Predicting the Future: Technology Roadmapping

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Abstract

This article suggests a methodology for technology roadmapping that puts forecasting of technological developments on more systematic grounds than previous approaches. A web-based system has been developed (http://elsnet.dfki.de/) that allows technology roadmaps to be encoded, presented to the public, and discussed widely. Within this system three roadmap documents have been encoded that highlight different aspects of the field of language technologies.

Technology Roadmapping

The concept of a roadmap is a powerful and intuitive metaphor. A roadmap is a document that

- indicates directions for a planned journey;
- shows how and in what order goals can be reached;
- indicates distances;
- is condensed in one structured presentation;
- is perspicuously presented.

A technology roadmap combines prediction of enabling developments, feasibility judgements and scientific or economic goals into strategic planning. It puts these ingredients on a time-line, serving as a planning tool. This is feasible for periods up to five or six years. Longer periods tend to involve less reliable predictions.

Existing approaches to technology roadmapping are highly diverse. They can roughly be grouped into three categories:

- **Product availability plans at company websites**: Using different visual means, the future developments of a product or product line are defined in terms of functionality.[1]
- **Overview presentations, e.g. at conferences**: Inquiries are evaluated that reflect experts' opinions on future applications, standards, and associated changes in society.[2]
- **Dedicated workshops**: Discussions and suggestions on technology forecasting in a small group.[3]

None of these approaches has adopted the roadmap metaphor for presenting information in one concise document – as a roadmap.

[1] See e.g. http://www.3m.com/us/electronics_mfg/microelectronic_packaging/mc/tech_roadmap.jhtml
[2] See e.g. Roger Moore's presentation at the IEEE ASRU Workshop in the Virgin Islands in 2003, http://www.elsnet.org/dox/moore-asru.pdf
[3] An overview of roadmap activities can be found at http://www.elsnet.org/roadmap.html

In 2002 the ELSNET network of excellence started building up roadmaps for the field of Human Language Technologies (HLT). We first developed a methodology of technology roadmapping that

- identifies the types of information needed;
- systematically specifies the elements of a technology roadmap; and
- can be implemented and made available on the Internet.

Based on this methodology we developed the HLT Roadmap System (http://elsnet.dfki.de/) and encoded several roadmaps representing workshop results that look at different aspects of HLT.

Requirements

While previous approaches to technology roadmapping provide useful insights and give rise to interesting and sometimes controversial discussions, they do not aim at systematically representing technological achievements and their mutual dependencies.

We call an achievement predicted to be available at a certain point of time a milestone. Usually milestones are not precisely defined in terms of functionality and status of availability when it comes to complex topics – while it is straightforward to formulate predictions on the throughput of electronic circuits or on the growth of a morphological stem lexicon, it is difficult to predict when, e.g., machine translation will be “generally useful”.

Obviously more precise milestones than that must be defined, yet different levels of granularity are needed for different prediction tasks. The usability of machine translation may well depend on progress with electronic circuits and morphological lexicons, but roadmaps may legitimately concentrate on more MT-specific milestones such as the availability of thesauri or translation memories.

The level of granularity of a presentation is, of course, limited by the need of presenting information in a concise roadmap document. Still relationships with the more fine-grained – and hence more basic – milestones are desirable and should be provided. This can be achieved most easily using Web-based presentations; different roadmap documents can be designed in such a way that they complement each other and can be interlinked to form a comprehensive presentation.

In addition, web presentations can easily meet the need of constantly and publicly maintaining roadmap documents over time.

Usage and Design Principles

To design a technology roadmap document, its purpose and scope need to be determined. The HLT community and industrial customers of that technology need to reach at a common understanding of the upcoming technological development in the field and of resulting applications. The common understanding is achieved by an interactive process of contributing and discussing on the Web.

The realisation of information in a technology roadmap is ontologically defined on a structural, a representational and a presentational level.

On the structural level, we distinguish (sub)areas, milestones (subdivided into technologies, resources, tools, applications), and relations between milestones, such as *enables* or *supports*. Milestones consist of a short name used for its presentation in the road map, a definition (a piece of prose – see below) and an index, locating it on the timeline of a ten years period. Milestones may be related to external resources, such as other technology

descriptions. Verbal comments from the public are associated with the respective piece of roadmap information.

On the representational level, the information types defined for the roadmap are represented as typed objects in a relational database. Hyperlinks to outside sources are represented as marked textual objects in the database.

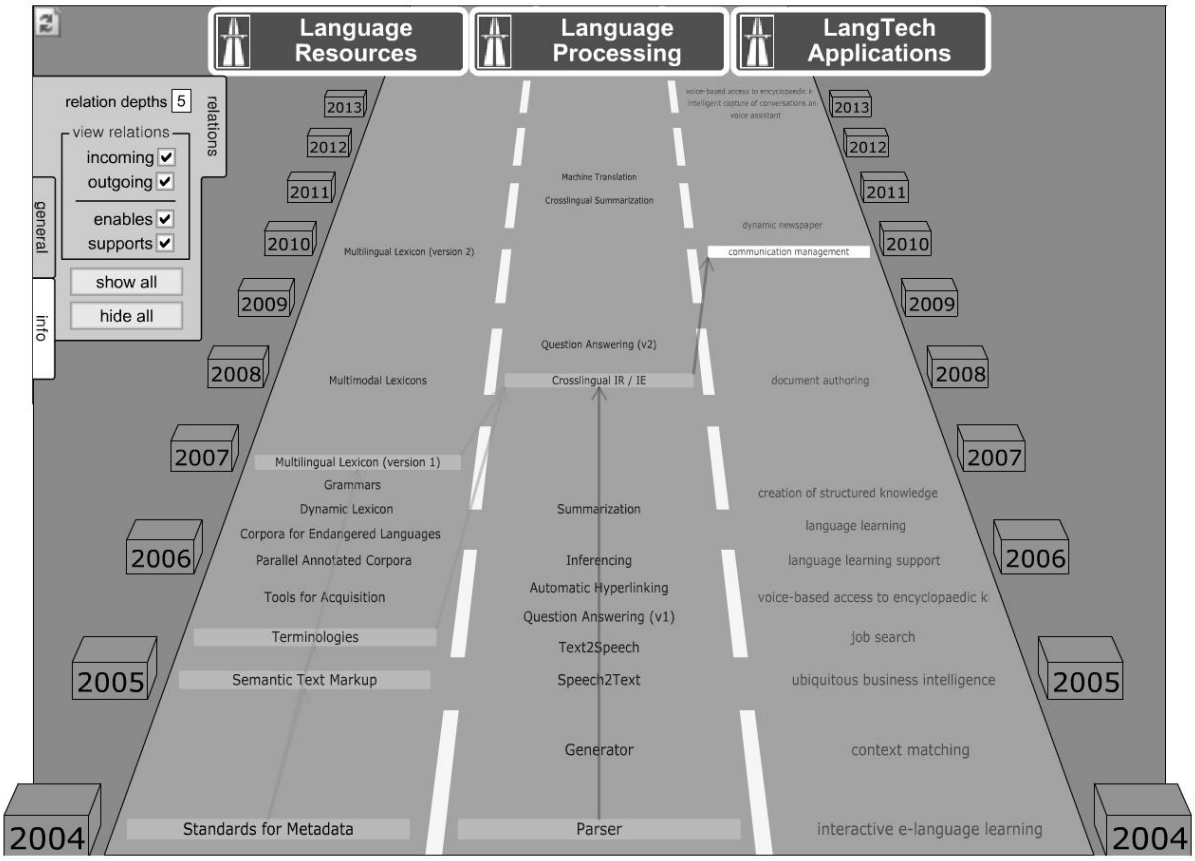

Figure 1: A Snapshot of a Roadmap Document.

At the presentational level the roadmap metaphor has rarely been taken serious. DFKI-internal roadmaps that have regularly been submitted to the board of shareholders for about ten years form a notable exception. The presentation has been refined and taken over into the HLT Roadmap System. It consists of a three-dimensional graphical representation of a straight road with three lanes leading slightly uphill, with distance marks depicting time periods (cf. Figure 1). The road is shown from a driver's point of view, from a slightly elevated angle. The major milestones are placed on the road surface. They fall into different categories that are marked by colours. The lanes correspond to the main areas of technology. Lane directions are shown on a highway sign spanning the entire road.

In addition, a tabular presentation is accessible (e.g. for printing) that maintains the time axis by listing the milestones in their temporal order in three rows corresponding to the three lanes.

One of the natural visual features of the roadmap metaphor is the relative difficulty with which more distant milestones, as opposed to near ones, are recognized. This corresponds to the fact that technologies in the far future are less precisely defined a less predictable than those in the near future. But forecasting requires us to mentally travel into the future; zooming along the time axis mimics this.

Milestones and Milestone Descriptions

Is “Ambient Intelligence” a milestone? In 2010, achievements attached to this buzzword will no doubt be available. Closer thoughts reveal that a milestone must be more clearly identifiable. “Ambient intelligence” is rather an R&D programme than a milestone in a roadmap.

“Machine translation” is another example. Certainly, achievements in machine translation are clearly identifiable, e.g. as systems. Still we may ask whether “machine translation” will eventually be “achieved” in, say, 2010. There will be emotional discussions, but hardly well grounded positive answers. Obviously, this milestone cannot be precisely defined. What is a good milestone, then?

A milestone in the HLT roadmap should be a piece of software (in a general sense) that is clearly identifiable. Thus its description should be precise. For a parser, we should specify the output, the type of grammars it can interpret, and the speed it processes, e.g., one gigabyte of text. For a resource such as a lexicon, we should specify its size, the kind of information it encodes, and the kind of grammars it can be used with. For an application, we should specify the intended users, the functionality, and possibly the price. For all three types of milestones, information about availability and sharability should be provided.

Moreover, the state of development is important. Since the HLT Roadmap will address both consumers of technology (e.g., industry) and creators of technology (e.g., researchers and developers), the technology must be “ripe” in a certain sense. This certainly means more than a validation of research results, and less than an off-the-shelf product. We might adopt the notion of *validated prototype*, to denote a piece of software for which the above information can be given and that can in principle be taken over by industry for use or for professionnal re-implementation.

The HLT Roadmap System enforces none of the above information. It is up to the encoder of milestones to specify appropriate milestone descriptions.

Implementation

The information underlying the HLT Roadmap System is represented in a MySQL database. It is made available on the Web server through PHP scripts. The roadmap presentation is implemented with Macromedia Flash. The zooming and navigation functionalities in Flash allow for viewing close-ups.

The roadmap site at http://elsnet.dfki.de consists of

- an introductory page,
- the selection of the roadmap to be visualized,
- the task description for that roadmap,
- the roadmap itself,
- extensive online help facilities,
- the discussion forum, and
- the password-protected administration area accessible to the roadmap and Web page designers.

For any milestone in the roadmap, a menu with entries for details, comments, and relations can be opened. “Details” include the short name, as seen on the road surface, the full description of the milestone, which cannot be presented on the road's surface due to space

limitations, and the category. The “details” view also allows for linking to external HLT resources such as the information portal LT-World (http://www.lt-world.org).

The “comments” entry takes care of interactivity. It allows the user to send a comment about this or any other milestone to the moderated roadmap forum. The user can reply to existing messages in the forum or open up a new thread.

The “relations” entry presents dependencies on other milestones. Only by establishing relationships between milestones it is possible to represent more than simple temporal subsequence. Currently, relationships for enablement and support are defined. A menu on the roadmap allows the user to visualize incoming or outgoing relations for a particular milestone with a specified depth. Depth 1 shows only the direct relations, whereas by choosing a higher depth, chains of e.g. enablement can be visualized.

Conclusion and Outlook

The HLT Roadmap System provides a framework for implementing technology roadmaps. So far different aspects of HLT are looked at without claiming for completeness or a wide consensus. In ELSNET, the discussion of roadmaps has so far been limited to the respective workshops. It proved difficult to have experts devote their spare time to a more continuous discussion and refinement of roadmap contents in order to reach a consensus document.

Therefore the ELSNET network of excellence went for a different approach: experts have been invited to prepare definitions for a “language resources and evaluation roadmap” closely related to the information structure needed. These documents will be discussed in a joint meeting[4], and the results will be made available within the HLT Roadmap System.

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[4] Building the Language Resources and Evaluation Roadmap: Joint COCOSDA and ICCWLRE Meeting in conjunction with LREC 2004 in Lisbon, May 30, 2004.