

**Title**

Dynamics of epistemic communities and emerging technologies:  
the need for local embeddedness and spaces of exchange

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Epistemic community; local embedding; spaces of exchange; cognitive networks, technology  
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**EXTENDED ABSTRACT***Objective of this paper*

We present the first findings of an international project<sup>1</sup> exploring the dynamics of emergence of new technologies. We are most particularly focusing on tracing the unfolding of emerging technologies. To do so, we argue that following the unfolding of communities that support the development of a technology when it faces uncertainty and lacks legitimacy is central. We build on epistemic communities (Haas, 1992), invisible college (Crane, 1972) and research space/field (Nedeva, 2011) to deepen our understanding of the dynamics of knowledge communities and to explain their role in getting technologies out of the niche.

We will present the scope of the project, our starting hypotheses and our findings from our pilot case study: Asynchronous Chip Design.

Our first round conclusions reveal that:

(1) Epistemic communities are more than cognitive alignments; they require investments into (a) *spaces of exchange* (conferences, journals, and other fora) and (b) *local embedding* (recognition and legitimacy in organisations, jobs, training programmes). Markers for these stabilisations can be traced, and we illustrate these in our case study.

(2) It is not because an epistemic community exists that a technology will emerge. Conversely; the stabilisation of the infrastructure for research, including *spaces of exchange* and *local embedding*, can mean an epistemic community can persist, in the face of the collapse of attempts to create technologies.<sup>2</sup>

(3) Single demonstrations of a proof-of-principle, or a prototype are not enough to open up a radically new technology field (see the literature of Strategic Niche Management and Transition Theory). The stabilisation of visions, legitimacy of the new option and associated evaluation structures, technical standards, etc. are necessary. We propose that *Technology Communities* are the locus of such stabilisations

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<sup>1</sup> The paper is part of 'Mapping the Dynamics of Emergent Technologies' (RES-360-25-0076), a collaborative Open Research Area (ORA) project of IFRIS (University of Paris-Est), SPRU (University of Sussex), and University of Amsterdam).

<sup>2</sup> An additional, and ongoing, element of our project is the exploration of the transformation of proof-of-principle/demonstrations technologies into those with are embedded in markets without the need for special dedicated support. This is beyond the scope of this paper.

*Introduction*

How do new technologies emerge? We position ourselves in the current rich debate on scientific and technological change. Considering the literature on innovation dynamics and more specifically on radical and disruptive innovations, we find a consensus on the role of niches in promoting change. Niches are “protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures” (Rip and Kemp, 1998). Various streams of research from strategic niche management to transitions and multi level perspectives (Kemp and Rip, 2001; Nils and Kemp, 2009; Kemp, Rip et al. 2001; Geels and Schot, 2007; Geels, 2002 and 2005) have contributed to develop a multi level framework to explain technological change essentially based on historical cases on long periods. We argue that the process through which technologies go out of their niches is still under-understood. In past studies, we have shown the role of communities of practice in fostering scientific and technological variety through exploration (Delemarle and Larédo, 2008) but also their limits in opening a market for these technologies outside of niches. Under various labels such as invisible colleges (Crane 1972), epistemic communities (Haas 1992) or communities of practice (Wenger 1998; Amin and Roberts 2008), the role of communities in the dynamics of S&T has been studied and acknowledged. We wish in the present paper to build on them and we use Nedeva’s notion of research field and research space (2011) to allow for a better characterisation of these communities by the disentanglement of their components and of their co-evolution with the technologies they support.

*Characterising communities to better understand their role in getting out of the niche for new technologies*

The research communities involved in the generation of such emerging areas of science and technology have been conceptualised as invisible colleges (Crane 1972), epistemic communities (Haas 1992) and communities of practice (Wenger 1998; Amin and Roberts 2008), among others. We adopt Luukkonen and Nedeva’s (2010) conceptualisation of epistemic communities as social and cognitive networks based on convergent bodies of knowledge that transcend organisational boundaries. Moreover, Nedeva (2011) with the notions of research field and research space adds an important element that can have impact on the dynamics of these communities: the institutional space in which researchers

(i.e. members of networks) can find resources to support and maintain their engagement in these communities. These could be financial but also political resources. Social, cognitive and institutional aspects are thus central in the development, sustaining and evolution of communities. Luukkonen and Nedeva (2010) in investigating the notion of integration bring all these elements together and also allow to better precise the notion of social integration: beyond the constitution of networks, communities also allow the diffusion of values and visions, which are central for emerging fields.

Based on these, we characterise communities in three steps. First, the degree of integration (Luukkonen and Nedeva, 2010) can be described in terms of the ***density of the research networks*** in various dimensions such as collaborations, shared epistemologies or methods, etc., building on social network theory (Scott 2000). The use of the concept of proximity across various dimensions (social, cognitive, institutional, etc.) offers a powerful and well-defined operationalisation (Boschma 2005; Frenken and ter Wal, 2009).

Second, we explore the integrative mechanisms of ***values and visions*** that bring disparate actors together, and into the values and visions of the actors so mobilised, drawing on STS research on how anticipations shape research activities (Latour 1987) and organisational science research on industry creation and the role of institutions as markets of progressive legitimation (Aldrich and Fiol, 1994, Delemarle 2007). These institutions include shared databases, large experimental facilities, journals, dedicated conferences, learned societies, etc. The expectations, visions and values that constitute the *enacted normativities* provide insights into the aims and intentions that are mobilised, thus helping to form and drive the actions of researchers or policy makers. It has been argued that one cannot comprehend system dynamics involving intentional agents without paying attention to their anticipatory, self-referential understandings (Guice 1999; Leydesdorff, 2010).

Third, we investigate the organisational environments (such as new interdisciplinary centres), policy instruments and ***local embedding processes*** that promote integration.

We argue that characterising communities (see table 1) based on these would allow to better understanding their dynamics. We argue that their state of evolution - in relation to their social, cognitive, organisational and institutional dimensions – will allow explaining the unfolding on new technologies and ultimately the move (or not) outside of the niche.

Table 1 – characterisation of epistemic communities<sup>3</sup>

Density indicators	Number of researchers, number of publications, number of patents, number of collaborations, number of conferences and workshops
Values and visions indicators	Number of special issues in journals, number of specific conferences and workshops, number of shared training programs, development of new journals
Local embeddedness indicators	Existence of a research group in the field in the researcher's university, existence of a teaching program in the field of the researcher, number of grants in the field

*The illustrative case*

The case has been selected because the development of the technology from a scientific to a technological credible option has been supported by a community (Delemaerle and Laredo, 2008; Delemaerle, forthcoming). This community has evolved over time as it attempted to: (1) move from a scientific option to a credible technological option, (2) develop a research agenda, (3) test the technology and develop niches and (4) develop a stable market for the technology. The last element has been a failure up to now. We illustrate with the case the development of the community and put in parallel the evolution of the technology.

Asynchronous design has been “emerging” since the early 1950s, but it is only recently that it has become recognized as a competitor of the dominant synchronous regime of processor designs. Issues such as high power consumption, clock distribution challenges with increasing speed, multiple elements running at differing speeds has led to an interest in opening up the synchronous integrated circuit approach, in favour of modular approaches.

During the period end of 1980s/beginning 1990s we have observed an opening up of this alternative option and the growth (and fluctuation) of the community as the technology was tested under various application framework. The various European Framework Programmes (ESPRIT and OMI most notably) from the mid-1990s until the early 2000s provided spaces for visioning, coordination and co-development of design tools and training systems.

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In the mid-2000s, the support in Europe ended, technology demonstrators ceased to be developed, small companies went out of business or became merged into other parts of the dominant development departments in firms. However, in spite of the decline of the production of demonstrators and the drastically reduced involvement of firms in the production of asynchronous devices, the community remains and continues.

In this paper we characterise the emergence and evolution of the community that is Asynchronous Chip Design, and focus specific attention on the period 2007 – 2012 and show the changes between the various periods based on the markers our theoretical framework derived us to define.

#### *The approach taken*

We explore the emergence and evolution of the field combining quantitative, qualitative and combined approaches to fill out table 1.

**Quantitative:** The quantitative analysis focuses on the Web of Science, mapping the changes in the publication data over time

**Qualitative:** Our qualitative studies are three-fold:

1. Desk research and interviews
2. We also draw upon the results of a workshop organised by the authors in the key annual conference of the community, IEEE-ASYNC, which is the only dedicated arena to date. Here we explored the visions and values of the community at this specific point of time (May 2012).
3. We continue this analysis retrospectively by analysing analysis of this arena since from 2007 – 2012 to explore the evolving visions and values of the community (the heuristics that become important as well as the broader scenario-visions of the position of the community in the wider world).

**Combined:** we explore the local embedding processes by applying quantitative mapping tools to identify key actors in the community and then combine quantitative and qualitative tools to build up *embedding profiles* of each specific actor. This allows us to see how the epistemic community is stabilising (is it a recognised and coherent field, viewed from within and from without (outside the community) or does it remain an incoherent field with little embedding in the institutions in which the key actors work.

The application of these approaches together allow us to capture the macro-level dynamics of the epistemic community and link to the micro-dynamics of institutions. Together they provide insights into the stabilisation of epistemic communities.

*Discussion of results*

We here discuss the co dynamics of the community and of the technology. The main result from the case is that asynchronous chip design is very much still at the niche level. The niche grew and deeply evolved as the epistemic community developed. But the latter was unable to get asynchronous chip design out of this status.

(1) Epistemic communities are more than cognitive alignments; they require investments into (a) spaces of exchange (conferences, journals, and other fora) and (b) local embedding (recognition and legitimacy in organisations, jobs, training).

(2) It is not that an epistemic community exists that a technology will emerge. Conversely; the stabilisation of the infrastructure for research, including *spaces of exchange* and *local embedding*, can mean an epistemic community can persist, in the face of the collapse of attempts to create technologies.<sup>4</sup>

(3) Single demonstrations of a proof-of-principle, or a prototype are not enough to open up a radically new technology field (see the literature of Strategic Niche Management and Transition Theory). The stabilisation of visions, legitimacy of the new option and associated evaluation structures, technical standards, etc. are necessary. We propose that *Technology Communities* are the locus of such stabilisations

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<sup>4</sup> An additional, and ongoing, element of our project is the exploration of the transformation of proof-of-principle/demonstrations technologies into those with are embeded in markets without the need for special dedicated supprt. This is beyond the scope of this paper.

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