

# Modelling and Applying Learning Strategies in a Networked Higher Educational Context

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## Abstract

Project Based Learning (PBL) is an innovative instructional method widely used in higher education in recent years. The introduction of such innovative instructional methods has made the design of the learning process by instructors more imperative than it used to be when traditional methods were used. IMS-LD is a specification created to standardise and facilitate the learning design process, whilst allowing produced designs, often called scenarios, to be shared and reused. However it cannot be easily applied by non-technical users such as teachers, despite the existence of specially developed tools that visualize the design process. Our goal is to provide the instructors with IMS-LD templates which they can easily customize to produce their own complete designs. We present our methodology of how to design such templates as graphical models by providing one that is based on the PBL method. Since our model makes extensive use of learning patterns, we investigate how these patterns were identified, designed and incorporated in the PBL model. Finally we provide a set of guidelines to instructors on how to use this model in order to produce their own complete designs.

## Keywords

Project Based Learning, Patterns, IMS-LD specification, Learning Design.

## Introduction

Within recent years great of effort has been put into the introduction of innovative instructional methods in higher education that incorporate the use of technology and cultivate skills considered as valuable for the learners of our era. Project Based Learning is one of the most promising ones with regard to this requirement. Research in the field of applied PBL has revealed several important findings (Thomas, 2000). PBL, in comparison to other instructional methods, has value for enhancing the quality of learning by promoting active learning (application of knowledge in novel, problem-solving contexts). PBL can be considered as an effective method for learners to develop complex skills, i.e. planning, communicating, problem-solving and decision making. From a learners and educators' point of view, PBL is a more popular method of instruction than traditional methods.

IMS Learning Design is a specification used to describe learning scenarios (Koper et al., 2004). In IMS-LD the structure of the learning scenario is separated from the learning materials and services. Materials can then be reused within the same or different scenarios. The scenarios can also be reused and new materials can be added. The IMS-LD specification is expressed as an XML binding which cannot be easily used by non-technical users such as teachers. Special tools have been created for this reason, which facilitate the learning design process (eg. the RELOAD editor). However the process of transforming a lesson plan from a simple narrative to a complete learning design is still not trivial and requires a deep knowledge of the specification itself. We claim that by providing teachers with pre-designed learning

scenarios based on a concrete learning approach like PBL, we give teachers the opportunity to create their own learning designs in less time (accelerate the process) and allow them to focus on adjusting the core model to their own specific needs, adding their own resources and services.

Using the IMS LD specification we have modelled a PBL learning scenario at a generalised level. Our goal was this model to serve as a template for instructors who want to design their own PBL units of learning. We based our approach on pattern theory: basic modules can be considered as patterns that can be combined in many different ways by educators. The current paper is organized in two parts: in the first part we present how the basic PBL model was developed and how this model can serve as a template for instructors to design and produce their own courses, whereas the second part manifests our approach towards pattern identification and design, meant to be used in PBL scenarios.

## **Developing the PBL model**

In this part we present the methodology for the design of the PBL model. Note, that although the example presented is based on PBL, the methodology can be applied for the development of similar models based on other instructional methods, as well.

### **Design requirements**

We firstly defined a set of requirements that the resulting model has to fulfil. Our final model has to be:

1. General purpose: the model should not be neutral to any specific educational context: subject area, discipline, student age or level of expertise.
2. Extensible-modifiable. The model is incomplete in the sense that not all the specifications' elements have been defined e.g. there are no learning objects. In this sense, the model is not ready to be executed by an LD engine. However due to its incompleteness, teachers are capable of extending the model, adding their own resources, activities, material, services, etc.
3. Modular: should comprise various reusable modules eg. negotiation, presentation, etc. that can be assembled in different ways to implement a specific PBL learning scenario.
4. Graphically presentable: since LD specification uses an XML binding it is difficult to be used by non-technical users. Therefore we use the MOT+ graphical modelling editor to model our design at an abstract level. XML code is automatically generated and can be imported in some LD modelling tools i.e. the Reload editor, for further processing.
5. Capable of supporting the blended learning paradigm: both face-to-face and on-line learning methods should be combined to implement the proposed activities. The teacher should be able to decide himself/herself which activities should be electronically supported.

These requirements guided the entire design model and the final model was checked against them for validity.

### **The design process**

#### *The project setup*

The PBL scenario that we elaborated is indented for application in a higher education course framework, but it is not tied to a specific course, subject or discipline. Students are given the option to undertake the project or take the final exam at the end of the semester. An information delivery module of the course takes place in parallel with the project (lectures). The assessment criteria of the students' performance are known beforehand. Students undertaking this project will have to form groups of 3 to 5 persons and they have a 6-8 weeks period to finish their work (a semester usually lasts about 10 weeks). Each group works on a different subject, independently of each other. The scenario foresees however certain points (at time and place) of collaboration between groups. The subject of each project can be proposed either by the instructor or by the students' group and normally gets unanimously approved after negotiation. The instructor of the course is also assisted by a number of teaching assistants which supervise the activities of the groups and provide technical support as regards the on-line components of the scenario. The whole team of instructor and assistants will be called hereafter the "staff team" hereafter, whereas the groups of students will be called "project teams".

*First level narrative: text written in natural language*

We start by writing the narrative of the project scenario in natural language without following a certain template. Our goal is to produce a script that incorporates all the necessary information to inform by staff teams that have no contact with the designers of the scenario (our team). It is divided into sequential steps attempting to describe how things should happen in reality, including advice, experience and hints to the staff team that is going to run it during the semester period. It is about 5 pages long. The scenario is based on the blended learning paradigm i.e. there are parts to be carried out as face to face activities and parts that are to be performed as on-line (web-based) activities. Although recommendation is provided, it is up to the staff team to make the final decision on delivery mode of the individual activities, taking into account the following quote (Dertl et al. 2004):

...in blended learning scenarios most interactions take place face – to –face with the on-line acting as a backbone for the transmission and sharing of material, for its preparation and organization for administration and for intermediate sharing of ideas and experiences...

#### *Second level narrative: natural language text using the IMS-LD information mode*

After writing the complete narrative we have processed it in accordance with the IMS-LD terminology. This task involves the identification of acts, activity-structures, activities, roles and environments. Since our scenario does not relate to a specific course, subject or discipline we did not have to specify any learning objects resources, learning objectives, prerequisites, etc. This is part of the instantiation phase, where the details of the projects will be identified and finalized. For each act, activity structure and activity there is a description of what is going to happen, which roles contribute to the act and which services (if any) are used. All the useful information included in the first level narrative for i.e. advice to the teacher, recommendation, explanation, is shared among the descriptions of the identified IMS-LD elements. The narrative produced at this level is part of the template accompanying the final graphical model.

#### *The graphical MOT+ model*

A graphical model gives a better overview of the activity flow diagram that cannot be easily extracted from the narrative. Both the model and the narrative are necessary in order to run the scenario. As mentioned earlier, the designed PBL scenario is to be followed by people, not run by a machine, consequently there is a lot of useful information that should be conveyed to them along with the graphical representation. MOT+ is an object-oriented modelling tool intended to express various fields of knowledge as graphic knowledge models (Paquette et al., 2005). It can also be used as a graphical IMS-LD editor providing all the elements of the IMS-LD information model and a set of semantic links for the representation of their relationships. The designed model can be exported in XML according to the IMS-LD XML binding. This is an important reason why we opt for using MOT+ instead of another general purpose modelling tool. The IMS-LD Best practice guide recommends the use of UML for the modelling of the narratives. However, these diagrams must then be transformed manually to the XML format, which in general can hardly be done by non-technical users.

Apart from the direct use of the IMS-LD elements two other features of MOT+ were considered as attractive and useful for our work:

- The use of submodels, that enables the designer to place part of the model on separate submodels that interconnect with each other. This feature facilitates the creation of modular models, reduces complexity and enhances clarity and permits the design of larger models. A submodel may also contain other submodels (nested submodels).
- The “copy-by-reference” feature, providing the designer with the opportunity to define once and then reuse elements wherever needed. This feature expresses to some extent the IMS-LD reference philosophy.

Our scenario foresees 3 phases: **Preliminary Actions**, **Main Phase** and **Assessment** (a lot of similarity with the example presented in Dertl et al. 2004). Each of the phases is represented by an Act element in our model. The scenario refers to a long-term project. Acts work as points of synchronization in IMS-LD, upon completion of an act all roles must have finished all activities before proceeding to the next Act. Acts need to be serialized (executed one after another). This is implied by the P link between them. Each act consists of several activity structures that they fall in one of the following categories:

1. They are further analyzed forming a subtree whose nodes are either activity structures or activities according to the IMS-LD information model.
2. They are no further analyzed.
3. They are instances of patterns.

Figures 1 and 2 illustrate the graphical models of Act1 and Act2 in MOT+.

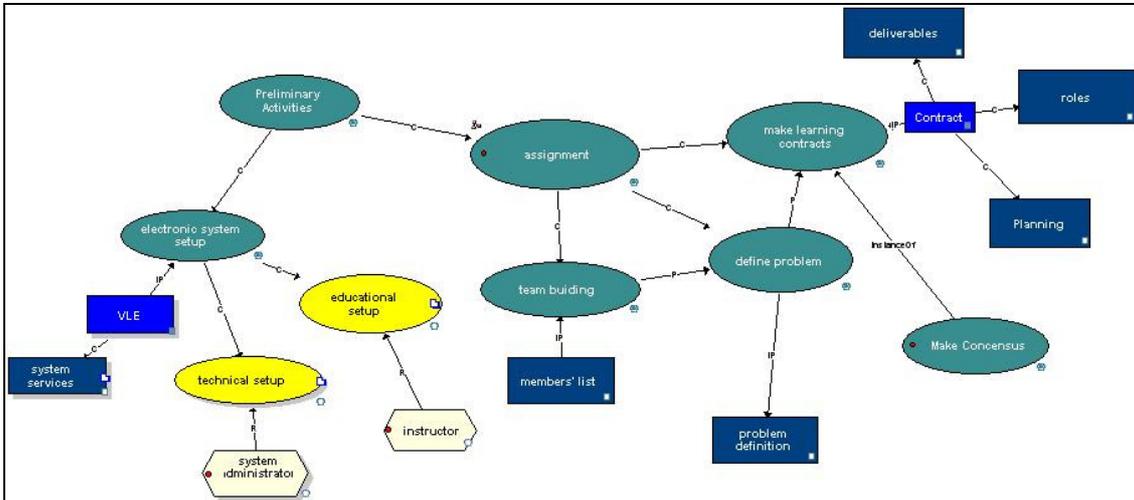


Figure 1 – Act 1: Preliminary Phases

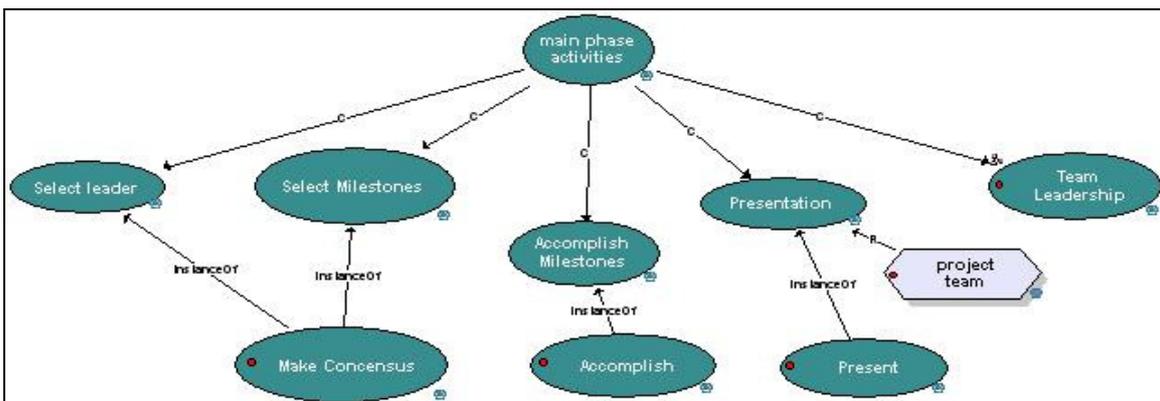


Figure 2 – Act 2: Main Phase

### The roles and services definition submodels

#### Role submodel

We created a shallow role hierarchy that contains only the basic roles needed for our PBL scenario. All roles are divided in staff roles and learner roles according to the IMS-LD specification and are placed in two separate tree structures. Role hierarchies may be modified by instructional designers and teachers. More roles may be added, others can be removed. We, however, recommend to keep roles that are used inside the pattern models. All roles used in models are copied as references from the role submodel.

#### Services Submodel

The services submodel contains all the services to support the on-line components of the PBL blended scenario. Services may be offered by means of an integrated environment or by individual tools eg. “the mailer offers the mail service”. A designer may add more services or remove (or simply not use) certain services. All these services constitute a workspace that may have various descendants. In our design we have foreseen two of them: the “team workspace” which is shared by the members of a project team and the “class workspace” that is shared by all project teams. The final implementation will include several “team workspaces” since each project team has its own team workspace. These can be considered as instantiations of the “team workspace”. The class workspace is shared by all project teams and it is a

central meeting point for the whole course unit. In other designs one might include a student workspace or a staff team workspace, etc. All workspaces contain the set of services that appear in this model or subsets of this set.

## Patterns

### Exploring the idea of the pattern

There are many definitions for patterns starting from the original definition that Alexander (Alexander 1979) gave: “A pattern is a solution to a problem that occurs in various contexts and can be reused ever and ever”. In the learning domain the definition of the Pedagogical Patterns Project seems more prevailing: “patterns are designed to capture best practices in a specific domain or “capture expert knowledge of the practice of teaching and learning...”. While writing the narrative of the PBL scenario, we noticed that there are several reoccurring situations that can be modelled in a similar manner. For instance the cycle “propose-negotiate-synthesize”, appears constantly in a PBL scenario whenever a decision has to be taken and therefore consensus is required. No matter if the members of the team have to choose their leader or make up their minds about the project milestones, or assign roles to individual members, they always have to follow the abovementioned activity cycle. These situations are not identical; there are a number of parameters that may vary (subject, time, place, outcome, etc.) but they all share a common core that can be identified as a good common practice or solution wherever the situation of reaching consensus arises. Therefore we claim that this activity cycle constitutes a pattern that can be called the “Consensus” pattern.

### Pattern mining

The identification of patterns is a process called “pattern mining”. It is difficult to identify patterns because it is hard to define what is a pattern and what it is not a pattern. Pattern identification has mostly to do with intuition and although there is no good methodology for pattern identification, there is a set of characteristics that identified patterns should possess, namely: *Encapsulation and Abstraction, Openness and Variability, Generativity and Composability and Equilibrium* (Appleton, 2000). We attempted to identify patterns in our scenario according to the following criteria:

1. Patterns must represent situations, procedures or problem solutions that preferably appear more than once in a PBL scenario.
2. They must be applicable to all kind of project setups, independently of number of participants, duration period, or other parameters that may vary.
3. In our model not everything oughts to be a pattern. Only some of the activity structures of the model have been identified as patterns, and some others make use of patterns.
4. Patterns should bear some pedagogical value, e.g. Activities related to the system setup by technical staff are not considered as patterns
5. They must be analyzable in order to represent a solution. This means that they must be roots of an activity structure subtree. Activities or activity structures that are no further analyzed cannot be patterns. (Later we will see that some of the activities or activity structures that have not been analyzed in our model have been placed in the list of the candidate patterns).
6. They are not identical to tools or services that may also be reusable. For example there is no pattern called “chat” or “online discussion”. These are services offered by the on-line system and although they may often appear in PBL scenarios, they do not constitute a practice or solution to a problem. Patterns can make use of such services, but they are more complex human activities.

### Designing the patterns

There is no really good methodology for designing patterns, as well (Appleton 2000). We designed our patterns according to a few basic principles:

- We tried to design patterns that encapsulate experience, expertise and common sense.
- We wanted our patterns to be less descriptive and more prescriptive. Our goal was to model human activities and give parameterised solutions that can be further explored.

- Our patterns cannot be played in their current state by a computer learning system, but they can act as guidelines for helping teachers and educational designers to design their own courses implementing good practices.
- We also want them to have the basic pattern characteristics mentioned above.
- We deliberately avoided the use of specific tools or services inside the patterns. For instance in the “Consensus” pattern there is a need for a team workspace, a general place where the negotiation, presentation, etc and other activities of the pattern will take place. However, it is up to the teacher to decide the exact media that will support the on-line activities.
- Some patterns have no roles attached to them, for instance the “Presentation” pattern, does not include either staff or learner roles. It turned out from our analysis that both learners and staff may present various topics at various steps of a PBL scenario. In the scenario presented in this paper, each group of students presents the final solution/results of its project, at the end of the Main Phase. In another project setup the instructor may decide to present the details of the project at the preliminary phase.
- Patterns may contain other patterns: example the “Presentation” and the “Accomplishment” patterns both contain the “Feedback” pattern.
- Not all of the activities inside the pattern need to be executed. As an example, the “Consensus” pattern the “Vote” activity is an alternative choice when the synthesis phase does not lead to any decision.

### The pattern list

After performing the analysis of our PBL scenario we ended up with six patterns and a list of candidate patterns. The patterns are: *Accomplishment*, *Approval*, *Consensus*, *Feedback*, *Presentation* and *Supervision*. We claim that these patterns can be useful in every PBL scenario. The fact that most of the patterns presented here (or their variations) are also found in other learning patterns repositories (eLen patterns (Goodyear et al. 2004), the Pattern repository (Derntl, 2005), etc.) strengthens our approach. The modelling language is perhaps different, the proposed solutions may vary, but the stated problem is more or less the same, which enforces the idea that there is a set of common problems/situations that keep on appearing in learning scenarios and that learning design can be considerably improved and facilitated by the use of predefined solutions (patterns) to those problems. The list of patterns as well as the list of the candidate patterns may be extended by other designers and instructors whilst more PBL scenarios are being modelled using the same methodology that we used for our scenario.

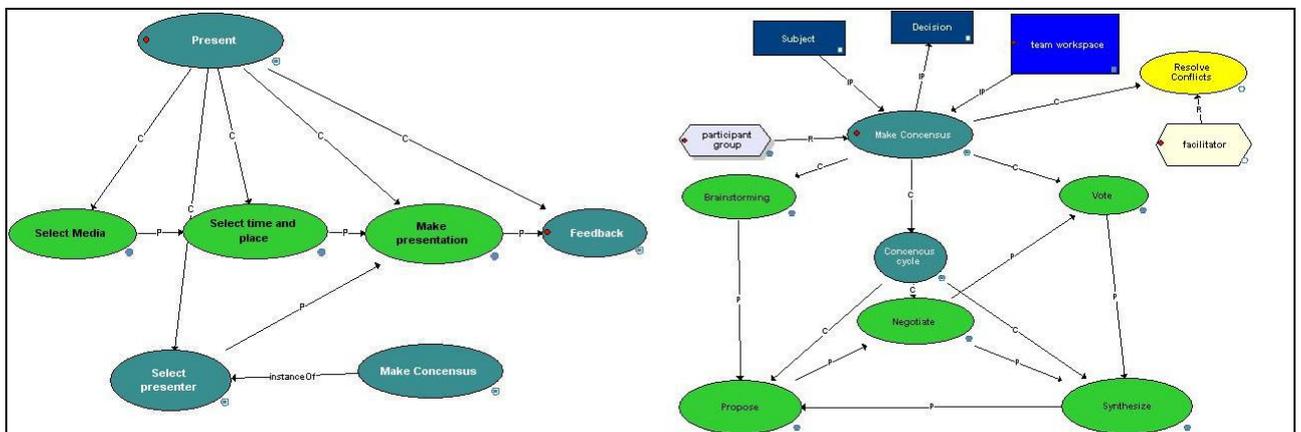


Figure 3 – The “Presentation” and “Consensus” Patterns

### Candidate patterns

There are a number of activity structures in our model that may be considered as patterns in a future attempt. Most of them are already met in other learning pattern repositories and/or represent a problem that seems to be recurring in PBL scenarios. The reason why we did not proceed with describing them as full patterns, was mainly due to time restrictions to propose a good solution to the problem that they represent. We preferred to focus on a limited set of patterns, whose solution was already mature and they turned out to appear more than once in the current PBL scenario. The Activity Structures that form the candidate patterns list are the following: Resolve conflicts, Make learning contracts, Team Building and Team leadership.

## Modelling Problems

In this paragraph we present some of the modelling problems that we faced trying to model our pattern based template with the MOT+ editor.

### *The lack of instantiation*

Patterns are modelled in the MOT+ environment in separate definition submodels. Patterns in our model act as classes according to the object – oriented paradigm: they need to be instantiated. The idea of reusability of a pattern is expressed via instantiation. If an activity structure is identified as a certain pattern, then we say that this activity structure is an instance of that pattern. One or more activity structures may be instances of the same pattern i.e. the “select leader” and “select milestones” activity structures are both instances of the “Consensus” pattern. Because the IMS-LD model and the MOT+ editor, lacks the “instance-of” kind of relationship, we modelled it not as a direct link but using the following method: let’s suppose that an activity structure called AS has been identified as an instance of a pattern P that has a root node called N. The pattern P model is placed in a separate submodel, from which we copy by reference the N node to the model where AS is placed. Then we create an untyped link (offered by MOT+) that starts from the copy of N and stops to AS and give the name InstanceOf to that link.

### *The lack of recursion/iteration*

There are some activities that may be carried out recursively. For instance in the “Consensus” pattern the cycle “propose-negotiate-synthesize” may be carried out for an arbitrary number of times until consensus is reached and a decision is taken. In order to model the iteration of activities, we introduce a new activity structure and give it a suitable name like for instance “consensus cycle” to indicate the iteration. Then we link every activity that is part of this cycle with a C link with the newly created activity structure and a P kind of link with the other activities of the cycle to indicate the order of execution.

### *The lack of generalization/specification relationships*

In many cases there is a need to define an IsA relationship between two elements. In the services submodel the “team workspace” and the “class workspace” both inherit the services of the “workspace” environment, but they are meant to be used for different purpose i.e. in different activity diagrams. We use the untyped kind of link offered by MOT+ to model such kind of relationships giving it a suitable name IsA.

### *Distinction of Support and learning activities*

It seems that there can be no clear distinction between a learning and a support activity as specified by the IMS-LD information model. The fact that an activity can be carried out/related to either a staff or a learner role does not make it a different activity. The “Give Feedback” activity found in the “Feedback” pattern is a good example of this case. In our model we had to duplicate these activities (one copy as a learning activity and one copy as a support activity), retaining the same name and relate each copy with a different role (one from the learners’ hierarchy and one from the staff hierarchy).

## Using the graphical model as a template

The graphical representation of our narrative constitutes a template and not a complete IMS-LD Unit of learning. We call it “a template” because:

- The exported IMS-LD XML files cannot be played by an IMS-LD player (like SLED or RELOAD player)
- Not all the activity structures are fully analysed.
- Many things are deliberately left open for the instructor to choose.
- No resources or services have been attached.
- Some untyped links have been used to represent new kind of relationships between elements as shown later.

The current version of MOT+, allows models to be saved as templates (having the .gab extension) and then new models can be opened using one of these templates. The teacher or educational designer that will use our template to design his/her own PBL scenario has the following options:

- Open a new model using the existing template and decide which parts will be executed on-line and which face to face. Copy and paste the on-line parts of the model in new models, add placeholders for learning objects and services, then export the model in IMS-LD XML format. Edit the resulting xml files (better use the RELOAD editor for this purpose) to add recourses and services and create the corresponding zipped packages. Play the exported packages with an IMS-LD player, whenever needed to support the on-line activities of the PBL scenario.
- Open a new model using the existing template and create another play in the same model that will represent another PBL scenario to be used for another project setup (for instance a project of shorter duration or larger groups of students, etc.) Create new acts, and activity structures based on the patterns, role hierarchies and services available from the definition submodels of the template. Decide which parts will be executed on-line and which face to face and follow the same steps as above.

## Conclusions and further work

In this paper we tried to illustrate our methodology on how to produce a complete PBL scenario starting from an IMS-LD model template that makes use of patterns. We explained how this model template was created starting from a detailed narrative and what problems were faced while modelling this narrative using the IMS-LD information model in the MOT+ editor. Since our model is based on patterns, we made an extensive reference to what is a pattern, how patterns can be identified and which principles we followed for their design in our model. In the future we plan to explore other modelling environments that have some of the features that are inherent to pattern theory (like instantiation, specification/generalization, etc.) We will also try to extend our pattern list, analyzing more patterns and produce several PBL scenarios to prove their validity in various learning situations. We also plan to implement a case study that uses our current scenario in a real higher education course, hoping to get valuable feedback about how useful and helpful can be to instructors and learners.

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