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4

Framework of Intelligent Systems to Support Project Scope

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1. Introduction

Project Managers defines project deliverables in a tree chart called Work Breakdown Structure (WBS) to control scope of project. Creating WBS is one of the most vital planning processes of the project management since WBS is considered to be the fundamental of other processes like scheduling, controlling, assigning responsibilities, etc. In fact WBS or activity list is the heart of a project and omission of a simple task can lead to an irrecoverable result. Mind mapping is one of the most powerful tool for generating WBS. Mind map which is introduced by Buzan as a method for thinking together, helps a project manager to stimulate the mind of project team members to generate project WBS. Here we try to present a framework for generating WBS of two sample projects involving with the building construction and electrical panel production using the aid of mind map, semantic network and the artificial intelligence (AI) programming language. For this purpose, Mind map concepts are transformed to a semantic network to represent project team knowledge in a computerized way, and then based on the resulted network and with the aid of Prolog language, project activity list is extracted intelligently. The framework will be presented step by step through the project samples. This method will result a comprehensive WBS and decrease the probability of omitting project tasks and it does better control of the project scope.

The purpose of this chapter is to review the studies of application of Artificial Intelligence in Project Management and proposing an intelligent framework to control and manage one of the project management knowledge areas which is "Scope".

In the following sections we will describe project management, AI application in project management and project scope management. The chapter is followed by the basic definitions of mind map, semantic network and brief description of their applications. At the end we present our intelligent framework to generate the WBS of two sample projects (project of building a construction and an electrical panel production) with the aid of prolog programming.

2. Project Management and Artificial Intelligence

Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements [PMBOK]. Also, AI is defined as the study and design of intelligent agents where an intelligent agent is a system that perceives its environment and takes actions which maximize its chances of success. The central problems of AI include reasoning, planning, learning, communication, perception. Using of AI results in accomplishing mentioned problem more accurately, so, because of the nature of today's world, AI is applied in many fields now. One of the fields is Project Management. The needs of using AI in project management arises from the characteristic and the size of projects being developed today which involve organizations working together which are located throughout various countries and continents.

Project management is accomplished through the application and integration of its processes which are: initiating, planning, executing, monitoring and controlling, and closing [PMBOK]. Through these project processes, project manager involves managing different major areas of project such as scope, time, cost, quality and risk. AI could be used to help project management to support these areas in intelligent and effective way, without the effect of human mistakes, and with less injuries and stress to human beings.

Our area of concern in this chapter is "Project Scope management".

2.1 Historical overview

From the advent of expert systems (ES),which is defined as a computer program which simulates the behaviour of a human expert to share knowledge and experience in a particular field, and artificial intelligence (AI) up to now, they were used in different areas of project management widely. These tools can help project management teams to capture their experiences and share such experiences with others. Some of AI applications on different area of project management are presented in table 1.

Year	Author	Description
1987	Hosley et al	They explained how project managers can use AI/ES to more effectively practice project management and reviewed the principles defining AI and ES and described a process for creating an ES
1988	Adedeji et al	They examined the emerging technology of ES that enables project managers to analyze cost by integrating multiple cost factors. They explained ES's function and three categories-data structure, knowledge base, and inference engine-and the ways that ES differs from traditional decision support systems
1989	Kangari, et al.	They described a method of using expert systems (decision support programs containing a large body of knowledge from field experts) to resolve the difficulties associated with traditional risk management models and examined a prototype expert system for construction projects, a system named Expert-Risk

1990	Nordin et al.	They explained the development of a knowledge-based schedule planning system
1991	Kermit et al.	They developed a prototype expert system, called PROJCON, that helps to generate management plans and strategies for a given construction task. The system also helps to survey, control and revise the plans according to the current change of condition
1992	Mango, Ammar	They introduced a new planning system that provides valuable historical and development process expertise to the planning team which is particularly useful for a cross-functional/multi-projects organization with a complex process
1998	Leung et al.	They presented a knowledge_based system to identify potential risk factors incorporating work breakdown structure
1999	Carlos Zozaya-Gorostiza	They reviewed the capabilities and application of a knowledge_based expert system named Construction Planex system which is used in construction projects
2000	Schuyler, John R	They overviewed expert systems, explained how they work, and cited numerous examples. He described artificial neural networks (NNs) and inference engines and offers a set of guidelines for deciding when a problem is appropriate for an expert system solution
2001	Avots, Ivars	They examined how ES can help project managers to analyze and control project schedule
2002	Nemati, H.R. et al.	They showed how a hybrid intelligence system with expert system and artificial neural network components can be used to aid in project estimate validation and quality prediction of the deliverables
2006	Xiaoqing (Frank) Liu et al.	They discussed design, implementation, and evaluation of an experimental intelligent software early warning system based on fuzzy logic to make sponsors, users, project managers aware of many potential risks as early as possible
2007	K.C.Lam et al.	They proposed a model for risk allocation decision in construction contracts using a set of knowledge_based fuzzy interface rules according to the expert knowledge
	K.C. Iyer et al.	They devised a rule_based expert system to assist contract administrator to evaluate worth of their claims before taking it to litigation and decrease the number and frequency of claims and disputes beside time and cost overrun in Indian construction contracts

Table 1. reviewing the studies of application of artificial intelligence in project management

As it can be inferred ESs and AI were applied in different areas of project management like risk, scheduling, controlling, etc. In spite of the importance of planning process, especially developing WBS, in project management there are no or limited work in this area, as it is shown in the next section.

2.2 Project Scope Management and WBS

Project Scope Management includes the processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully. Project scope management is primarily concerned with defining and controlling what is and is not included in the project [PMBOK]. Project scope management processes includes: scope planning, scope definition, create WBS, scope verification and scope control. In this chapter we will discussed about the third process: "Creating WBS".

"The WBS is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team, to accomplish the project objectives and create the required deliverables. The WBS organizes and defines the total scope of the project" or as it is defined in Practice Standard for Work Breakdown Structure "WBS serves as a guide for defining work as it relates to a specific project's objectives". A sample work breakdown structure organized by project phase is presented in figure 1.

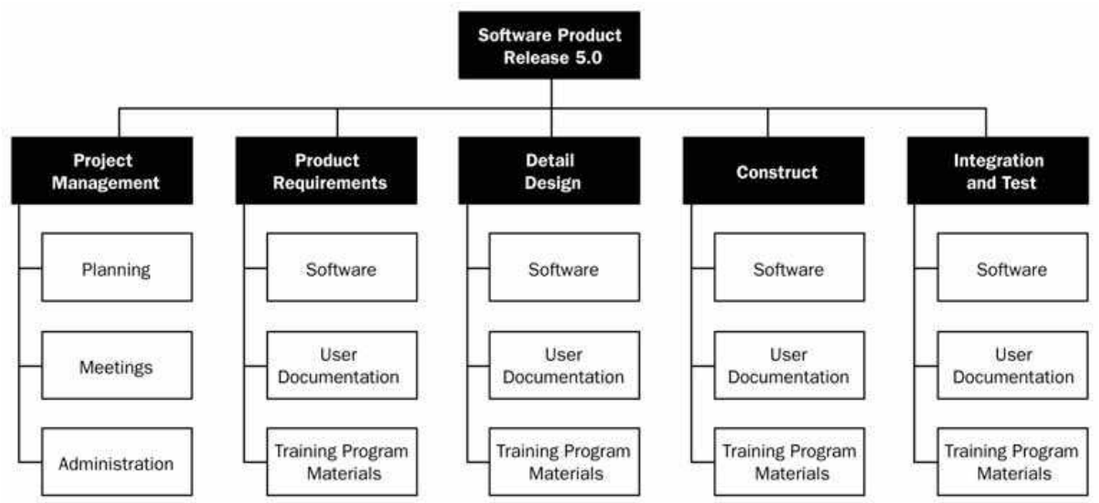


Fig. 1. A sample WBS

WBS can be considered as the heart of the project, because it provide a structure for estimating project costs, schedule, and resource information and therefore it can be served as a project planning and controlling framework.

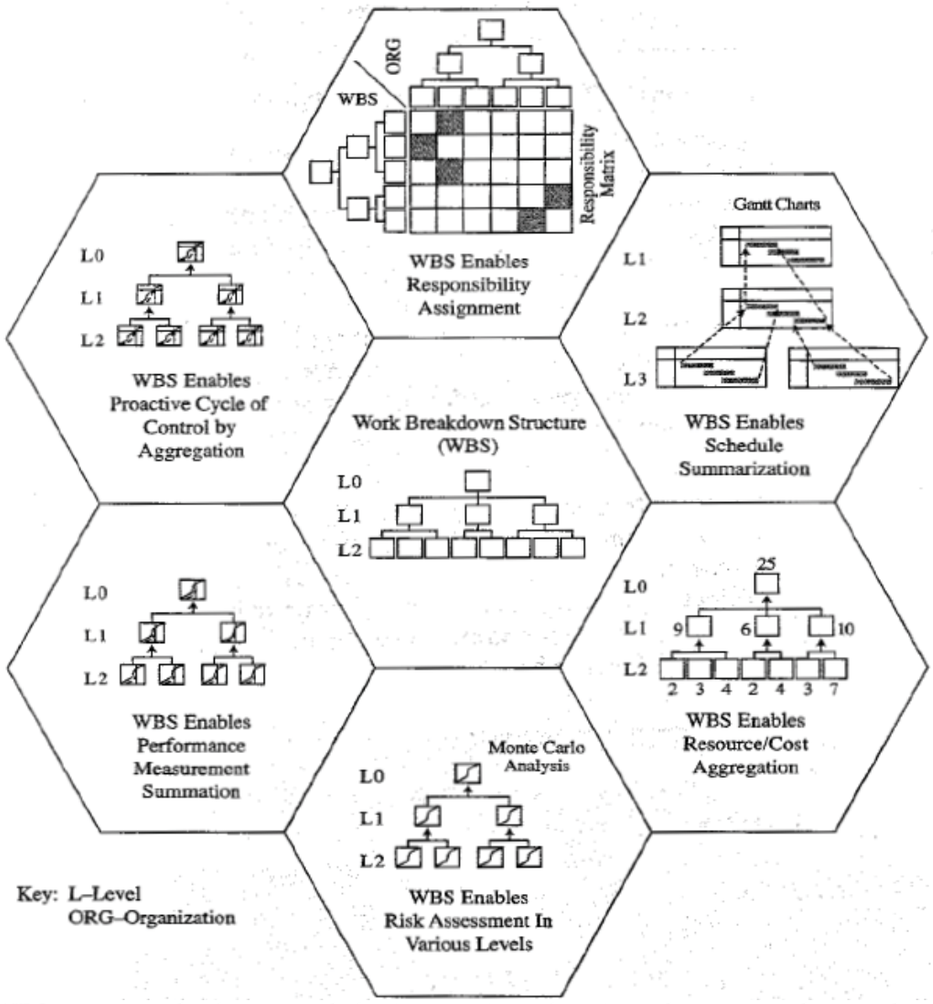


Fig. 2. WBS serves as the framework for integration of project planning and control

WBS enables project team to achieve the following fundamental project management actions (Figure 2):

- Assign the responsibility of the project work.
- Schedule the project work and summarization.
- Estimate and aggregate cost or resources
- Develop the response to risks associated with project
- Measure performance.
- Aggregation project control and proactive actions

So creating WBS can be considered as a vital process and as a prerequisite for other processes. Some studies were performed on the application of AI on project scope management. Rad (1999) presented the rationale and method to obtain a deliverable oriented WBS. Also Hashemi et al (2007) proposed a framework which plan WBS of a limited project domain using neural networks.

Because there are limited works on this area and due to the importance of WBS, it is essential to develop a tool to satisfy this project management need.

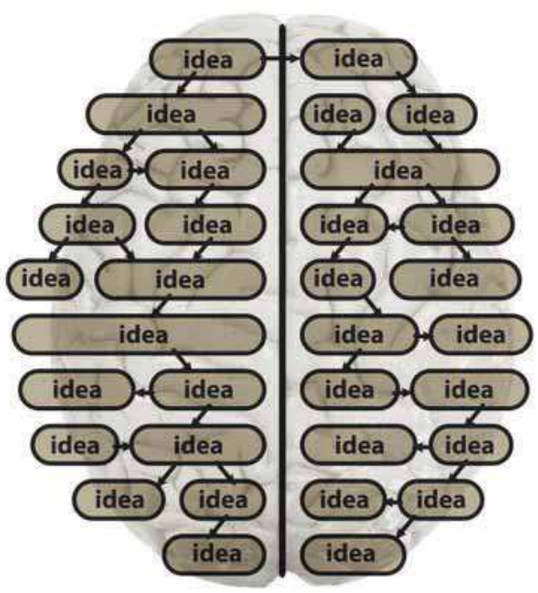
3. Basic Definitions

3.1 Mind map

A mind map is a diagram used to represent words, ideas..., or other items arrange radially around a central keyword or idea. In other words it is a way of capturing concepts and their relationships on the two-dimensional surface of a sheet of paper. It is used to generate structure and classify ideas as an aid of study, problem solving, decision making, etc.

With the aid of mind map you are mapping knowledge in a manner which will help you to understand and remember new information and think creatively with brainstorming approach. Mind mapping encourages structured capture of unstructured thoughts and helps you to boost your creativity, create winning ideas, enhance your memory, structure your knowledge, and sharpen your focus. Mind map is one of the best methods to optimize ones' learning capacities and understanding of how the elements of complex structure are connected. Mind maps have been used for centuries for learning, brainstorming ,visual thinking, problem solving, decision making, etc. by educators, engineers, psychologists and people in general .But the claim to the origin of mind map has been made by a British Popular psychologist, author, Tony Buzan. Buzan claims that mind map is vastly superior to note taking method and utilizes the full range of left and right human cortical, skills, balances the brain, taps into the alleged 99% of your unused mental potential(figure 3).

Buzan reasoned that the brain is composed of right and left halves. The left part of the brain tends to be very analytical. Logic, language, and numbers are primarily left brain activity. In the other hand relationships, shapes, colors, emotion and creativity are associated with the right part of the brain. Buzan develop Mind Maps to combine logic and language, with colors, shapes and relationships. When this format is used, both halves of the brain are intentionally stimulated and you use both sides of your brain. Tests conducted found that brainstorming with this format tended to provide a richer solution set; and learning with this format tended to have a longer retention span. A sample mind map is shown in Figure 4


idea
idea
idea

3.2 Mind Map as a Project Management Tool

Mind maps have great applicability in project management. Mind maps are useful for any topic or task in which seeing the big picture, recognizing relationships, and stimulating creativity are important. They are very visually oriented, an ideal place to store ideas related to your project, and enables you to gather, manage and share a large variety of information. Left-brain or linear thinking may be important for scheduling, resource allocation, and monitoring project progress. But, the definition and early planning stages require more whole brain thinking. Mind maps not only help you with initial project planning, but also status reporting and various aspects of project management like assigning priorities, determining which specific resources are needed for both individual tasks, processing , time management, task management, agenda setting, event planning, and creation of effective presentation. They can provide a mechanism for bringing out the project team creativity and stimulating whole brain thinking at project critical steps.

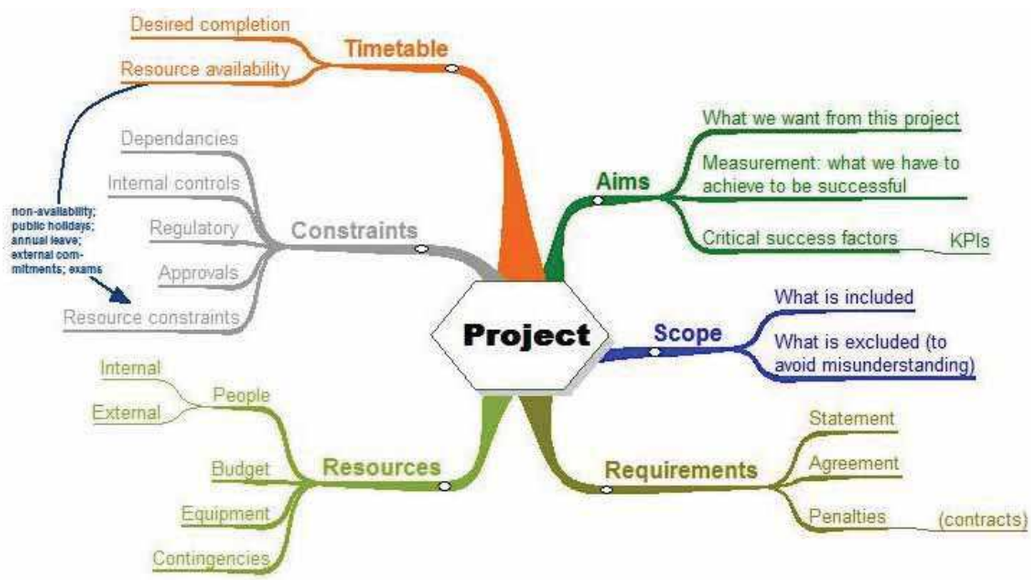


Fig. 4. A sample mind map for analyzing a project

Mind mapping allows project manager and project team to more easily collaborate, brainstorm, solve problem, visualize structure, classify and gather ideas, analyze complex ideas and concept. This means that team can get a lot accomplished in single meeting and in a very short time. All in all mind mapping is a powerful brainstorming, visualization and facilitation tool for project management and can save an organization time and money in its project planning and management process.

Finally what mind map can do is:

- Promote inter-team communication, thereby aiding decision-making.
- Optimize and simplify any project may you have.
- Quickly gain insight into the big picture of any project.
- Boost your creativity.
- Help your mind to become a powerful idea generator.
- Instantly see connections and links between different subjects.

3.3 Mind Map as a WBS Generating and Developing Tool

You can't start a project without thinking, "What do I do first?" , Even with small projects you need to know what the project aims to do, how you'll know if you've finished and etc. In the initial and planning stage, a successful manager should use his team creativity, in fact a creative leadership is not enough and leader should facilitate the context and introduce an appropriate tool to his team for exchanging opinions and making new and creative ideas. In this stage we may face to these questions:

- What will be the major project deliverable?
- What will not be considered in the project scope?
- What tasks must be done to complete these deliverables?
- What might go wrong if we implement the project in this way (with these tasks)?

Omission of these important project aspects can lead to irrecoverable and serious outcomes. The tendency for planners to jump immediately to scheduling and "doing" is a function of organizational biases toward "left-brain" or linear thinking that led to these events. Many of these unwanted outcomes happen because of being inattention to think strategically and creatively at the time of planning projects, so there is a vital need for a tool to help the man mind to think creatively at the planning process, Mind map can be served as helpful tool to understand what the project aims to produce, what it covers, what you will need to finish it and generally what the scope of the project will be.

As it is discussed in section 2.2 one of the vital phases in planning process in "Creating WBS". WBS is a hierarchical breakdown of the work to be done in the project or as it is defined in PMBOK is the process necessary for subdividing the major project deliverables and project work into smaller, more manageable components. The value of WBS can be stated as follows:

- WBS organizes the project work and creates a framework which integrates the management of the project and other processes like controlling, planning, scheduling, etc.
- WBS enables project team to organize the work into small deliverable and make easy the assigning responsible for each deliverable and activity.

A WBS can be created using any techniques of listing and Grouping project tasks. One of the most powerful tools for creating WBS is mind mapping. With this approach project team begin to brainstorm, keeping in mind the various categories of major deliverables and appreciating connections. Each major component gets a branch, and the team captures ideas in words and symbols using color, size, and shape to add emphasis. Writing down each output on a separate note and brainstorm with the project team to find all the tasks that would need to be completed to deliver the output the mind map is formed (as it is shown in Figure 5).

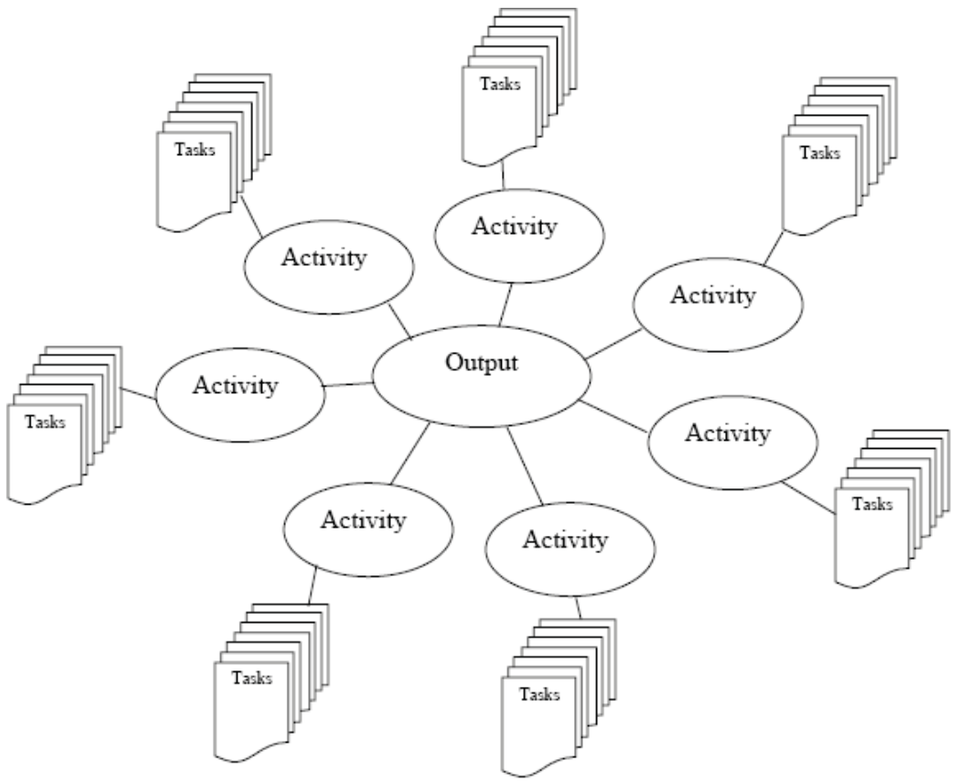


Fig. 5. Mind map showing an output broken to tasks

3.4 Prolog

Prolog is a logic programming language and its name is abbreviation for programmation en logique (French for programming in logic). It is a general purpose, high-level programming language widely utilized in artificial intelligence. Prolog enables the user to build programs by stating *what* they want the program to do rather than *how* it should do it. In the other words unlike many other programming languages, prolog is declarative rather than procedural and that's enough to expresses the logic of a computation without describing its control flow. Due to Prolog's grounding in first-order predicate logic it is intended to be more analogous with human deductive reasoning than other programming languages.

The program logic is expressed in terms of relations, and execution is triggered by running queries over these relations.

Prolog programs describe relations, defined by means of clauses. There are two types of clauses in prolog programming: Facts and rules.

A rule is of the form:

Head: - Body.

and is read as "Head is true if Body is true". A rule's body consists of calls to predicates, which are called the rule's goals. Clauses with empty bodies are called facts.

For further information about prolog you can study "Prolog programming for artificial intelligence" by Ivan Bratko.

We used prolog programming as an AI tool to implement our intelligent framework to create project WBS.

3.5 Semantic Network

"Semantic Networks" were first invented for computers by Richard H. Richens of the Cambridge Language Research Unit in 1956 as an "interlingua" for machine translation of natural languages and it is defined as a graphic notation for representing knowledge in pattern of interconnected nodes which represent concepts, and arcs which represent semantic and binary relationship between concepts. In the other words, a semantic network is a way of representing relationships between concepts, which often each concept is represented by a word or set of words. Knowledge representation (in AI) is used to represent knowledge in a manner to facilitate drawing conclusion from knowledge and its fundamental aim is to store knowledge so that computer program can process it and achieve the verisimilitude of human intelligence. There are some ways of knowledge representation like: rules, frames, etc. but we use semantic network. Semantic networks were motivated by cognitive models of human memory; they are a compromise between the logic "declarative" and the "procedural" forms of knowledge representation. Firstly semantic network have long been used in psychology, philosophy and linguistic. But later they have been developed for artificial intelligence and machine translation.

Mind map and semantic network are similar to each other, but there are some differences between them: In mind map there are no restrictions on the kinds of links and relationships used, in fact in mind map kind of the relation between objects are not important but in semantic network a binary relation between objects must be determined. A fairly major difference between mind maps an semantic networks is that the structure of a mind map, with nodes propagating from a centre and sub nodes propagating from nodes is hierarchical, whereas semantic networks, where any node can be connected to any node, have a more heterarchical structure. The most important relations between concepts are subclass relations between classes and sub classes, and instance relations between particular object and their parent class.

However any other relations are allowed. Some of common relations are as follows:

- ISA – relates an object to a class, i.e. it defines an instance of a class
- AKO (a-kind-of) – relates a class to another class, or may define a subset. This link type demonstrates the relationship between classes.
- PARTOF (part-of) – represents how an object is composed of other objects, or inherits only part of the parent class.
- HASA (has-a) – relates an object to a property or attribute.

But it is possible to define any relation between objects in a semantic network.

Sample of a semantic network with "is a" relation is shown in figure 6.

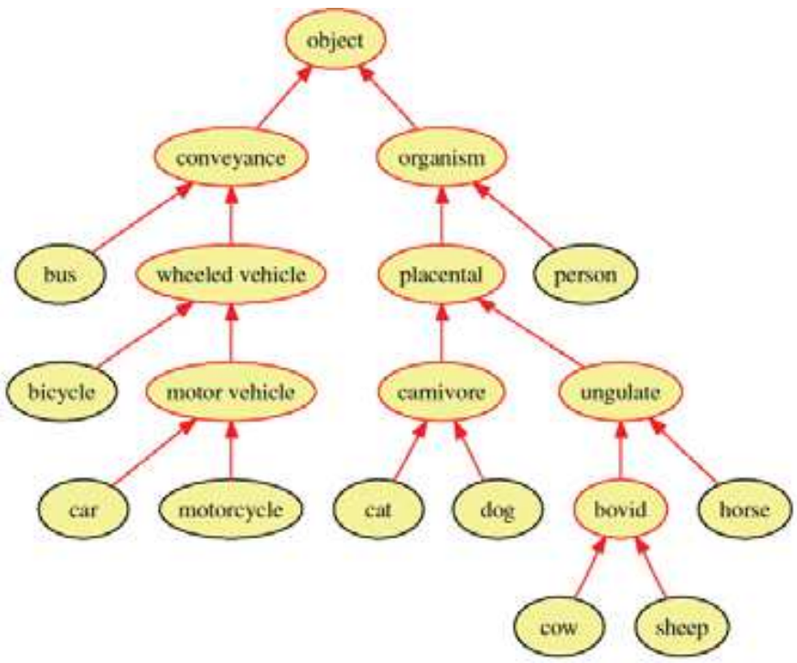


Fig. 6. A sample semantic network

4. The Proposed Intelligent Framework

Due to the usefulness of mind map and AI, as discussed in previous sections, in this section a new method based on these two tools for generating WBS or activities list is proposed. The framework of the proposed method is presented in figure 7.

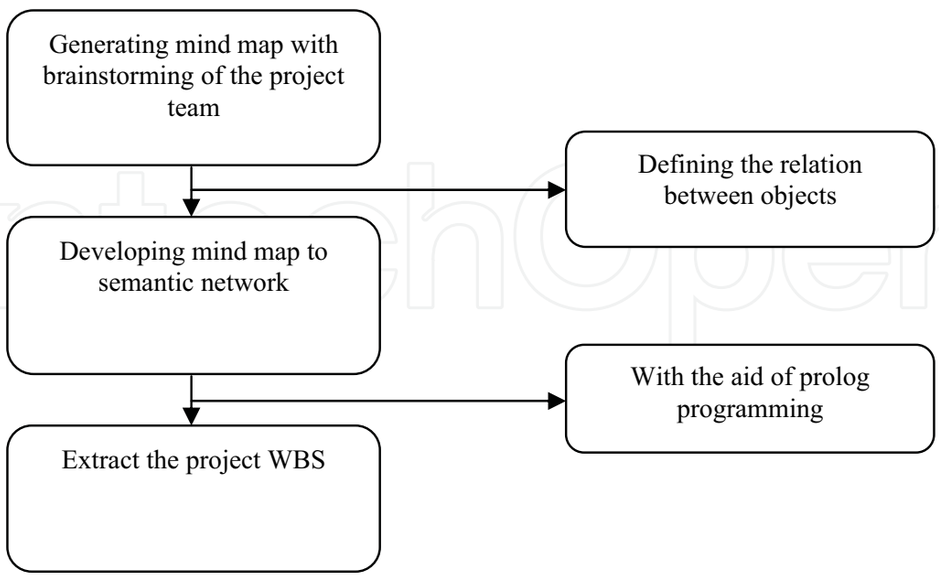


Fig. 7. (Proposed method) - The process of extracting WBS

In fact we extract project WBS from the obtained mind map of brainstorming project team by an artificial intelligence (AI) tools which is prolog programming language.
The proposed method can be used in every domain for generating WBS.
To show the capability of this method in practical situations two sample projects are considered and this method is applied on them. One of the samples is a building construction project which has three floors and another is an electrical panel production project. Figure 8 presents a set of electrical panels.



Fig. 8. Electrical panel

For two sample project, as shown in figure 7, at first project team members created and developed mind map, then they transmuted it to semantic network. Finally projects WBS were extracted by the aid of the resulted semantic network and prolog programming.
As a schematic sample, a part of the related semantic network of the second project is shown in figure 9.
Some of two project activities, which are extracted from the related semantic network, are as follows:

Building construction

- Execute of foundation.
  - Excavation of foundation.
- Execute base of columns.
- Execute columns.
- Execute walls.
  - Plastering of wall of grand floor.
  - Painting of wall of grand floor.
  - etc.
- Install of powerhouse's equipments
- Execute hot/cold water piping.
- Install of door and windows
- Water proofing of roof.
- Execute of face:
  - Install face's stone.
- Etc.

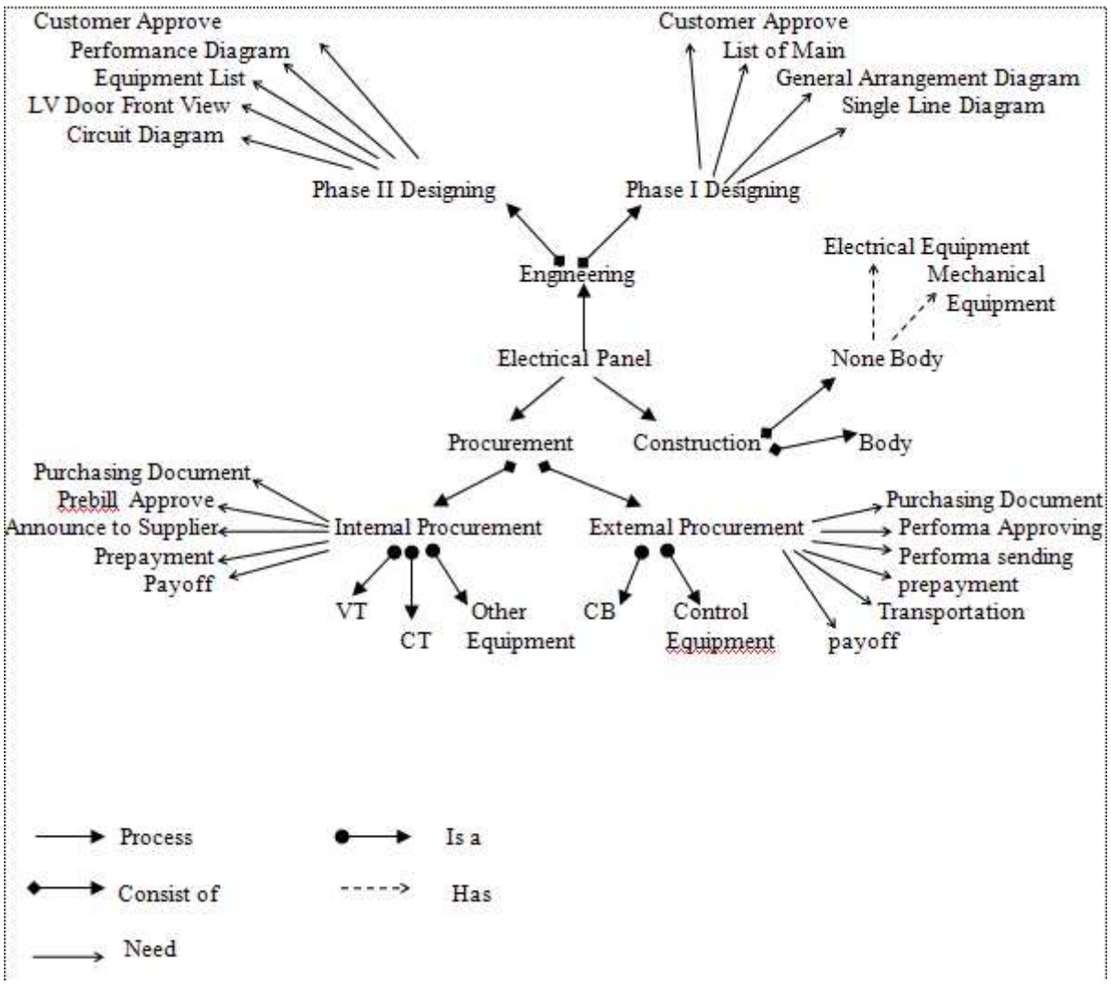


Fig. 9. Semantic network for the electrical panel production project

-electrical panel production

- Engineering
  - Phase 1 Designing
    - single Line Providing
    -General Arrangement Providing
    -List Of Main Providing
    -Approve By Customer I
  - Phase 2 Designing
    -Circuit Diagram Providing
    - LV Door Front View Preparing
    - Equipment List Preparing
    - Performance Diagram Providing
    - Approve By Customer II

- Procurement:
  - Internal Procurement:
    - -Purchasing Document of VT
    - Prebill Approve of VT
    - Announce To Supplier of VT
    - Prepayment of VTT
    - payoff of VT
    - Purchasing Document of CT
    - Prebill Approve of CT
    - Announce To Supplier of CT
    - Prepayment of CT
    - payoff of CT
    - Purchasing Document of Other Equipment
    - Prebill Approve of Other Equipment
    - Announce To Supplier of Other Equipment
    - Prepayment of Other Equipment
    - payoff of Other Equipment
  - External Procurement:
    - Purchasing Document of CB
    - Performa Approving of CB
    - Performa Sending of CB
    - Announce To Supplier of CB
    - Prepayment of CB
    - Transportation of CB
    - Payoff of CB
    - Purchasing Document of Metering Equipment
    - Performa Approving of Metering Equipment
    - Performa Sending of Metering Equipment
    - Announce To Supplier of Metering Equipment
    - Prepayment of Metering Equipment
    - Transportation of Metering Equipment
    - Payoff of Metering Equipment
    - Purchasing Document of Control Equipment
    - Performa Approving of Control Equipment
    - Performa Sending of Control Equipment
    - Announce To Supplier of Control Equipment
    - Prepayment of Control Equipment
    - Transportation of Control Equipment
    - Payoff of Control Equipment
- Construction
  - Body Assembling
  - Mechanical Equipment 's Installation
  - Electrical Equipment 's Installation

A part of source code of the second project is shown in appendix.
These examples show the proposed framework can be used for extracting the activities list of project successfully.

5. Concluding Remarks

As you know there are gigantic projects in some fields with thousands activities. For these projects creating a comprehensive WBS, is a demanding task. With respect to the importance of WBS, developing of a method to manage this process is a vital need. As you see with the aid of mind mapping and AI you can overcome this problem and generate a comprehensive WBS.

As a future survey, brainstorming of experts in such especial domain and generating a mind map WBS in the first phase and developing an expert system with the aid of AI and semantic network in the second phase to create and develop WBS of project can be suggested.

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Appendix:

PROLOG Resource Code of Electrical Panel Production

```
process("Tableau","Engineering").
process("Tableau","Procurment").
process("Tableau","Construction").
consistOf("Engineering","PhaseI Designing").
consistOf("Engineering","PhaseII Designing").
consistOf("Procurment","Internal Procurment").
consistOf("Procurment","External Procurment").
consistOf("Construction","Body").
consistOf("Construction","Inter Body").
has("Inter Body","Mechanical Equipment").
has("Inter Body","Electrical Equipment").
isa("InternalProcurment","VT").
isa("InternalProcurment","CT").
isa("InternalProcurment","Other Equipment").
isa("ExternalProcurment","CB").
isa("ExternalProcurment","Metering Equipment").
```

```
isa("ExternalProcurment","ControlEquip").
need("PhaseI Designing","single Line Providing ").
need("PhaseI Designing","General Arrangement Providing").
need("PhaseI Designing","List Of Main Providing ").
need("PhaseI Designing","Approve By Customer I").
need("PhaseII Designing","CircuitDiagram Providing").
need("PhaseII Designing","LV Door Front View Preparing").
need("PhaseII Designing","Equipment List Preparing").
need("PhaseII Designing","Performance Diagram Providing").
need("PhaseII Designing","Approve By Customer II ").
need("InternalProcurment","Purchasing  Document").
need("InternalProcurment","Prebill  Approve").
need("InternalProcurment","Annonce  To  Supplier").
need("InternalProcurment","Prepayment").
need("InternalProcurment","payOff").
need("ExternalProcurment","Purchasing  Document").
need("ExternalProcurment","Proforma  Approving").
need("ExternalProcurment","Proforma  Sending").
need("ExternalProcurment","Annonce  To  Supplier").
need("ExternalProcurment","Prepeyment").
need("ExternalProcurment","Transportation").
need("ExternalProcurment","PayOff").
not(P):-
 P,!,fail ;true.

 eng1(P):-
   write("  Phase 1"),nl,

   need("PhaseI Designing",P), write("      -").

 eng2(P):-
 write("  Phase 2"),nl,

  need("PhaseII Designing",P),write("        -").

  eng3(P):-
  write("Designing"),nl,
    eng1(P).
    eng3(P):-
    eng2(P).
 proc1(P):-
  write("         Internal Procurement:"),nl,
  isa("InternalProcurment",X),need("InternalProcurment",Y),
  write("            - ", Y, " of ",X).
 proc2(P):-
  write("         External Procurement:"),nl,
```

```
 isa("ExternalProcurment",X),need("ExternalProcurment",Y),
  write("           - ", Y, " of ",X).
proc3(P):-
write("    Procurement:"),nl,
proc1(P).
 proc3(P):-
proc2(P).

 con1(P):-
consistOf("Construction",X),
not(has(X ,Y)),
write("         -", Y ," Assembeling").

con2(P):-
consistOf("Construction",X),
has(X,Y),
write("          - ",Y," 's Instalation").

con3(P):-
write("    Construction"),nl,
con1(P).
con3(P):-
con2(P).
task(P):-
eng3(P).

task(P):-
proc3(P).

task(P):-
con3(P).
```

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