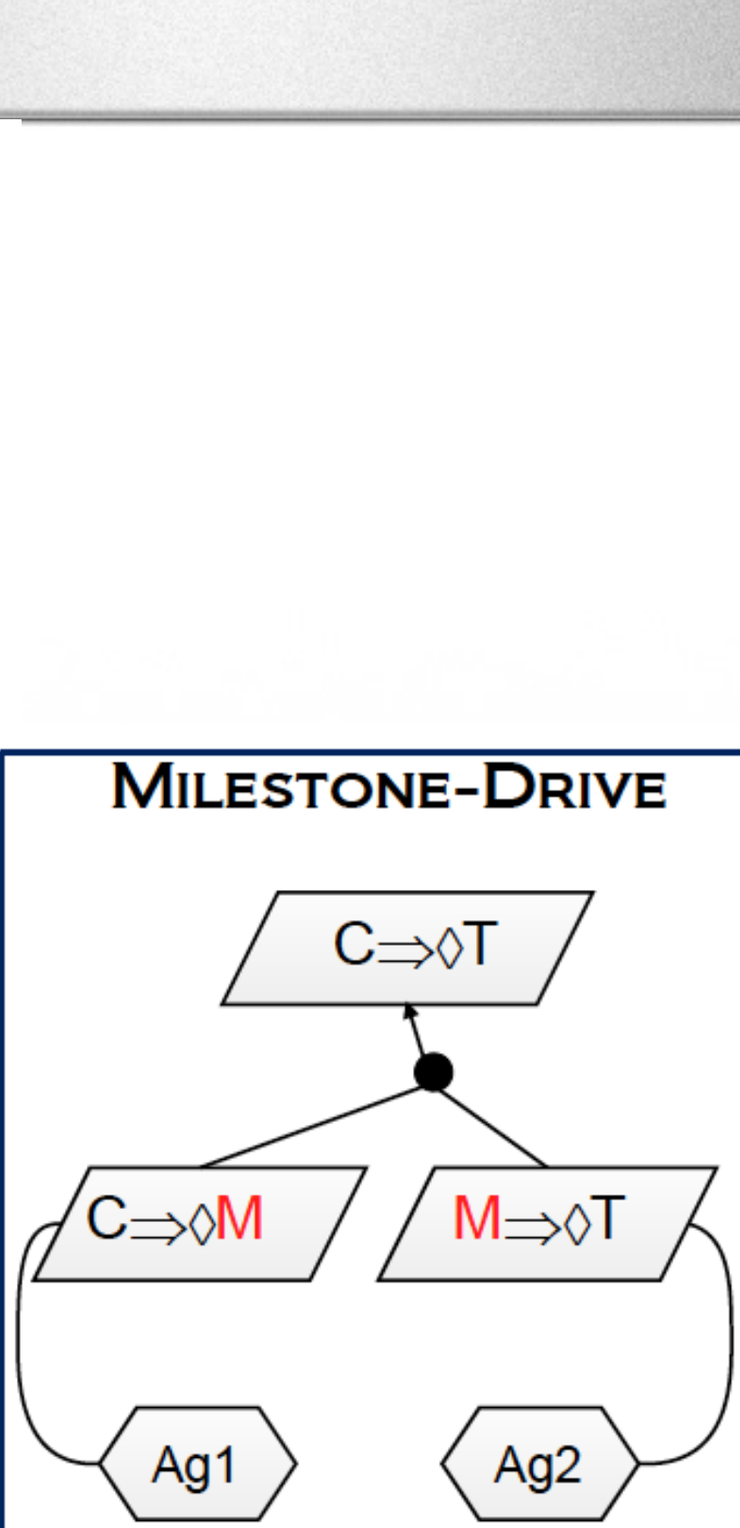


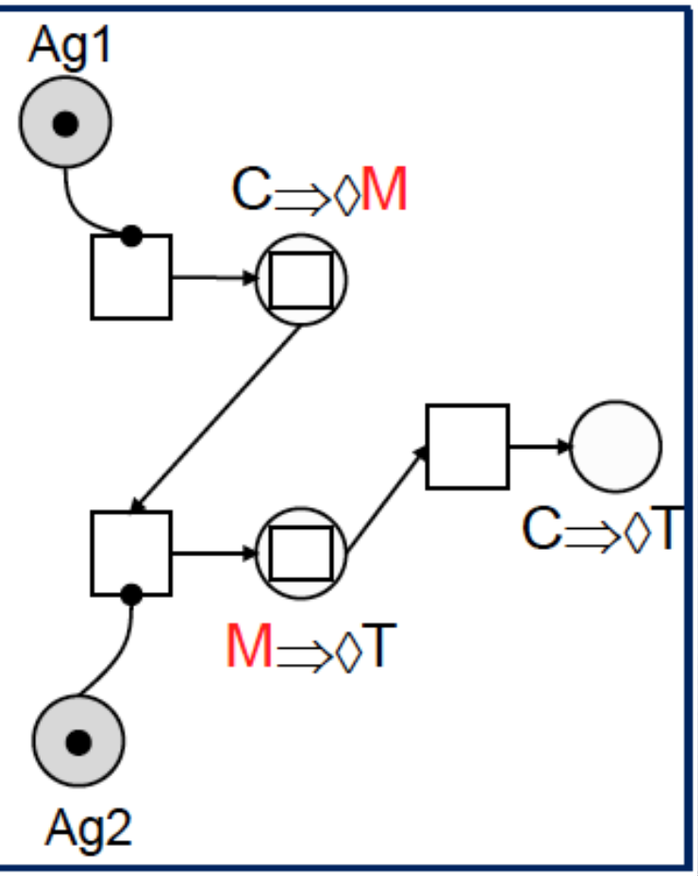
Refinamento-or





MILESTONE-DRIVE



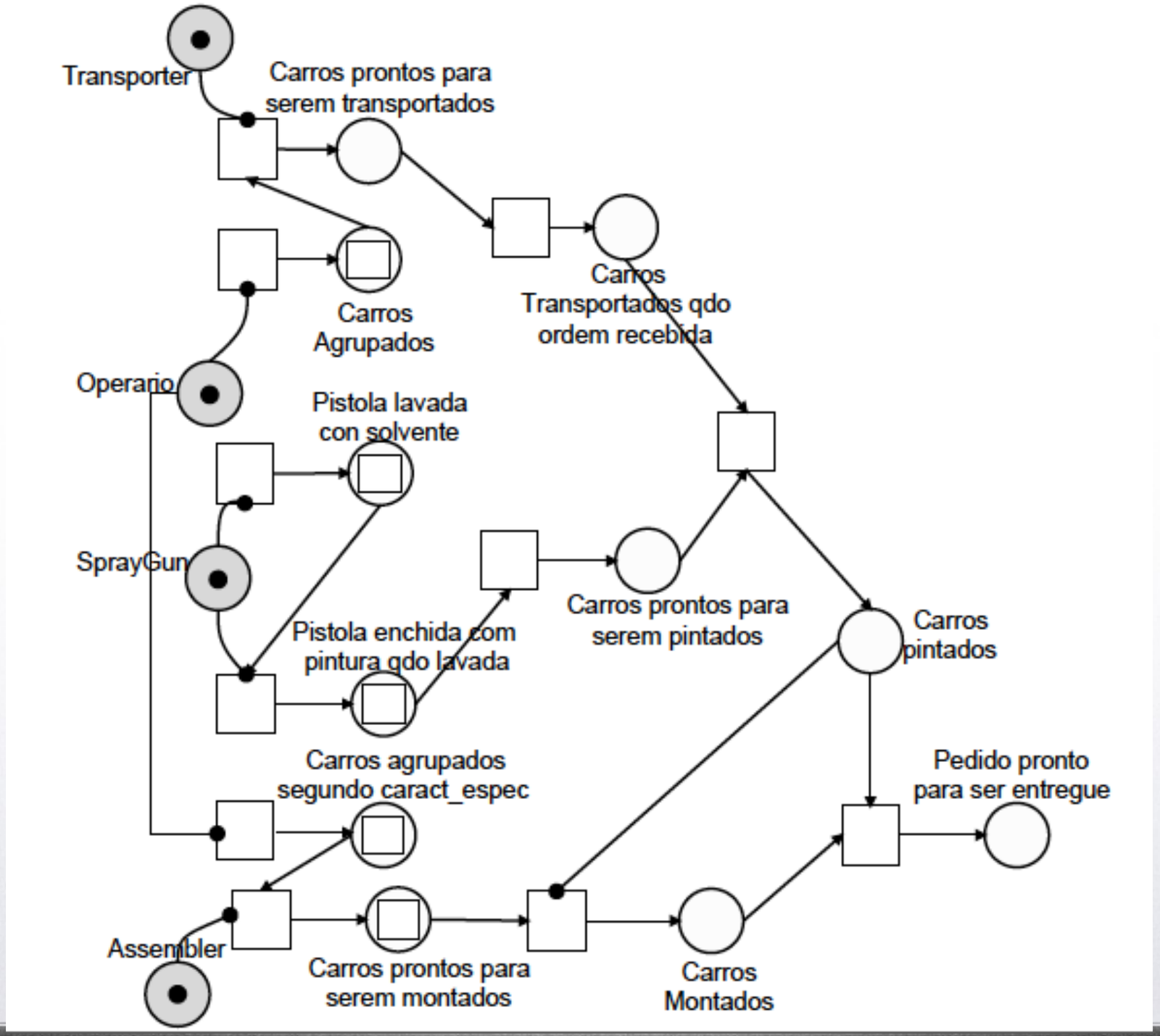


The goals take the general formal form:

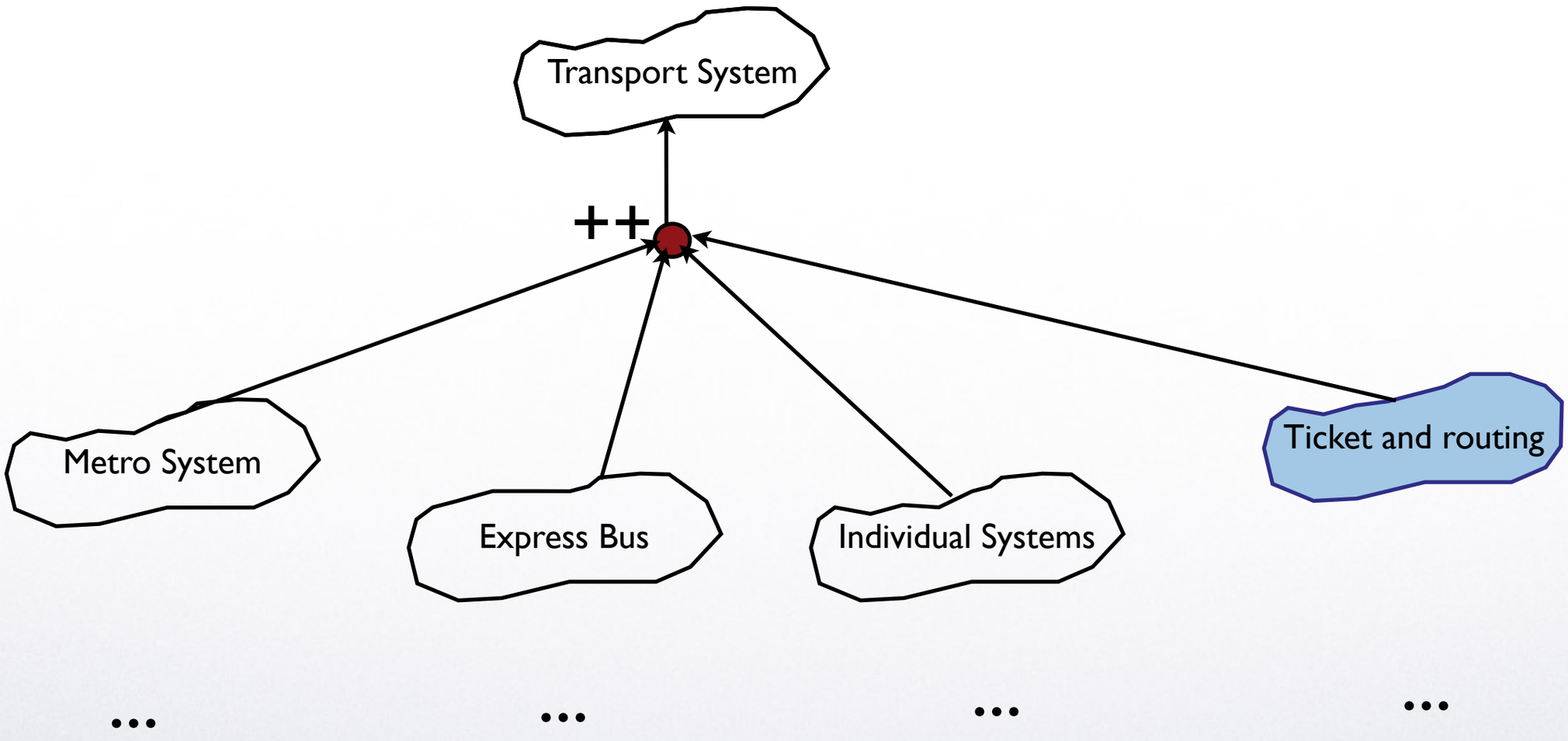
$$C \Rightarrow \Theta T$$

where:

- C is the current condition
- T is the target condition
- Θ represents a LTL operator such as:
  - $\bigcirc$: In the next state.
  - $\Diamond$: Sometimes in the future. [$\Diamond_{\leq d}$: Sometimes in the future before deadline d].
  - $\Box$: Always in the future. [$\Box_{\leq d}$: Always in the future up to deadline d]


Transporter
Carros prontos para serem transportados
Carros Agrupados
Carros Transportados qdo ordem recebida
Operario
Pistola lavada con solvente
SprayGun
Pistola enchida com pintura qdo lavada
Carros prontos para serem pintados
Carros pintados
Carros agrupados segundo caract_espec
Pedido pronto para ser entregue
Assembler
Carros prontos para serem montados
Carros Montados

Kaos and the system of system approach



Exemplo BART (Bay Area Rapid Transit)

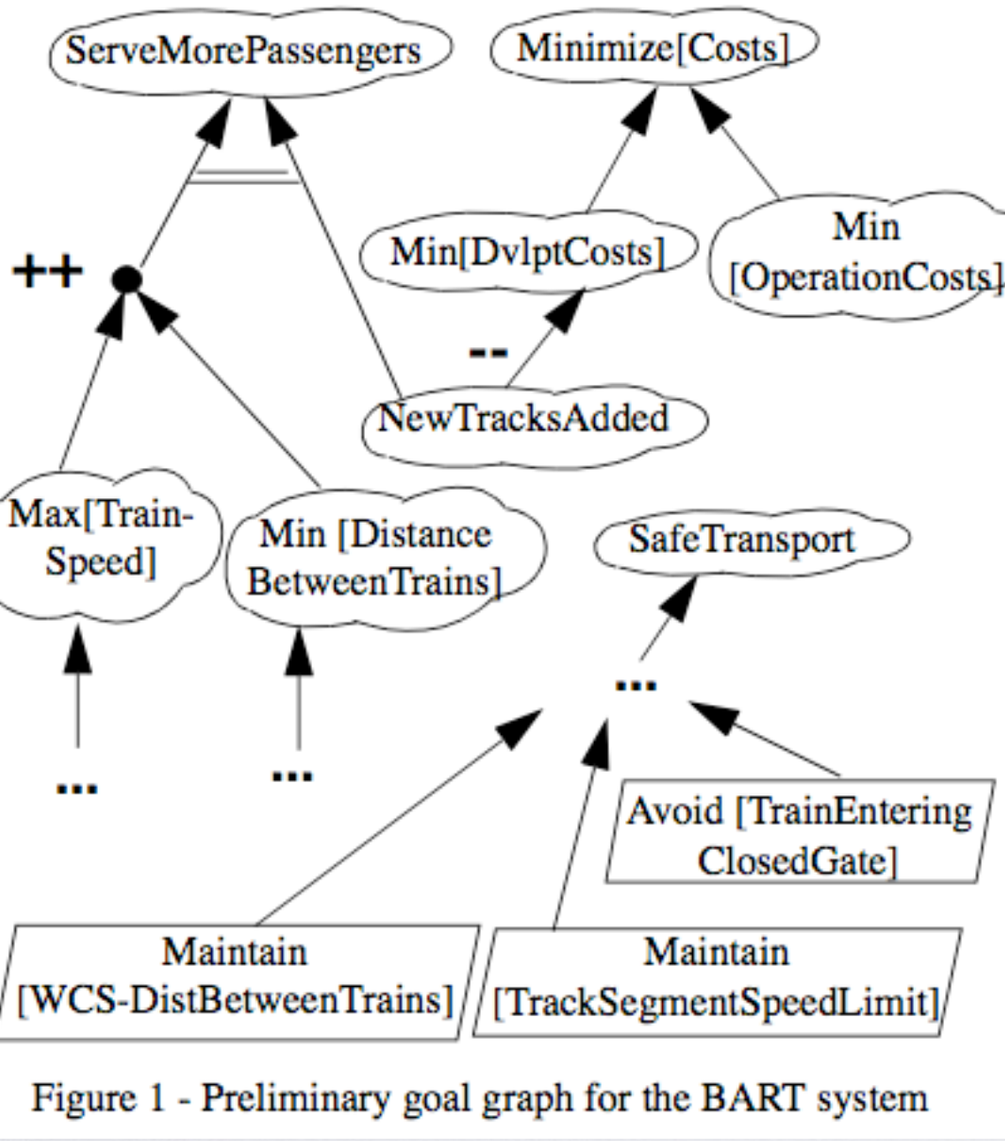
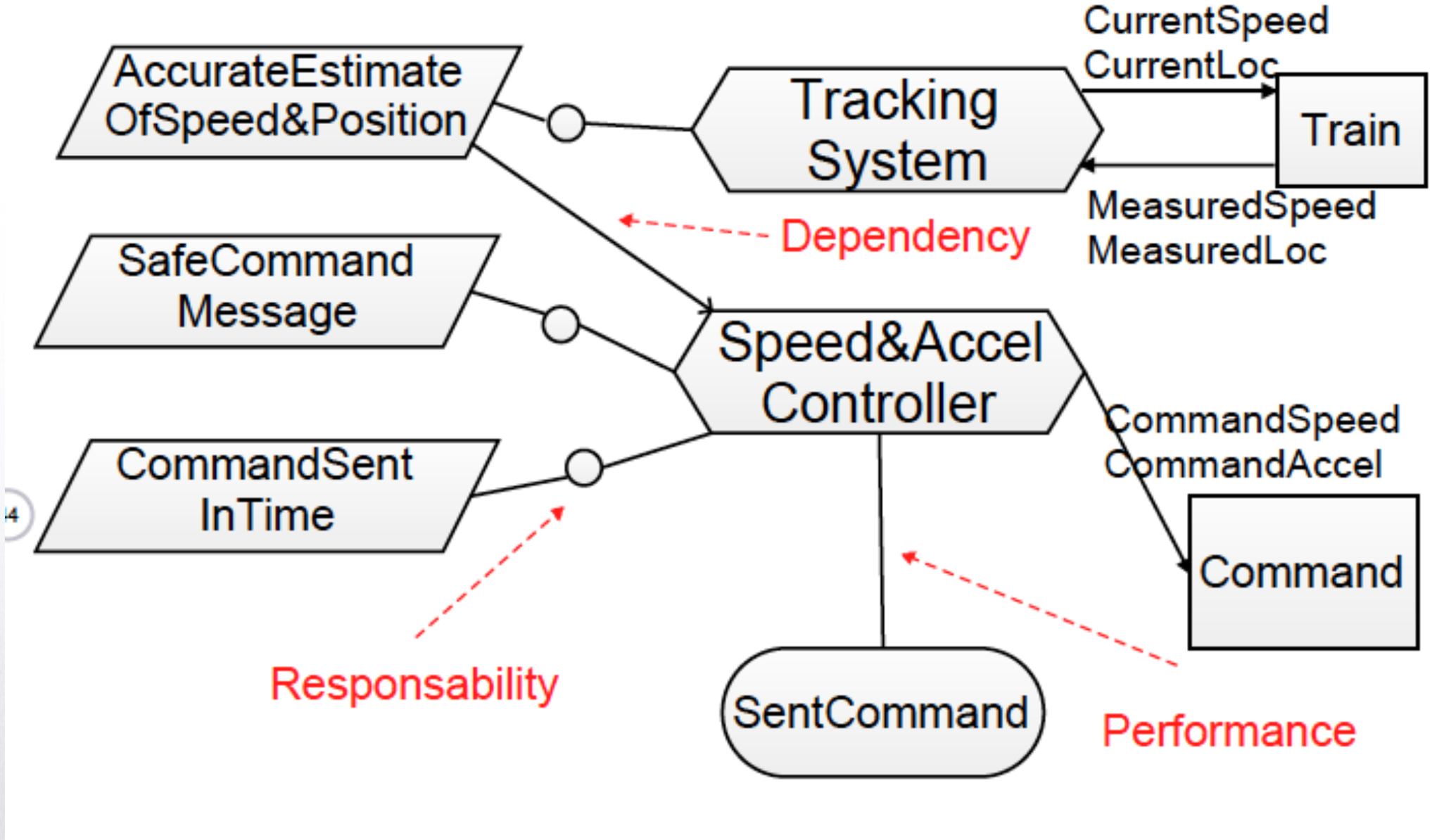


Figure 1 - Preliminary goal graph for the BART system


AccurateEstimate
OfSpeed&Position
SafeCommand
Message
CommandSent
InTime
Tracking
System
Speed&Accel
Controller
SentCommand
CurrentSpeed
CurrentLoc
Train
MeasuredSpeed
MeasuredLoc
Dependency
CommandSpeed
CommandAccel
Command
Responsability
Performance

Detectando conflitos

Conflitos podem ser detctados e representados graficamente localizando os pontos de negociação direto na documentação de forma mais explícita e expressiva.

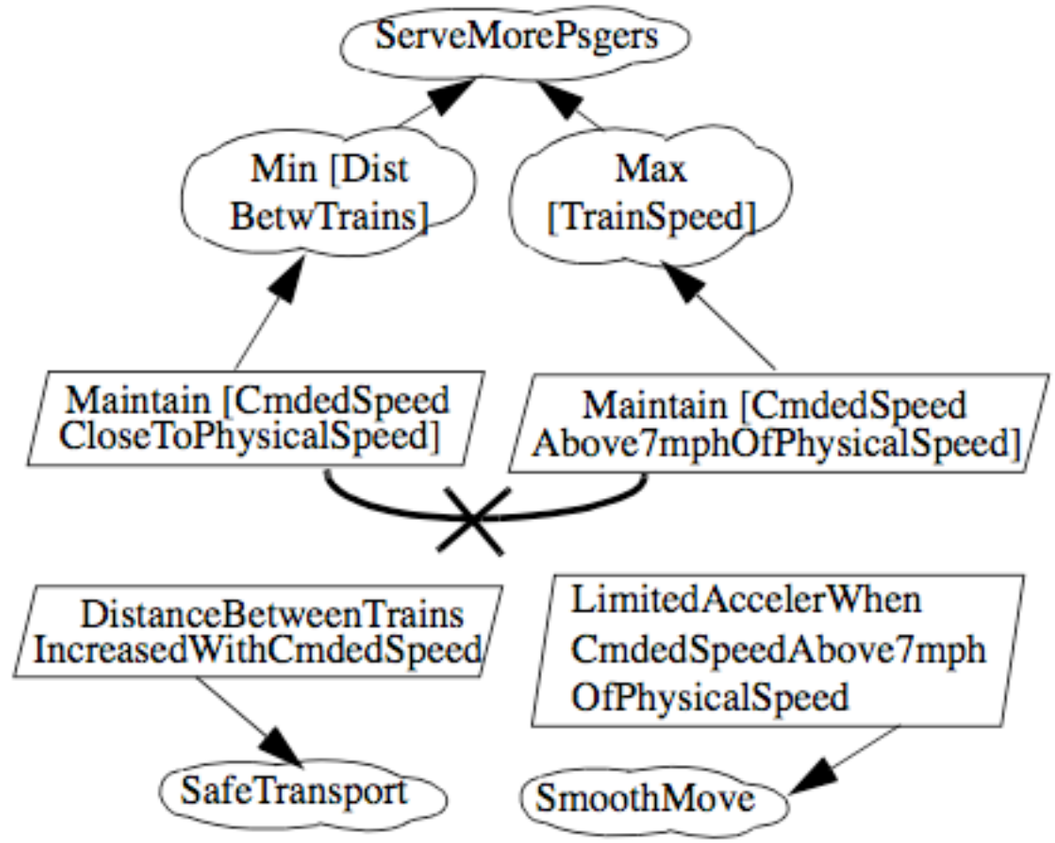


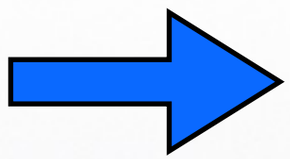
Figure 4 - Conflict in speed/acceleration control

Resolvendo conflitos

Goal Maintain [CmdedSpeedAbove7mphOfPhysicalSpeed]

FormalDef $\forall$ tr: Train

$$tr.Acc_{CM} \geq 0 \Rightarrow tr.Speed_{CM} > tr.Speed + 7$$



Goal Maintain [CmdedSpeedAbove7mphOfPhysicalSpeed]

FormalDef $\forall$ tr: Train

$$tr.Acc_{CM} \geq 0 \Rightarrow tr.Speed_{CM} > tr.Speed + 7$$
$$\vee\ f\,(dist\text{-}to\text{-}obstacle) \leq 7$$

A documentação

GOAL *TipoComportamento NomeObjetivo*

DEF *Descrição textual informal do objetivo*

[**FORMALSPEC** : [*Sentenças LTL*]

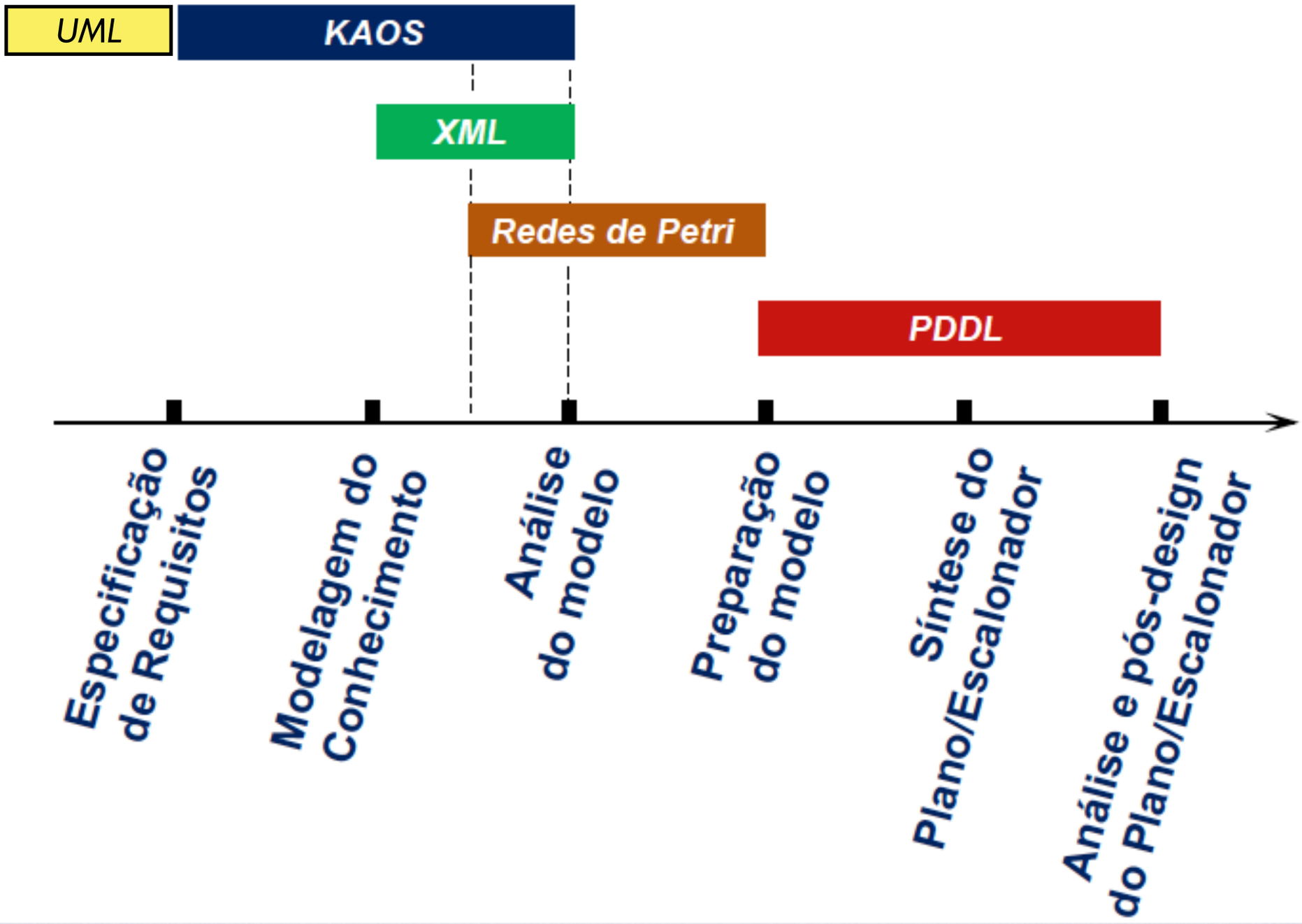
EXEMPLO:

Goal Achieve CarroPintadoQdoTransportado

Def **A carro ficará pintado em algum momento uma vez na área de pintura.**

FormalSpec $\forall c : Carro, ap : AreaPintura$

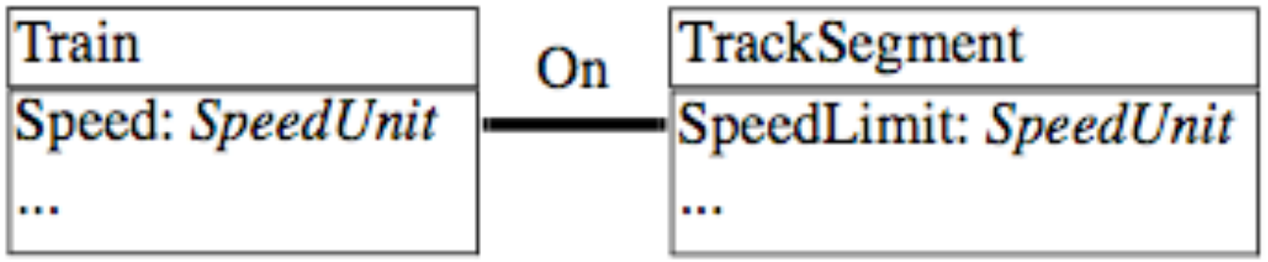
$$Em(c, ap) \Rightarrow \Diamond c.pintado = 'true'$$


UML
KAOS
XML
Redes de Petri
PDDL
Especificação de Requisitos
Modelagem do Conhecimento
Análise do modelo
Preparação do modelo
Síntese do Plano/Escalonador
Análise e pós-design do Plano/Escalonador

Refinando e formalizando goals (objetivos)

Goal Maintain[WCS-DistBetweenTrains]
InformalDef *A train should never get so close to a train in front so that if the train in front stops suddenly (e.g., derailment) the next train would hit it.*
FormalDef ∀ tr1, tr2: Train :
Following(tr1, tr2) ⇒ tr1.Loc - tr2.Loc > tr1.WCS-Dist

Regra de segurança



Goal Maintain[TrackSegmentSpeedLimit]
InformalDef *A train should stay below the maximum speed the track segment can handle.*
FormalDef ∀ tr: Train, s: TrackSegment :
On(tr, s) ⇒ tr.Speed ≤ s.SpeedLimit

Segunda fase da modelagem de requisitos

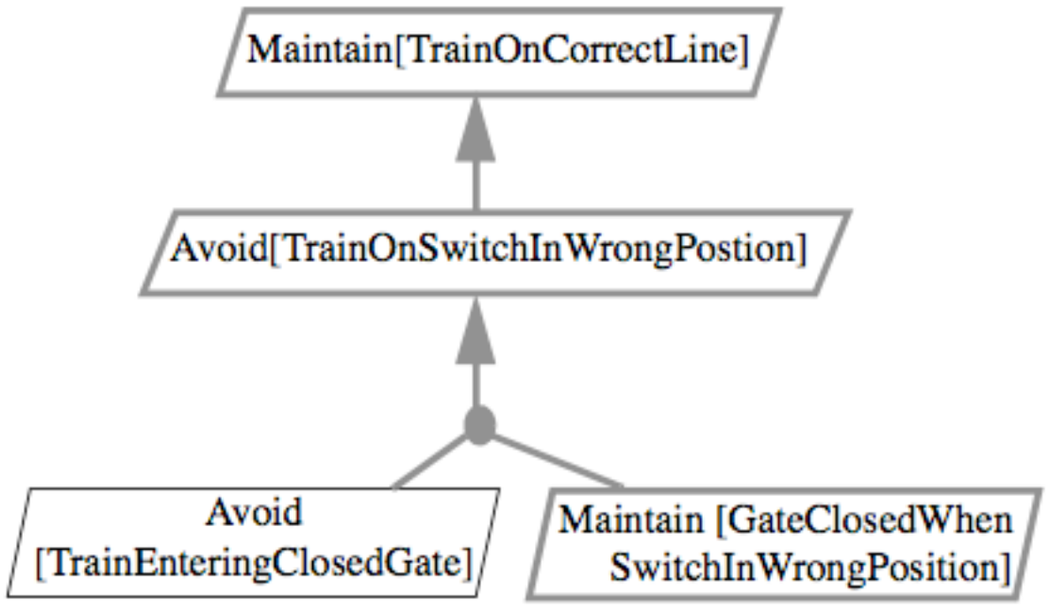


Figure 2 - Enriching the goal graph by WHY elicitation

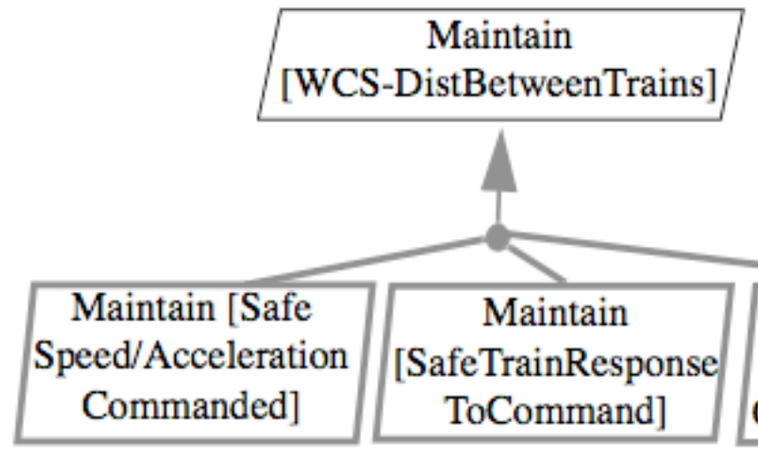


Figure 3 - Goal refinement

A base da modelagem está na relação WHAT-WHY, onde se introduz o conceito de *rationales*, isto é porque as decisões são tomadas.

Atribuindo respnsabilidades

O agente responsável pelo goal Maintain[SafeCmdMsg] é o controle de aceleração e velocidade Acel/SpeedControl, que por sua vez tem a seguinte interface de ação sobre as variáveis cm.Accel e cm.Speed:

Goal Maintain[SafeCmdMsg]

FormalDef $\forall$ cm: *CommandMessage*, ti1, ti2: *TrainInfo*

cm.Sent $\wedge$ cm.TrainID = ti1.TrainID $\wedge$ FollowingInfo (ti1, ti2)

$\Rightarrow$ cm.Accel $\leq$ F (ti1, ti2) $\wedge$ cm.Speed $>$ G (ti1)

Operacionalizando Goals

Operation SendCommandMessage
Input Train {**arg** tr}, TrainInfo; **Output** ComandMsg {**res** cm}
DomPre ... ; **DomPost** ...
ReqPost for SafeCmdMsg:
Tracking (ti1, tr) $\wedge$ Following (ti1, ti2)
$\rightarrow$ cm.Acc $\leq$ F (ti1, ti2) $\wedge$ cm.Speed $>$ G (ti1)
ReqTrig for CmdMsgSentInTime:
$\blacksquare_{\leq 0.5\ sec}$ $\neg \exists$ cm2: CommandMessage:
cm2.Sent $\wedge$ cm2.TrainID = tr.ID

A Nova Fase do Curso

Chegamos no segundo módulo do curso onde faremos uma mudança estratégica passando de uma fase de discussão mais conceitual para uma fase mais prática, visando a aquisição de habilidades juntamente com os novos conceitos.

Mini-projeto

Fase 1: Modelagem de um sistema automatizado para controle de equipamento dos laboratórios de pesquisa em KAOS (individual); deadline: **26 de março, à meia-noite**.

Nesse sistema todo o material do laboratório (software, hardware, livros, documentos, etc.) seriam identificados por número de série (hardware), licença (software), número de tomo (livros e documentos). Eventualmente, alguns deles podem ter RFID e o laboratório deve ter um leitor na porta de entrada.

Um sistema de banco de dados deve guardar toda a movimentação de entrada e saída de material do laboratório e o responsável pela guarda. Eventualmente uma saída sem registro poderá ser identificada pelo RFID (se o item possui RFID) e com a imagem guardada na hora da saída. Um operador deve então fazer o registro à revelia.

Três movimentações à revelia suspende o usuário que fica então impedido de fazer novas movimentações. O tempo que cada item pode estar fora depende do item e da atividade. O sistema deve então enviar mensagens (e-mails ou torpedos) solicitando a devolução ou renovação da saída. O equipamento deve necessariamente VOLTAR (fisicamente) para que possa ser usado em uma nova movimentação.

Leitura da semana

Goal-Oriented Requirements Engineering: A Guided Tour

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Abstract

Goals capture, at different levels of abstraction, the various objectives the system under consideration should achieve. Goal-oriented requirements engineering is concerned with the use of goals for eliciting, elaborating, structuring, specifying, analyzing, negotiating, documenting, and modifying requirements. This area has received increasing attention over the past few years.

The paper reviews various research efforts undertaken along this line of research. The arguments in favor of goal orientation are first briefly discussed. The paper then compares the main approaches to goal modeling, goal specification and goal-based reasoning in the many activities of the requirements engineering process. To make the discussion more concrete, a real case study is used to suggest what a goal-oriented requirements engineering method may look like. Experience with such approaches and tool support are briefly discussed as well.

1. Introduction

Goals have long been recognized to be essential components involved in the requirements engineering (RE) process. As Ross and Schoman stated in their seminal paper, *"requirements definition must say why a system is needed, based on current or foreseen conditions, which may be internal operations or an external market. It must say what system features will serve and satisfy this context. And it must say how the system is to be constructed"* [Ros77]. Many informal system development methodologies from the good old times included some form of goal-based analysis (one notable exception is [Rub92]). UML advocates sometimes confess the need for higher-level abstractions: *"In my work, I focus on user goals first, and then I come up with use cases to satisfy them; by the end of the elaboration period, I expect to have at least one set of system interaction use cases for each user goal I have identified"* [Fow97, p.45]). The prominent tendency in software modeling research has been to abstract programming constructs up to requirements level rather than propagate requirements abstractions down to programming level [Myl99].

Requirements engineering research has increasingly recognized the leading role played by goals in the RE process [Yue87, Rob89, Ber91, Dar91, Myl92, Jar93, Zav97b]. Such recognition has led to a whole stream of research on goal modeling, goal specification, and goal-based reasoning for multiple purposes, such as requirements elaboration, verification or conflict management, and under multiple forms, from informal to qualitative to formal.

The objective of this paper is to provide a brief but hopefully comprehensive review of the major efforts undertaken along this line of research. Section 2 first provides some background material on what goals are, what they are useful for, where they are coming from, and when they should be made explicit in the RE process. Section 3 discusses the major efforts in modeling goals in terms of features and links to other artefacts found in requirements models. Section 4 reviews the major techniques used for specifying goals. Section 5 on goal-based reasoning reviews how goals are used in basic activities of the RE process such as

Obrigado

Reinaldo