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Hydra

Networked Embedded System middleware for
Heterogeneous physical devices in a distributed architecture

D2.1d Scenario Thinking

Integrated Project
SO 2.5.3 Embedded systems

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1. Introduction

The Hydra project develops middleware for networked embedded systems that allows developers to create ambient intelligence applications. System developers are thus provided with tools for easily and securely integrating heterogeneous physical devices into interoperable distributed systems.

The middleware will include support for distributed as well as centralised architectures, cognition and context awareness, security and trust and will be deployable on both new and existing networks of distributed wireless and wired devices that typically are resource constrained in terms of computing power, energy and memory. Hydra middleware will be based on a Service Oriented Architecture (SOA), to which the underlying communication layer is transparent.

This document describes the methodology used for deriving a set of plausible usage scenarios on 2015 involving the typical use of Hydra in three different domains: Building Automation, Healthcare, and Agriculture.

Creating scenarios of end-user behaviour and interaction with platform functionality is an extremely useful instrument for identifying key technological, security, socio-economic and business drivers for future end-user requirements. The scenarios will provide the framework for subsequent iterative requirement engineering phase.

From the scenarios and storylines, a systematic formalisation of all relevant user requirements and subsystem functional, security and societal requirements will be derived. Functional user requirements specifications will involve the most important aspects of user expectations in the chosen application domains.

2. Scenario planning of the future

2.1 Navigate the uncertainties of unknown futures

Accountable decision-making about future user requirements needs a high element of certainty - an adequate level of knowledge and confidence in our assumptions about that knowledge. But defining user requirements today is far more complex than ever before, taking place in a fast changing, highly uncertain information and technology driven environment. Compounding this, the illusive interlacing of shifting values and policies, social structures and behaviour increasingly undermine predictions on how the future will look. On their own, familiar planning and forecasting practices that have served us well in the past, cannot deliver the insights and answers we need now.

The process of Scenario Thinking (or Scenario Planning as it is sometimes called) is widely recognized as a tool for creating user requirements specifications under uncertainty.

Scenario Thinking is not about predicting the future and, surprisingly enough, not about choosing the best way forward, though it is indeed a powerful and invaluable tool, which helps this. Its primary value lies in the development of new skills for improving the definition and planning of user requirements.

Developing and deploying these skills enables us to transcend the specific or localised circumstance solution, to go beyond short-term or one-off successes and acquire a consistency and robustness in coherent long-term user scenarios. We come to know the right questions to ask and where to look for missing pieces to the puzzle; how to spot unique opportunities and choose the best way forward.

2.2 Context scenarios

The first step in Scenario Thinking is to fix ourselves firmly in the present. When thinking about the future, we do so within a context; a starting place or how things are now, gives rise to an opening array of ideas or facts, which in turn are related to some sense of a desired goal or objective for future user interaction.

As we convert this information into well defined stories of possible future situations and what our options for action in them are, we surface the inherent uncertainties facing us that need to be dealt with or overcome. An obvious fact often forgotten is that these uncertainties have sprung out of our original thinking, assumptions, omissions and commissions.

The quality and disposition of original input will strongly influence the flow of thought, handling of material and quality of output. In order to make the best use of scenarios it is important to clarify our intentions and identify the issues or areas to test with the multiple futures.

2.2.1 What is a scenario?

The future is awash with uncertainty. Scenarios are snapshots of possible/alternative futures that help us plumb that uncertainty. Scenarios provide coherent, comprehensive, internally consistent descriptions of plausible futures built on the imagined interaction of key trends. It essentially requires you to think from the outside in and takes you through a process that starts with creating context for the unknown.

2.2.2 What is the purpose?

The purpose of Scenario Thinking is to challenge the preconceived notions people have of the future, or their maps, and to afford people the flexibility to change those maps. The process is intended to open up the way you think about the future. Scenarios help identify threats, recognize opportunities and makes choices about issues of strategic importance. Scenarios illuminate the possible, what might be. It asks you to do something a bit counterintuitive, which is to go beyond the known into the unknown, outside your expertise.

2.2.3 How to use scenarios?

As you read the scenarios, think about how you might answer each of these questions:

- Is this even remotely possible?
- Would the world be a better place in this scenario?
- If you were a user in this scenario, what would you be doing differently?
- If you knew for sure that this scenario was to come true, what would you as a user do now?

In essence the Scenario Thinking process is designed to arrive at several parallel hypotheses about the future, which can be held at the same time. These hypotheses are given form and are able to be pictured by users by embedding them in a story or scenario. In turn this means that the same person can look at the evidence through different sets of glasses and see things in a different perspective.

2.3 IDON Scenario Thinking

Mapping approaches have received a great recognition in the education and business professional activities. Hexagon Mapping is part of visual facilitation approach, which combines dynamic representation with creativity using visual idea representing units, called idons. Idons afford manipulating, combining and rearranging as a continuous process of formulating thoughts. Hexagon mapping accepts some of the basic theoretical assumptions of system dynamic mapping and the principles of lateral thinking.

Having established the context of investigation, through a variety of information gathering techniques, dialogue and modelling methods, the knowledge is shaped into distinctive alternative stories of the future or scenarios.

IDON Scenario Thinking is based on the logical intuitive story-and-simulation approach to scenario thinking and was originally developed in consultation with Arie de Geus, author of "The Living Company" while head planning coordinator of Shell International.

IDON Scenario Thinking has a well-established track record in a wide variety of fields.

2.4 Development of scenarios in Hydra

The scenarios will in Hydra be used to derive detailed user requirements, to investigate the consequences of emerging new or disrupting technologies, as the basis for security and trust analysis and as a model for deriving user validation frameworks.

The scenarios have been developed in three one-day user workshops involving a varied group of experts from the selected domains. The workshops have been conducted in three different countries to stimulate the European dimension. Representatives from partners IN-JET, INNOVA and C-LAB have facilitated each workshop.

The workshop starts with a short introduction to the Hydra project and an overview of the IDON method for scenario planning. A short introduction was mailed to the participants prior to the workshop.

3. Implementing the IDON method

Using the IDON method step by step will result in a set of scenarios that all points to alternative use cases within a give user domain and at a given point in time. All scenarios will have the same frame of reference and – ideally – be equally likely to happen.

The IDON method consists of two parts: Scenario Development and Scenario Deployment. The scenarios are developed in the *Scenario Development* part using experts and based on knowledge and systematic analysis. The aim is to develop four mind-challenging scenarios by mixing inevitable trends with creative fiction.

In the *Scenario Deployment* part, technical experts and project decision makers interpret the scenarios and extract a framework for the functional and trust and security requirement specifications. By applying a systematic approach as is used here in Hydra, the interpretation of the scenarios becomes very convincing. The scenario deployment into user requirements takes place in WP3. They become the guiding specifications for the technical development work in Hydra. The validation of the resulting platform will also be linked to the scenarios.

3.1 Creating and writing scenarios with a group

Hydra scenarios are constructed from a varied background of knowledge and guesswork about the relevant environment and the trends and discontinuities likely to happen in the future and affecting the users business and way of work. The scenarios will draw on both available research and application knowledge in the consortium and on the opinion of a divers set of experts form different parts of the domain.

The process and group dynamics is managed by a group facilitator, who is also responsible for the final documentation and write-up of the scenarios.

3.2 Environmental factors

The core of the IDON technique is to examine a set of wider environmental factors ambiguities and uncertainties identified by the group in order to resolve, which role they are likely to play in the unfolding of a variety of scenarios.

Some of the environmental factors that might be covered in the discussion process are:

- research and technology trends
- institutional and market trends
- social values and life-styles
- economic futures
- management and delivery systems
- ethical and value questions
- global political influences
- ecological and environmental issues

It can be difficult to move from such a set of factors to actually construct scenarios, but the IDON method and its systematic approach is a good way to do it and has proven its usefulness in many other projects.

3.3 The "Trigger Question"

The initial phase of the IDON method involves three steps. After this phase, a variety of environmental factors should have been identified, evaluated and ranked.

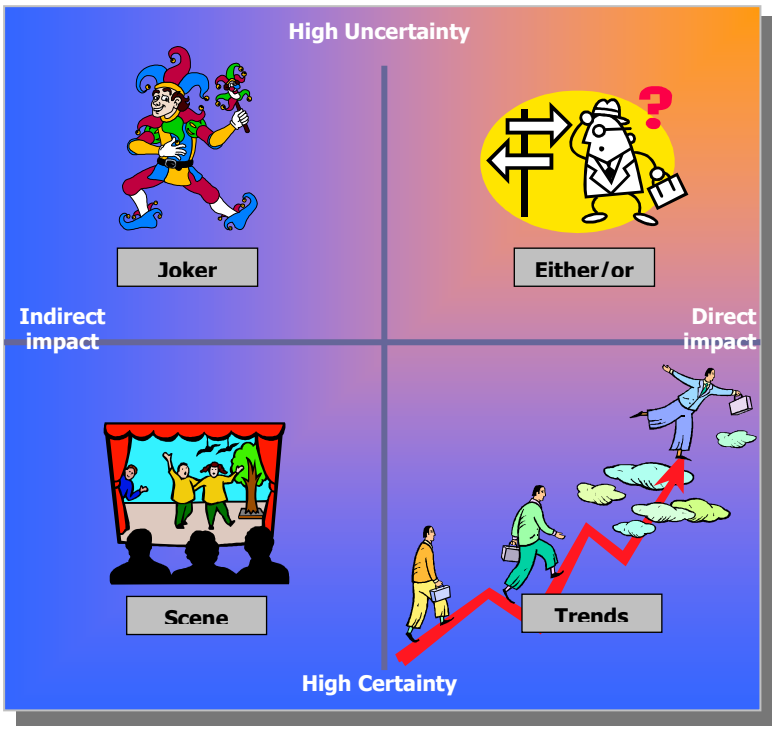
Step 1 – gathering environmental factors

The facilitator formulates a question designed to elicit responses from participants, which will cover the subject of either of the three user cases in Hydra. This is called the "Trigger Question" because it triggers a whole range of creative thoughts about the subject.

Step 2 – positioning on the grid

The next step is to group factors according to their degree of uncertainty and how direct their impact is likely to be on the user cases.

The method is visualized using a conventional two-dimensional grid:



The dimensions of the grid are introduced, without interpretation at this point. The idea here is to begin to sort the different factors, placing them on the grid, where the participants feel they best belong. Each factor is taken in turn and its position discussed and provisionally fixed according to its perceived "Higher" or "Lower" degree of uncertainty and "Indirect" and "Direct" impact in the user cases. Note that absolute positioning is not the point; it is the relative positioning that is important.

Step 3 – Survey all factors

When all the factors have been placed in position, the whole set is reviewed by the group and fine adjustments is made in relative positioning.

3.4 Characterization of the quadrants

Each quadrant has a different interpretation but that there is no sharp line of distinction either vertical or horizontal. The behaviour of each group of factors in broad terms is as follows:

Top - right: Pivotal uncertainties (Either / or)

These factors are likely to have a direct impact on the user cases, but their outcome is uncertain. They are pivotal in the sense that the way they turn out may have strong directional consequences. These factors will determine the shape of the different scenarios.

Top - left: Potential jokers (Joker)

These factors are pretty uncertain as to their outcome and maybe also less relevant to the user cases. However, it could be dangerous to treat them as merely noise. They represent factors that should be monitored in case they move strongly to the right, i.e. develops a direct impact on the user cases.

Bottom - right: Significant trends (Trends)

These factors impact more directly on the user cases and it should be possible to anticipate their effect.

Bottom - left: Context shapers (Scene)

These are relatively certain factors and are bound to shape the future context.

3.5 Use of the quadrants

In the scenario building we are going to explore the uncertainties from the "Either / or" quadrant to derive a set of different scenarios for the user cases. Each scenario will thus reflect the uncertainties attached to those environmental factors that have been grouped in this quadrant.

The environmental factors grouped in the other quadrants will be retained for reference and inclusion in the final stage of writing up the scenarios in the following ways:

> The factors in the context shapers quadrant are those that should be woven into every scenario, if it is written up fully. These factors will be used to describe a common scene for all scenarios.
>
> The significant trends will also run through each scenario but in a manner in which they manifest, will be different in each one. The factors in this quadrant can be said to constitute different sets placed on the scene.
>
> The potential jokers are useful factors to bring into the scenarios during the process, if the scenarios are starting to become too uniform.

A further description of the use of the various quadrants will be given in each of the Hydra user cases.

3.6 Creating prototype scenarios

Scenarios can be thought of simply having three levels. At base level there are the context shapers, which seem pretty inevitable and will tend to underpin all scenarios at a given time – these are changes that are common throughout, like the *stage* in a theatre.

At the intermediate level there are trends and these can be quite complex, because of the variety of ways they can interact with each other. These will be modified from scenario to scenario but still retain their basic condition. These can be likened to the changing scenery in a play.

At the differentiated level each scenario has some unique variances. These differences arise from the uncertainties we perceive. An uncertainty about something means at least things could go this way or go the other way. Uncertainties may be main line or they may be jokers.

As these uncertainties interact in different ways that affect how things turn out, the combinations of even twenty variables are astronomic. We need a way to simplify this information, without diluting its impact, into different emergent stories of the future. These may be perceived as the different dramas that might be put on in a theatre. In order to do this we go through the following stages in creating prototype scenarios from which a full set of scenarios can be developed.

We have chosen here a way to generate four contrasting scenarios. The purpose of this technique is to create simple scenarios that bring out distinct future challenges. At the end of the Scenario Development phase, one of the scenarios will be chosen for implementation as the Hydra user scenario in the respective user area.

Arriving at the prototype scenarios involve three steps.

Step 1 – Reframing the Pivotal Uncertainties as Questions

Looking at the factors in the quadrant marked "Either / or", participants are invited to think of each one as an uncertainty question for which there are two possible outcomes. We will call one outcome state the "flip" (e.g. Yes, education will be affordable) and the other contrasting outcome state the "flop" (e.g. No, education will not be affordable). When the factor in question has either "flipped" or "flopped", the uncertainty is resolved.

An example may illustrate the technique. Assume that the group is working on writing scenarios in a teaching environment. The group has identified a number of uncertain environmental factors (listed in column 1 in the table below). For each factor, a flip (+) and a flop (-) question is formulated (column 2).

Price of education How will the price of education develop in the future?	+	Education will continue to be affordable
	-	Education will become relatively more expensive than today
Access to information How accessible will information be?	+	Easy access to information
	-	Difficult to get access to information
Media types Which media type will proliferate?	+	Electronic media dominates
	-	Traditional media will be retained
Mobility How will people move around?	+	Commuting will be increasingly difficult
	-	Mobility will increase
Equipment Will people have access to the necessary equipment?	+	Access to learning equipment is facilitated
	-	Equipment is only available to few
Learning method What will be the dominant leaning method?	+	Emphasis on individual learning
	-	Emphasis on shared learning
Organizational	+	No take-up of organizational learning

	-	Adoption of organizational learning
Collaboration Will people collaborate with co-workers?	+	Minimal collaboration
	-	Collaborative thinking at work

Step 2 – Grouping the factors

The group will now search for connections and associations between the various factors (uncertainties). Uncertainty areas connect because of the impact of their influence of each other, either because if one "flips" the other will "flop" or because they are likely to align by association. This is a kind of domino effect. The group will continue to work with the associations until there are two main clusters or at least two priority clusters out of a set.

In the example above there are 10 environmental factors (uncertainties) of which the first 5 have to do with how people will approach learning ("Learning Location"). The remaining five can be said to relate to the "Learning Culture".

Step 3 – Naming the sub plots

In the clusters we now have groups of questions. When one if the uncertainty questions resolves to, say, a "flip" side, it will tend to correlate with the "flip" side of all the other uncertainties in that cluster. This will end up resolving the entire cluster as a large scale "flip" or "flop". It is rather like a group of little magnets organizing themselves to a main N-pole and S-pole. The two outcomes of the whole cluster are called sub-plots, which will combine in different ways according to the "flip/flop" questions to give us different scenarios.

In the example we can now group the uncertainties in the "Learning Location" cluster as big "flips" and "flops":

Big Flip Cluster "Learning Location"	**Big Flop Cluster "Learning Location"**
• Education affordable • Easy access to information • Electronic media dominates • Commuting increasingly difficult • Access to learning equipment	• Education will be expensive • Difficult to access information • Traditional media retained • Mobility will increase • Equipment only for the few
leads to the name:	leads to the name:
REMOTE LEARNING	**LOCAL LEARNING**

In a similar way we can group the "learning culture" cluster:

Big Flip Cluster "Learning Culture"	**Big Flop Cluster "Learning Culture"**
• Emphasis on individual learning • No up-take of organizational learning • Minimal collaboration • Poor feedback system • Global pressure reducing	• Emphasis on shared learning • Adoption of organizational learning • Collaborative thinking at work • Effective feedback system • Global pressure for best in class
leads to the name:	leads to the name:
INDIVIDUALISM DOMINATES	**CORPORATISM DOMINATES**

Each name needs to express a coherent alternative view of the combined uncertainties – more than simply "good" or "bad" but suggestive of how things might develop. They should be imaginative and evocative, like good chapter headings of a novel, and easy to remember, because throughout the project, the names will project be used to quickly identify a tremendously complex set of future uncertainties in a large number of environmental factors.

3.7 Generating multiple images of the future.

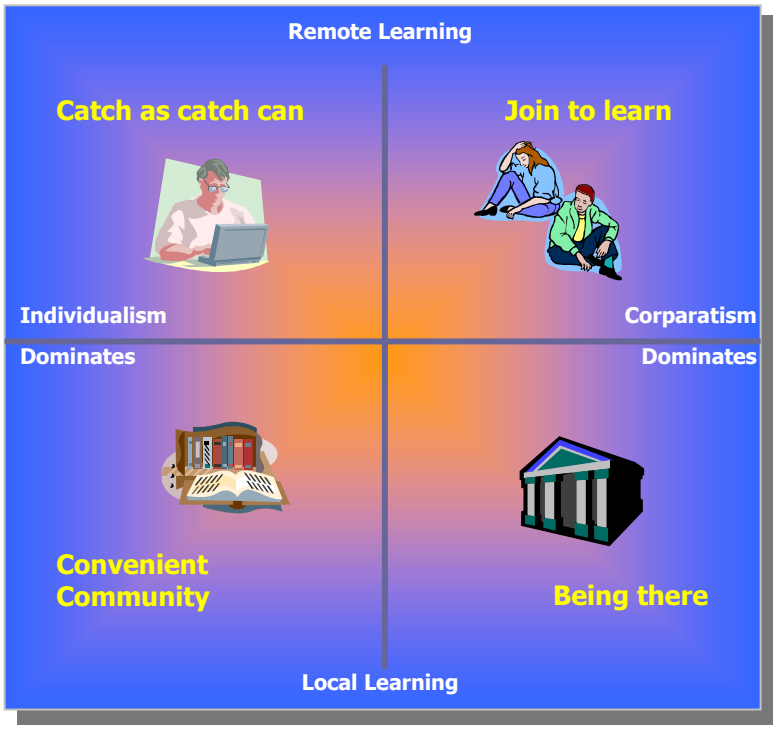
When the subplots have been generated using the "flip-flop" method, they need to be combined to form scenario structures. On the one hand this is a logical process in which there are a set number of combinations statistically. On the other hand it is an intense exercise of imagination and judgment where the participants are challenged to synthesize each set of combinations to formulate scenario stories, which are stimulating and relevant to the thinking task.

The purpose of this is to arrive at creating four scenarios generated from the two clusters, each of which has two states or sub-plots. The titles of these scenarios will represent four distinct possible futures extrapolated from the thinking done by the group and will hold rich meanings, which can be further fleshed out when the scenarios are written up after the exercise is completed.

The four outcomes from the two clusters can be combined in four different ways to form images of the future. In our example, the possible combinations are as follows:

1. Remote Learning + Individualism Dominates
2. Remote Learning + Corporatism Dominates
3. Local Learning + Individualism Dominates
4. Local Learning + Corporatism Dominates

The group now uses their imagination to form a mental picture of the world that emerges within each of the four combinations and formulate a provisional title for that world. The result will be presented in a two dimensional grid like this:


Remote Learning
Catch as catch can
Join to learn
Individualism
Dominates
Corparatism
Dominates
Convenient
Community
Being there
Local Learning

3.8 Writing up scenarios

At the end of the exercise the scenarios are written based on the group discussions and the imaginations and visions crated during the workshop. Group members usually perform the writing up of the stories after the workshop.

Step 1 – Development of the scene

When a scenario is written, the writers start with the scene, which is common for all scenarios. The elements for defining the scenes are found in the lower left "Scene" quadrant of the original grid of environmental factors. The scene must reflect the basic characteristics of the user area, for which the scenarios have been developed.

Step 2 – Building the set

The environmental factors in the lower right "Trend" quadrant constitute the changing sets that are built on the scene for each scenario. Trends have a direct influence on the story in the scenario, but only the environmental factors that are relevant to the scenario are used.

Step 3 – Defining the script

In the final step, the story is written from the prototype scenario so that the scenarios come to life as imaginative plays.

In writing the scenarios, it is useful to let the environmental factors enter the scene, set or script according to a simple grouping:

1. What is happening?
2. How is it happening?
3. Why is it happening?

The final scenarios are illustrated with pictures to stimulate the reader's imagination.

The entire IDON process can be illustrated graphically as in figure 1:

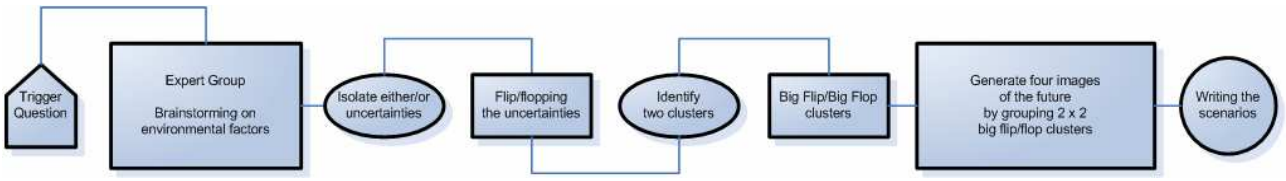


Figure 1 The IDON process