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## **On the role of small firms in cluster evolution: the case of internet development in Norway during the 1990s**

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**Abstract:** In December 1991, a group of 16 people from the University of Oslo, with core knowledge in the field of informatics and computing services, met for a 'pizza meeting' and decided to start a new company, Oslonett. In Norway, this case represents the first attempt to commercialise emerging internet technology. Diverse, multifaceted development followed. The Oslonett initiative led to a 'chain reaction' in which many different actors took part. The original Oslonett was transferred into new companies, and a number of spin-offs ensued.

The purpose of this paper is to present the Oslonett case in detail; and to illustrate important mechanisms of cluster evolution, by following the actors who were involved in the initial start-up. The role of different actors is analysed from the perspectives of innovation systems and high-technology clusters, and the role of small firms is examined in relation to other actors, in particular the University of Oslo and larger firms.

**Keywords:** cluster evolution; commercialisation; new technology; internet; business evolution; start-ups; entrepreneurs; small firms; large firms; university.

**Reference** to this paper should be made as follows: Steinsli, J. and Spilling, O.R. (2004) 'On the role of small firms in cluster evolution: the case of internet development in Norway during the 1990s', *Int. J. Entrepreneurship and Innovation Management*, Vol. 4, Nos. 2/3, pp.194–215.

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This paper is based on a case study included in the research project 'Evolution of high-technology clusters' funded by the Norwegian Research Council. A previous version of the paper was presented at the 12th Nordic Conference on Small Business Research, Kuopio Finland, 2002.

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## **1 The pizza gang**

On the 12th of December 1991, a group of 16 people met for a pizza meeting in seminar room 3B in the Informatics Building at the University of Oslo. Kjell Øystein Arisland, the organiser of the meeting, had invited some of his colleagues: a graduate student, a few doctoral students and other technicians and researchers from the Department of Informatics, the Norwegian Computing Centre and the University IT Centre, all institutions located at the University of Oslo Campus.

The meeting was conducted in an informal atmosphere, the colleagues enjoyed the pizza, although the important issue of starting up a new company was on the agenda. For a long time, Kjell Øystein Arisland had been considering the idea of starting a new firm which would exploit opportunities he thought would emerge in the field of internet. In spite of his young age, 30 years, he was already an experienced entrepreneur. He had carefully selected colleagues he knew well from his work as Assistant Professor at the Department of Informatics. Arisland presented his vision for the new business opportunity, asking his colleagues to participate as partners in the new company, on the condition that they contributed a share of NOK 5000 (approximately EURO 620) in cash, and committed themselves to a minimum of one month's work during the coming year with no guarantee of payment. Everybody accepted the invitation, and they decided to establish the new company Oslonett.

Ten years later, on the 12th of December 2001, the pizza gang met again, this time to celebrate their 10th 'anniversary'. They consumed pizza once again, and reminisced about the good old days when they had started up and not understood the extent to which they would influence the development of internet-technology in Norway. During the 10 years that had passed, many different events had occurred, and a lot of experience had been gained.

The original company, Oslonett, was no longer in existence. It was the first in a long and complicated series of new firms that had been started. The pizza gang had not worked together for many years. They had all spread into different organisations, partly as entrepreneurs, partly as employees in various companies, partly as professors and scientists at the University.

Oslonett had triggered a 'chain reaction'. The original business idea had been further developed and restructured, split into different fields, and transformed into different

organisations. What had once been the core of a small and growing company during the early 1990s, was now spread, diffused and merged with other ideas and concepts found in many different businesses.

The Oslonett case is about evolution. In many ways, it illustrates typical mechanisms in the capitalist system. Seemingly, it is a simple case about setting up a firm to exploit commercial opportunities provided by new technology. However, by following all the individual actors involved in the venture, and by following all the firms that in one way or another were triggered by this development, it will be shown that the pattern of development is based on a complicated interplay between a large number of actors. In particular, the focus of this paper will be on the role of small firms in this context.

## **2 Oslonett [1]**

At the time Oslonett was established, the only institutions which had expertise in internet technology in Norway were the University of Oslo, the Norwegian Telecommunication Company's Research Unit, the Norwegian Defence Research Establishment and the Norwegian Computing Centre. They were all located in the Oslo region; in fact, the Norwegian Computing Centre and the Department of Informatics were even located in the same building on the University campus. Since the mid-1980s, the University of Oslo has had access to an international university network of researchers involved in internet technology. Oslonett was the first Norwegian company to develop commercial activities based on the emerging internet technology and infrastructure.

In Norway, as in the USA, it was the defence sector that first got access to the internet. The first data communication technology was developed by a US defence research programme, Advanced Research Projects Agency, in the late 1960s in order to ease communication between their research institutes [2]. The universities soon showed interest in the new technology and the opportunities it provided. The first university networks were developed in the USA in the early 1980s. The US based network NSF, supported by the National Science Foundation, was the first university based internet network. It was later followed by BITNET, SPAN and UUPC, all US university networks. In the early stages of development, communication between the different networks was not possible. It was not until the so-called TC/IP protocol was developed in 1983, that it was possible for the different systems to communicate with each other.

Norway was, along with the other Nordic countries, Canada and France, among the first countries outside the USA to be linked to the NSF network. In Norway, a national network between the universities and the regional colleges was developed in the mid 1980s. The network, called Uninett, was funded by the Norwegian Research Council. In 1987, this network was linked to the NSF network.

When Arisland invited his colleagues to the pizza meeting and the start-up of Oslonett in 1991, commercial activity was not new to him. Employed as Assistant Professor at the University, he had one day off per week at his disposal. By the end of the 1980s, he had started two new companies within data technology and communication: Computers and Learning and Oslo VLSI. Both companies were established with colleagues from the University. One of these colleagues, Arne Kinnebergbråthen, was later a cofounder of Oslonett. Oslo VLSI, a microelectronics company established in 1985, went bankrupt in 1988. Arisland then established Computers and Learning AS which provided training programmes to the process industry based on Candle technology.

Although the company still exists, it is inactive, and functions as a holding company for some of the other companies Arisland started during the late 1990s. One of the customers of Computers and Learning, the Federation of Norwegian Process Industries, later became Oslonett's first customer.

The Process Industry Federation contacted Arisland during the autumn of 1991, and asked for his help in developing an electronic communication system that would ease communication between the organisation's many local branches around the country. This request triggered the start of Oslonett. Although Arisland had been convinced of the advantages of the internet for a long time, and had thought of starting a company based on the new technology, this opportunity provided by a customer gave the necessary push to start the new venture.

All the 15 people invited to the 'pizza meeting' on 12th December 1991 agreed to become partners of Oslonett and invest NOK 5000 and work 1 month with no pay. They did not collaborate with financial actors, because they considered it unlikely that anyone would understand Oslonett's business concept and the commercial opportunities it represented. Their hope was that one day in the future they would get their money back and get paid for their work, and they did. Four years later they sold Oslonett and got their money back with a solid margin.

None of the founders were able to leave their current jobs; they spent their spare time working for the company. Given the uncertainty of establishing a new company, it would not have been possible to take part on a full-time basis. Arisland had, however, spent some time prior to the meeting talking to people in the corridors of the Informatics Department, so the idea was not new to them when they received the invitation to the meeting. Arisland also had credibility as an entrepreneur, since he had already established several companies. He was a person they listened to.

In total, the 16 cofounders of Oslonett represented core competence in internet technology in Norway. At the time a high degree of technical knowledge was necessary in order to utilise the technology. Even accessing and using the internet was relatively complicated. After an intense period developing a system for internet access, Oslonett welcomed their first customer aboard in the spring of 1992. However, it was not until November the same year that Arisland was able to leave his job at the University and start working full-time as Manager of Oslonett. During the first period, the company was very careful with money. They borrowed localities from Computers and Learning and did not employ anyone; they only hired people on an hourly basis.

### **3 The business idea**

The business idea of Oslonett was to deliver internet access to private persons and businesses in Norway, and to provide services to customers via internet. Although the Universities had access to the internet, it was rather complicated for private persons to get access to the net, and commercial activity on the net had until that time been limited. In the USA, it was not until 1988 that the net was opened up for any kind of commercial activity. Prior to 1988, the universities in the USA tried to hinder such a development, to keep the internet for academic use only. But financial needs forced the universities eventually to accept the commercial development.

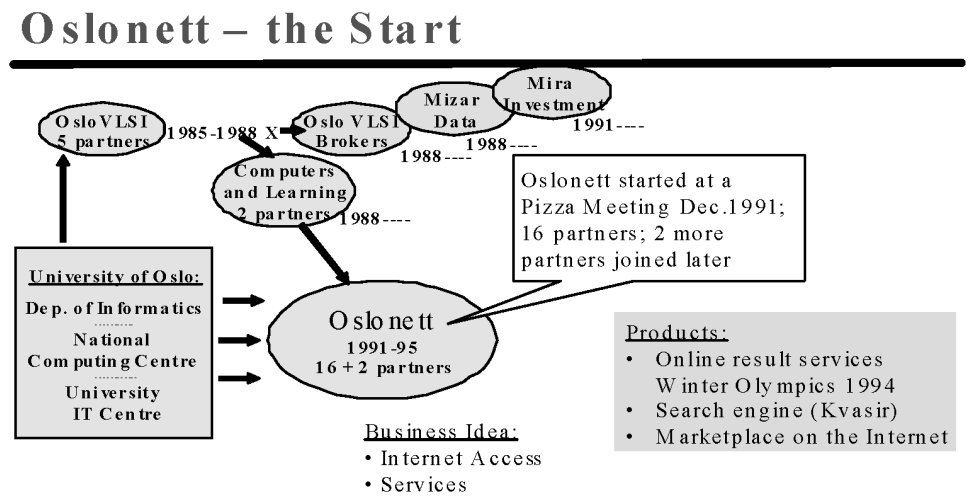
Oslonett had no direct access to internet, and instead provided access to their customers via NUUGs (Norwegian Unix Users Group) which was linked to the net.

At that time, it was, as mentioned above, quite a complicated process to get access, and all components needed had to be constructed from scratch. Therefore, it was not surprising that the first internet company in Norway was established by academics with a high degree of technological knowledge. Even if competing technologies for data communication existed (see under the role of the university later), Arisland was never in doubt about the advantages of the internet technology. As a researcher he had used the technology for many years to exchange information with colleagues all over the world, and he was quite sure about its superior quality.

In the beginning, the Oslonett entrepreneurs travelled around to potential customers to sell internet access. Their best sales argument was the opportunity to use e-mail. But most of the larger companies already had internal e-mail systems, and only a few of them actually believed it would be possible to send e-mail to other companies. Adding to this scepticism, was the confusion around choice of technology. An alternative system called X400 was provided by TelePost Communication, a company owned 50% each by the Norwegian Mail Company and Norwegian Telecom, both 100% owned by the state.

After a while, the founders of Oslonett realised that they needed to think of alternative strategies to get customers, and the development of various web services would later prove to be of vital importance, since these services illustrated very well the opportunities provided by internet.

Figure 1 Start-up of Oslonett



#### 4 Products

One of the first occasions Oslonett placed themselves in the spotlight was during the Winter Olympics at Lillehammer in 1994. They got the idea of providing results from the event on the internet. Coming up with the idea just a few weeks before the event, they did not have much time for their preparations. Due to various difficulties, they were not ready to start setting up the web page until a couple of days before the events started. Working night and day they made it. During the Olympics, Oslonett provided: online result services, links to relevant news papers and pictures from the events, and a system for

translation from Norwegian to English. All of these services were groundbreaking in Norway.

In 1994, Oslonett was also asked by the Norwegian National Broadcasting Company, NRK, to take part in a Friday night TV show, called Rondo, hosted by a popular TV personality. NRK wanted the programme to be the first to combine the internet and television technologies. Oslonett agreed to participate. Each Friday night different web pages were shown to TV viewers. With the help of Oslonett, the programme's host visited, for instance, the White House's web pages. The TV show gave Oslonett great publicity, and Oslonett got many new customers in this period.

Another product developed by Oslonett, was the internet search engine Kvasir, named after a god from Norse mythology. According to myth, Kvasir knew the answer to every question put to him. Kvasir was set up based on the model of the US search engine Yahoo. Kvasir soon turned out to be the most used and well-known search engine in Norway. Kvasir still exists, and the product has followed the company, which has been restructured and changed ownership many times since 1995 (see Figure 2).

Oslonett has also developed various other products. One of the first, was a net-based 'marketplace' in which customers could present advertisements for their products. One of their customers, Artic Adventours, a travel agency selling tours to Northern Norway and Svalbard, would soon notice the power of this new medium, and had problems answering all the requests they received. Another very successful product was based on the idea of selling flowers via internet. The Norwegian flower chain Interflora liked the idea; today it is one of the largest e-commerce successes in Norway.

## **5 Intervention of larger players**

It soon became clear that Oslonett needed a direct link to the internet in order to provide quality access services. This was expensive. The nearest access point was in Sweden, and it would cost the company millions just to get connected. None of the founders had more money to invest, so they started to search for a potential coinvestor. A former colleague of one of the entrepreneurs worked at TelePost. Oslonett contacted him and suggested a partnership. TelePost had the money to invest in the necessary infrastructure, while Oslonett possessed knowledge of the internet technology.

TelePost was established in 1991 jointly by the Norwegian Telecom and the Norwegian Post Company, both state owned companies. Their business idea was to offer electronic messaging to the Nordic business market based on the X400 standard for messaging. However, they soon realised that the technology would shift from X400 to internet. Therefore, in 1993 their services were expanded to include internet access based on leased lines and dial-up connections.

TelePost was interested in collaborating with Oslonett, but not in the form of a partnership. Instead, they suggested a consultancy agreement. Oslonett got access to the internet through TelePost in return for helping TelePost build their access. They also agreed to divide the market between them. Oslonett would provide internet access to the private market, while TelePost would focus on the business market. The consultancy agreement with TelePost turned out to be of vital importance for Oslonett's survival during the first few years, but it also contributed to the growth of one of Oslonett's strongest competitors.

In 1994, internet technology had a breakthrough in the market, and in particular, larger companies started to show interest in the use of the technology. By this time, Oslonett had a sound financial basis. Although TelePost had taken some of the market, Oslonett had obtained around 1000 access customers, many of whom chose Oslonett because of their small size and a wish to avoid the state owned TelePost.

Oslonett had a good reputation in the market. In 1992, the company had no permanent employees. By 1994, the company employed 30 full-time and 20 part-time employees; their turnover had grown from around 500,000 NOK (62,500 EURO) in 1992 to 4.3 million NOK (537,500 EURO) in 1994; and they had made a profit.

In 1994 the relationship between Oslonett and TelePost became tense, and later that year cooperation between the two companies came to an end. Working on their own, it soon became clear that Oslonett needed more 'muscles' in order to continue growing and be able to compete with TelePost, as their former agreement to divide the market between them no longer applied. Other actors had also entered the market, like EUnet and Power and Tech Information System (later PowerTech). Both of these companies were small. EUnet, however, was part of a larger European network and had access to substantial competence and technology through this network. PowerTech, on the other hand, was started by two teenagers without any formal competence and financial means.

In 1994, Oslonett had the largest share of the private market with about 1000 customers; PowerTech had hardly any. In the business market, EUnet had approximately 300 customers while TelePost had 150.

Oslonett started to look for a partner, and was contacted by Schibsted, a leading Norwegian private publishing house, which was considering utilising the internet technology. However, Schibsted was not interested in a partnership. Schibsted saw that in order to succeed in the market, substantial investments were necessary, and since Oslonett did not have any money, Schibsted had to finance most of the investment themselves. They were, therefore, only interested in buying the company. After a while, Oslonett agreed, and in September 1995, Schibsted bought Oslonett for approximately 15 million NOK (1.9 million EURO), and created Schibstednett.

In buying Oslonett, Schibsted obtained important advantages. First, they got a significant number of customers (7000 in 1995). Second, they acquired an established access net. Third, they got access to a group of people with unique competence in the internet technology; many Oslonett employees agreed to work for Schibsted for a certain period of time, among them eight of the entrepreneurs behind Oslonett. But Schibsted also contributed with valuable knowledge, and with their extensive publishing experience, they were also able to improve the quality and design of Oslonett's various web services. Furthermore, they contributed to the further development of the market for using the internet as a market place and as a medium of communication.

There were now two large actors in the Norwegian market, Telenor Online (formerly TelePost) and Schibstednett. Both provided internet access and various services via internet.

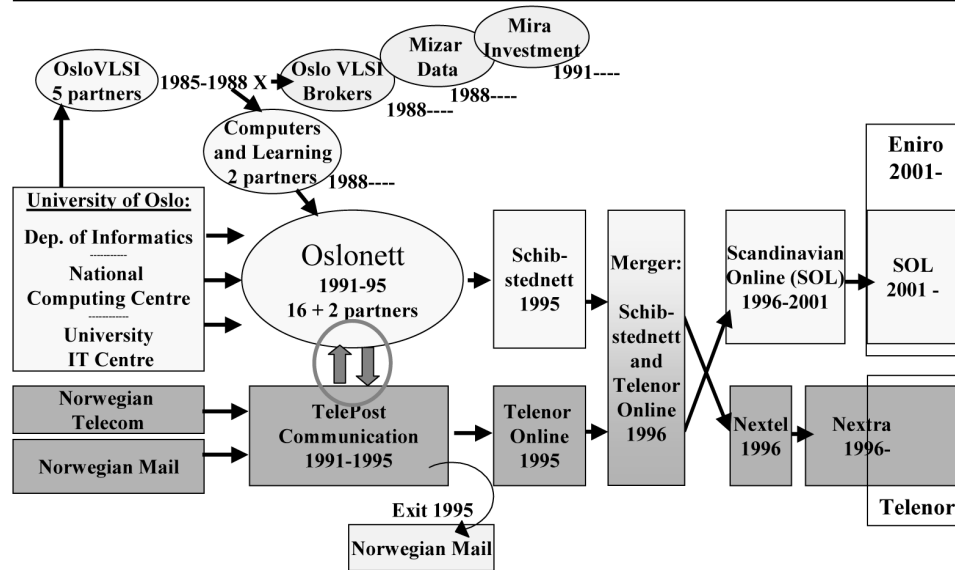
TelePost had changed its name to Telenor Online and was now owned 100% by Telenor. Telenor Online created the web portal Scandinavian Online, inspired by American Online, and Schibstednett had SN-Horisont as their portal. Clearly, this situation could not last, and after a period of tough competition, during the autumn of 1996, the two companies agreed first to merge, and then to split their activities into two separate companies, Scandinavia Online AS and Nextel (later Nextra). Scandinavia Online – or SOL – delivered internet services, while Nextel provided internet access.

The name of their common web portal was Scandinavian Online. The two companies operated closely together, which also was demonstrated by mutual ownership interests; Telenor had owner interests in SOL, and Schibsted in Nextel.

From this point on further development was characterised by new rounds of restructuring and spin-offs. Some of these companies are presented in Table 1, others are described under the section on the role of small firms and in Table 2 (see also Figure 2).

Figure 2 The main players in the development of the internet technology

## Oslonett - Acquisition - Restructuring



Scandinavian Online had the ambition to become the largest internet portal in Europe, and soon established companies in Sweden and Denmark, and later in Finland. The internet market did not, however, grow as fast as expected, and after years with deficits, the company was forced to undergo significant processes of restructuring in 1998 and 1999, but still without being profitable. In 2000, after a new round of restructuring, SOL was listed on the Stockholm and Oslo stock exchanges. The value of the shares grew quickly. At the time of emission, the company had a value of five billion NOK (about 750 million EURO). In autumn 2001, the Swedish company Eniro bought SOL, including the rights to the internet portal SOL and the former Oslonett product Kvasir (the search engine).

In 2001, SOL was the leading internet media company in the Nordic region. More than seven million people visited SOL's sites in the four Nordic countries in January 2001, i.e. 36% of all inhabitants over 14 years. During the same period, Nextra developed to become Norway's main internet access provider, with 75% of the private market and 35–40% of the business market in 2001. Nextra is now integrated in Telenor (cf. Figure 2 and Table 1).

**Table 1** The main direct or indirect actors in the development of the internet technology in Norway

<b>A University based institutions</b>	
<i>The Norwegian Computing Centre (Norsk regnesentral)</i>	
A research and consultancy company owned by the University of Oslo. One of the first milieu in Norway with expertise in internet technology.	
<i>Department of Informatics</i>	
Part of the University of Oslo. One of the first milieus in Norway which got access to the internet through the university's network.	
<i>University Centre for Information Technology</i>	
Part of the University of Oslo.	
<b>B Private and public 'background players'</b>	
<i>Telenor (The Norwegian Telecommunication Company, previously named Televerket)</i>	
A company 100% owned by the Government.	
Telenor established TelePost Communication with Postverket in 1991. TelePost changed its name to Telenor Online in 1995, parts of Telenor Online's activities were transferred to Nextel, later Nextra.	
Today, Telenor is one of Norway's leading internet companies.	
<i>Posten Norge AS (The Norwegian Mail Company, previously named Postverket)</i>	
Posten Norge AS established TelePost Communication with Telenor in 1991 (see below). They sold their part of the company to Telenor in 1995 when it became clear that the company would focus on the internet. Posten had at that time just taken over <i>Statens Datasentral</i> (the Government's Computing Centre) and wanted to continue their e-mail business through this company.	
<i>Schibsted</i>	
Leading Norwegian private publishing house. Schibsted bought Oslonett in 1996 and gave the new company the name Schibstednett.	
<b>C Companies directly involved in the development</b>	
The companies are listed in order of 'appearance'.	
<i>Oslonett</i>	
Norway's first commercially based internet company. Established in 1991. Bought by Schibsted in 1995.	
<i>Schibstednett</i>	
Oslonett was acquired by Schibsted in 1995 and renamed Schibstednett.	
<i>TelePost Communication</i>	
The company was started in 1991 by Telenor and Posten to deliver electronic message services. The ambition was to become the dominating company offering electronic mail in Norway. Posten and Telenor owned 50% each of the new company. Telepost based their e-mail service on the X-400 technology.	
The management of TelePost was not satisfied with the X400 technology. After some resistance by their owners, the board of TelePost eventually accepted that TelePost started an internet business. During the summer of 1993, TelePost became the first commercial company in Norway to offer direct internet access through permanent lines to businesses. TelePost changed its name to Telenor Online in 1995, later Nextra.	
The companies are listed in order of 'appearance'.	
<i>Telenor Online</i>	
Owned by Telenor, started in 1995. The company provides internet access as well as online services, such as the internet portal Scandinavian Online. The company was restructured into Nextra.	

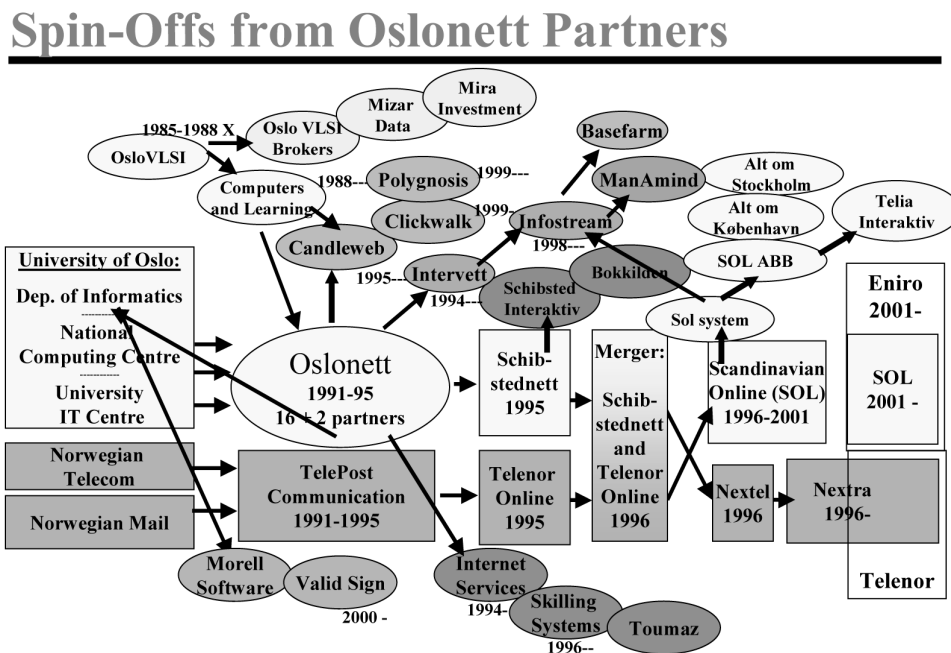
**Table 1** The main direct or indirect actors in the development of the internet technology in Norway (continued)

<i>C Companies directly involved in the development</i>
<i>Scandinavian Online AS (SOL)</i> Started in 1995 <i>SOL (Scandinavian Online)</i> The SOL group developed into the leading internet media network company in the Nordic region. SOL was listed on the Stockholm stock exchange and on the Oslo stock exchange.
<i>Eniro</i> Eniro is Northern Europe's leading provider of directory services online and offline, with operation in 23 countries. Eniro was listed on the Stockholm Exchange O-list in 2000 and has been expanding rapidly in the international market.
<i>Nextra (former Nextel)</i> In 1996 Schibsted and Telenor agreed to merge the two companies Schibstednett and Telenor Online. The company was then split into two divisions, one was named Nextel and was based on providing internet access. The company was renamed Nextra.

### 6 Spin-offs of new small firms

In addition to direct links between Oslonett and Schibstednett, SOL and Nextra, the founders of Oslonett contributed to the development of several other companies. By 2002 Oslonett's 'family tree' had branched considerably. Figure 3 presents an overview of spin-offs from Oslonett.

**Figure 3** Spin-offs related to the process around Oslonett



One group of spin-offs derived from Schibstednett and Scandinavian Online. The main companies in this group were Schibsted Interactive and the SOL system. Schibsted Interactive later led to the establishment of Bokkilden, which is now one of the leading internet based bookshops in Norway. SOL System, an operational unit outsourced from SOL in 1998, is based on Oslonett's technology; two of Oslonett's founders worked for this company. Sol System later became SOL ABB which developed '*Alt om København*' and '*Alt om Stockholm*'. Part of SOL System was acquired by Infostream, a company which had been merged with Intervett, a spin-out from Oslonett, at an earlier stage.

A second group of spin-offs was started by the Oslonett founders themselves, such as Intervett, Internet Service, Candleweb and Morell Software. Nine of the cofounders established other companies after 1991, either alone, together with colleagues from Oslonett, or with others (Figure 3). As shown in Table 2, in total, the 18 partners behind Oslonett have been involved in setting up 14 companies. Many of these companies have merged with other companies, which in turn have spun-out new companies.

Among the spin-off firms, is Infostream, which provided training and consultancy within ICT. The company was listed on the Oslo Stock Exchange, and was later acquired and restructured in several stages, and is currently called Manamind (see comments under no 8 in Table 2).

A significant number of the 18 Oslonett partners point to the positive experience with Oslonett as an important source of inspiration for further participation in business development. The success of Oslonett demonstrated that it was possible to establish a business. Furthermore, selling Oslonett to Schibsted provided financial means that could be used as risk capital in new companies.

**Table 2** Career pattern of the persons taking part in the start-up of Oslonett

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The following 16 persons participated in the 'pizza meeting' and became partners of Oslonett on the 12th of December, 1991. Title in brackets indicates formal position at the time of start-up. Listing in alphabetical order.

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*1 Arisland, Kjell Øystein (Assistant Professor at the Department of Informatics)*

Initiator of the 'pizza meeting' and the main organiser of the start-up of Oslonett.

Previous start-ups:

Oslo VLSI AS, 1985–1988, together with Arne Kinnebergbråthen (see below) and two other people, the company went bankrupt in 1988.

Oslo VLSI Broker AS, 1988– ; was based on the remains of OSLO VLSI AS. The main founder was Arne Kinnebergbråthen, Arisland participated in a minority position.

Computers and Learning AS, 1988–

Partner in Oslonett until 1994. When the firm was sold to Schibsted, he left the company and went to work at Computers and Learning. In 1994 he took a year's sabbatical to Canada.

Later start-ups:

Candle Web AS, 1995–

Polygons AS, 1999–

Click walk AS, 1999–

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*2 Berg, Yngvar (Employed at the Department of Informatics)*

Left Oslonett when it was sold in 1994, continued working at the University and is now Professor at the Department of Informatics.

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**Table 2** Career pattern of the persons taking part in the start-up of Oslonett (continued)

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3 *Ellefsrud, Anders (Engineer at the Department of Informatics)*

He never had a permanent job in Oslonett, but was employed by Scandinavian Online (SOL) when Schibstednett was reorganised to SOL in 1997. He later followed as an employee when SOL was restructured and activities transferred to the following firms:

- SOL System (outsourcing of the operation unit of SOL) 1998–
- Infostream ASP (SOL System was acquired by Infostream) 1998–
- Basefarm, 2000 – (this company was set up by a group of partners who previously worked in SOL System.

Since 1997, when Ellefsrud started as an employee at SOL, he has been working at the same desk in spite of being employed at four different companies.

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4 *Hannemyr, Gisle (Employed at the Norwegian Computing Centre)*

When Oslonett was sold to Schibsted, he followed the company to Schibstednett and SOL; he became manager of SOL with special responsibility for development activities. After a few years, he left his job, and returned to the university to finish his PhD in Informatics, where he still works as a researcher at the Department of Informatics. Since his return to the university, he has participated in other start-ups:

- Morell Software
- Valid Sign 2000 –

He has also worked for Schibsted Interactive Studio, which was a ‘think tank’ for developing new business ideas. One well known company to result from this is Bokkilden, an internet-based bookshop.

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5 *Holen, Hans Petter (Employed at the University IT Service Centre)*

He followed Oslonett to Schibstednett, for a short period he worked for Telenor Online before he returned to SOL, later to SOL System and Infostream ASP where he was central in the development of the internet portals SOL in Sweden (SOL ABB), ‘*Alt om Stockholm*’ and ‘*Alt om København*’. He is now head of technical unit at Tiscali Norway, an International company providing operation of databases.

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6 *Karlsen, Tore Solvar (Employed at the Norwegian Computing Centre)*

He was the first among the 16 partners of Oslonett to be employed by the company, and was manager of Oslonett from 1993 until the company was sold and converted to Schibstednett. He was also employed by Schibstednett for a short period of time, where he worked with internal systems development, before returning to the Department of Informatics, where he conducted research on the development of the next generation of internet Services, before he was employed by Telenor, the main Norwegian telecommunication company. At Telenor he works with establishing internet provision in Russia and other Easter European countries.

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7 *Kinnebergbråten, Arne (Employed at the Department of Informatics)*

Previous entrepreneurial experiences:

- Oslo VLSI AS, 1985-1988, with Kjell Øystein Arisland (see above) and two other people. The company went bankrupt in 1988.
- Oslo VLSI Broker AS, 1988 –; was based on the remains of OSLO VLSI AS.
- Kinnebergbråthen was the main founder, while his previous partner Arisland participated in a minority position.
- Computers and Learning AS, 1988 –, minority position, main partner: Arisland
- Mizar Data, 1988 –, investment company
- Mira Investment Company, 1991 –, investment company

He developed specialist competencies in financial issues, and assisted the partners in Oslonett in this field.

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**Table 2** Career pattern of the persons taking part in the start-up of Oslonett (continued)

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8 *Kjærnsrud, Steinar Arne (Head of the operation unit at the Department of Informatics)*  
 He had a special role in setting up most of the web services provided by Oslonett, including the Kvasir search engine and web services developed for the Winter Olympics at Lillehammer in 1994. He also developed internet courses that were later sold through Intervett, see below. He left Oslonett when the company was sold, and then started:  
 Intervett, 1994, which was started with a friend, Knut Jærstad. In 1998 Intervett started to look around for a partner, and Intervett and the company Infostream (established in 1989) merged in 1998. Infostream later became Norway's first internet company on the Norwegian stock exchange in 2000. Infostream was in 2000 bought by a French company, Integra, which again later was bought by the American company Genuity: Today the name of the former Infostream is Manamind.

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9 *Knudsen, Terje (PhD student at the Department of Informatics)*  
 He left Oslonett when the company was sold in 1995, went back to the Department of Informatics, where he still works as a senior engineering officer in charge of the data systems of the Department.

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10 *Lande, Tor Sverre (Assistant Professor at the Department of Informatics)*  
 When Oslonett was sold, he followed the new company and was a member of the board of Schibstednett until 1997. He returned to the Department of Informatics, where he is now a Professor. He has also been involved in other start-ups:  
 Skilling Systemer AS 1996 – (specialised technical consultancy services)  
 Internet Service AS 1994 – (with Otto Milvang, see below)  
 Toumaz

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11 *Milvang, Otto (Engineer at the Department of Informatics)*  
 When Oslonett was sold, he started a new company:  
 internet Service AS 1994 – (with Tor Sverre Lande, see above)  
 Axicon 1991 – (with a colleague from the Norwegian Computing Centre).

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12 *Neset, Leif Arne (Engineer at the Department of Informatics)*  
 After Oslonett was sold and converted to Schibstednett, he continued working in the new company until 1996. He then left and was employed by Bærum KabelTV, a local cable TV company which has recently restructured and now operates under the name alfaNETT.

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13 *Næss, Sigbjørn (PhD student at the Department of Informatics)*  
 He finished his PhD after the sell out of Oslonett and continued at the Department of Informatics as an Assistant Professor, and he is still in this position. He also works part-time for NERA Satcom, a leading Norwegian electronics company.

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14 *Olsen, Kjetil Otter (employed at the University IT Service Centre)*  
 He only participated in the start-up of Oslonett as a partner. He has worked at the University during the whole period, where he is responsible for the University's data- and telecom network.

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15 *Thomassen, Jens (Engineer at the Department of Informatics)*  
 He followed Oslonett to Schibstednett and SOL. For a short period he went back to the University, before he started working for the company Metamerge (established in 1998). Metamerge is a consultancy service on systems and software.

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**Table 2** Career pattern of the persons taking part in the start-up of Oslonett (continued)

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<i>16 Tvedten, Knut (Graduate Student at the Department of Informatics)</i>	After the sell out of Oslonett, he was employed by the company Sysdeco Mapmill. Recently, this company went bankrupt, and he is now considering starting a new related company with some of his former colleagues.  In addition to the above mentioned 16 partners that started Oslonett, two persons were invited and joined as partners in 1994.
<i>17 Martmann-Moe, Erling (employed at the Norwegian Computing Centre)</i>	He worked with Oslonett and Schibstednett until 1996. He then became CEO of New Media Science which later was merged and restructured into the new company Cell. Today, he works as an independent consultant and is a partner in Alliance Venture. He also established Martmann-Moe Nye Medier in 1997, and consultancy services on systems and software.
<i>18 Aas, Gisle (employed at the Norwegian Computing Centre)</i>	He worked with Oslonett and Schibstednett and later SOL, but left SOL in order to start his own consultancy firm, and work towards the international Pearl development milieu. He is now working for ActiveState in Canada.

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As shown in Table 2, the Oslonett partners chose different careers after the company was sold. Eight partners stayed with the company to work for Schibstednett, five partners went back to their previous employers at the University, and four partners established new companies.

Since 1995, the 18 partners have continued to play a role in the internet development in Norway. The eight partners who joined Schibstednett and later SOL, were important to furthering technological development of SOL. Oslonett partners also played a role through their positions at the University. First, they contributed to the training of new graduates through teaching and research. Second, they are important role models for students who want to establish their own companies; today a certain entrepreneurial culture is in evidence at the Department of Informatics. Third, they are of importance to the public decision-making process through their participation in public debates and advisory boards. Finally, by establishing new firms, they have also contributed to innovation and the growth of the dotcom industry in Norway, although none of their companies have grown large so far. One of the former Oslonett partners is employed by Telenor, and has contributed to Telenor's business development in Eastern Europe.

## 7 The role of the University

The University, in particular the Department of Informatics, played an important role in the development of the Norwegian internet market. First, because of their role as an early user of the technology. The University of Oslo was among the first in Norway to get access to the technology, and Norway was, through the University of Oslo, among the first countries outside the USA to get access to the networks.

The University played an active role in the debate on choice of technology when the Norwegian Government planned to build Uninett. However, they did not succeed in their attempts to persuade the government to choose the internet technology instead of the OSI standard (Open System Interconnect). Although the internet technology had been known for some time, there was uncertainty about what kind of technology would lead the

development. In addition to the internet and the OSI standard, a third technology existed in 1991, the BBS (Bulletin Board System).

The telecommunications companies argued that the OSI standard should be the leading standard. The OSI standard made it possible to control communication through the net in the same way that telecommunications traffic was controlled, thereby making it possible to charge users for using the net. The internet technology, on the other hand, was developed under the influence of the academic culture and based on principles of openness and easy access for users. For instance, there was no need for a technology that could identify users and how much time they spent connected to the net.

When the Norwegian Government decided to go for the ISO standard, a few internet enthusiasts at the University of Oslo contributed to the choice of the CISCO standard when they built the net, a standard which is applicable to the internet as well as the OSI standard. At the time no products had yet been developed for the OSI standard. In the University milieu there was no doubt about the superiority of the internet standard.

The three technologies existed side by side until the mid-1990s. The internet standard had the largest share of the market. In addition to the advantage of having a wider choice of products available through the internet, the internet technology had two additional advantages. First, it was based on a system that secured a much faster transfer of text. Second, it was based on an open and decentralised decision-making process. Everyone could set up their own web pages on the net and add whatever they liked to them. In the case of the OSI standard, one had to go through a complicated and time-consuming approval system. Without the influence of the internet enthusiasts at the University, it is unlikely that internet technology in Norway would have advanced as far as it did by the late 1980s and the early 1990s [2].

Second, the University played an important role in the commercialisation of the internet in Norway. As has been discussed above, there was a direct link between the University milieu and Norway's first internet company Oslonett. All the founders of Oslonett were either employed at the Norwegian Computing Centre; the University's Centre for Information Technology or at the Department of Informatics, and they continued as employees at their respective institutions either during the whole or parts of the period Oslonett existed. Oslonett was a pioneer in its development of several internet based businesses, and the persons behind Oslonett were also central in the development of Telenor's internet strategies.

An innovative milieu had developed at the Department of Informatics and the other related institutions. According to the persons behind Oslonett, the milieu was characterised by an open and including atmosphere; they were all good friends who shared a common passion for information technology. Several of them emphasised the importance of the heritage from the Department as an important success factor for Oslonett. It was their genuine interest in developing the technology that provided their main motivation, rather than the highest possible profit.

Third, the university also played an indirect role in the development of the internet market through its students from the Department of Informatics. They were all trained in using the internet technology; and acted as advocates for the new technology in their later working life.

Since the technology at that time was rather complex, and a high degree of technical knowledge was necessary to set up an internet business, it is not surprising that the first internet company was set up by academics. Nor is it surprising that the university played a pivotal role in the early days of development. The university's role is, however, often

underestimated in empirical studies of innovation systems in the Oslo region. According to a study of the regional innovation system of Oslo [3,4], there are few links between the university and research institutes, on the one hand, and businesses in the region on the other. Improving these links was therefore identified as a main policy task. There also seems to be a general impression that businesses regard universities and research institutes to be of marginal importance for their businesses (see also [5]).

Although we will not argue against a strategy for improving relations between the R&D institutions and the business community, the case of Oslonett illustrates that the influence of a research institution may be very significant, although very indirect, when many new internet based businesses are considered. The links to the university are not as visible in 2000 as they were in 1991. If asked in 2000, the managers of SOL or Manamind would most likely not regard the University of Oslo as important. This case illustrates that it is necessary to look at business evolution in order to understand the importance of the different actors.

## **8 On cluster evolution**

According to many authors, technology is the main driver of economic development, and innovation is the process in which new technology is implemented into new and economically useful products and processes [6–8]. There also seems to be broad agreement that the best way to analyse these processes is based on a system approach, within the framework of innovation systems [7,8], innovative milieus [9,10] or clusters [11–14].

The case of Oslonett serves as an illustration that it is fruitful to apply these concepts to an analysis of local processes. The case also reveals the complexity of the processes involved in the evolution of high-technology clusters. In line with recent research on clusters and cluster evolution [11–13,15–17], the case illustrates the importance of geographical proximity for development. Not only were all the major actors located within the urban area of Oslo, they were also located in specific areas of the city. This proximity allowed people to meet informally in different arenas and form various constellations, which is important for the dynamics of the process.

What characterises functioning clusters, or regionally confined innovation systems, is the presence of a large number of actors in specific industrial sectors, partly competitors, partly organised along the value chain as suppliers and customers, partly complementary organisations. The concept of critical mass is often mentioned [15,16,18], i.e. a minimum number of actors is necessary to form a cluster that has sufficient strength to take a leading role in international competition and maintain and further develop the core competencies of the cluster. However, defining critical mass is a difficult issue, and the literature tends to be vague in this field. Obviously, critical mass may vary depending on the industry and field of competence concerned, as well as links to resources located elsewhere. In the present case, there were a sufficient number of actors involved. It is important to note that the development took place in interaction between several local actors.

Private actors in the form of entrepreneurs and established companies are found at the core of the cluster and serve as the main drivers of the evolutionary process. However, the presence of various institutions is also essential to the functioning of clusters and innovation systems. In the case described here, the University of Oslo was the cradle for

the development. Competencies available at the Department of Informatics and the National Computing Centre, provided the knowledge base for the internet technology. However, development could not have taken place without the presence of actors with entrepreneurial capacity, i.e. with the ability to see the commercial potential of the technology and to take steps to organise new ventures to exploit these opportunities. Entrepreneurs in the Schumpeterian sense played a crucial role as agents of change [19,20].

The first stage of development may be characterised as technology-based or technology-driven, in the sense that it was the technologists that identified the opportunities. Although their motive was to exploit commercial opportunities, it was their recognition of the potential of the technology that was probably the main driving force. All the founders of Oslonett had expertise in the field of information and communication technology.

Oslonett's business concept may be identified as a radical innovation – based on Autio's typology of technology-based companies as innovators [21], the firm may be classified as a 'paradigm innovator'. The classification of Autio is based on the combination of two dichotomies; novelty of market (established–emerging) and novelty of technology (established–emerging) [22]. Obviously the role of Oslonett was to explore an emerging technology as well as an emerging market. During the first stage of development, i.e. as long as Oslonett existed as a formal unit of operation, the main orientation of the firm was more towards technology than the market.

However, the processes around Oslonett provide an opportunity to challenge simple ways of classifying the role of companies in the innovation process. Although the radical and paradigmatic aspects of the new venture are obvious, its development is characterised by small steps; steps that may be regarded as incremental innovations and incremental contributions to the overall development. Rather than perceiving the company as a paradigm innovator, it may be viewed as an actor shifting between the roles of application innovator, technology innovator and, to some extent, market innovator. Taken together, these add up to the role of paradigmatic innovator.

During its first stage of development, Oslonett took advantage of the Oslo Science Park, where they rented office space for some time. Again, the aspect of geographical proximity is important, as the Science Park is located in the building next to the Department of Informatics on the university campus. So this part of the institutional structure may also have been of some importance.

On the other hand, the financial sector of the institutional structure was absent during the first stage of development. The founders of Oslonett did not consider collaboration with financial actors, because they considered it unlikely that anyone in finance would be able to understand the business concept and the commercial opportunities. Basic funding for the initial development of Oslonett was provided by the partners' own financial resources, and supplemented by investing their spare time in the venture and by selling consultancy services.

The next stage of development serves as an example of the limited capacity of technology based entrepreneurs. With their limited financial resources, the founders of Oslonett faced problems in following up their venture. By the end of 1994, the activity of the company was the equivalent of 40 full-time employees, and more financial resources were required both to manage growth in general, and, in particular, to make investments that would allow them to further exploit the opportunities.

A new organisation was required; it was time for a shift from technology-driven to finance-driven development. The technologists gradually left this particular business arena to continue with activities in other businesses or institutions, while more formally dressed businessmen took over. This also implied a shift from small, entrepreneurial firms to a dominance of larger firms in the evolution of this particular field of business.

## **9 On the role of small firms**

There are many ways to analyse the role of small firms in cluster evolution. Oslonett showcases the different roles that small and large firms may have in the development and application of new technology. One main point, however, is to emphasise the importance of an evolutionary approach [6,23] and analyse the role of small firms in this perspective. In recent years a number of studies have been published in the field of cluster evolution (cf. [11,12,15,24–27,28]). Many of these studies focus on developments in the high-technology area, and, within this context, on the role of small firms [29–33].

The purpose of the evolutionary approach is to explain how changes occur and identify the basic mechanisms of evolution. Based on Schumpeter's ideas regarding entrepreneurs as agents of change [20], new, primarily smaller firms, may be regarded as the main vehicles implementing this change.

Another way of regarding new, non-imitative (small) firm start-ups, is that their primary roles are to test out new business ideas. This was already suggested in 1975 by Ramström [34], and is in line with a more recent understanding of the capitalist system as an experimental economy [19,35].

There are many possible outcomes of a high tech start-up. The most likely outcome, which is in accordance with findings from a number of studies on firm formation and the development of populations of firms, is that the new firm closes after a short while, when it becomes apparent that the business idea is not viable. Of course, there may be more 'positive' outcomes of a start-up as well, in the sense that the new business idea may turn out to be profitable and sustainable. In rare cases, the new business idea may reveal significant growth potential, and either be interesting as a candidate for acquisition by a large firm, or develop into a large independent firm. Other more likely outcomes are that the firm will remain small, for instance, based on serving a specialised niche market, or providing services to the local market.

In the present case, all these outcomes are represented. First, the 'pizza gang' has been involved in a significant number of small firm start-ups. With one exception, i.e. Oslonett, all of these companies have stayed small for their life time. All the new firms may be regarded as experimental, although the degree of risk involved has varied a lot – from less risky consultancy and investment companies, on the one hand, to more risky start-ups based on the application of technology in new fields, on the other. Second, Oslonett, which was 'successful' in terms of identifying a business idea with great potential, soon experienced the constraints of the initial organisational form, and was transformed into a new organisation which could provide significant financial resources to further exploit business opportunities. A similar pattern may be identified for one of the other firms with growth potential; i.e. Intervett, which was started in 1994, merged with Infostream in 1998, acquired by the French company Integra and later by the US company Genuity to become today's Manamind.

In total, then, the role of these small firms has been to create variation, to test out new business ideas, and provide a mechanism of selection to identify 'successful' outcomes. In the case where a business concept with a significant growth potential was identified, larger firms followed up the development by acquisition, as has been analysed more systematically by Dahlstrand [30,31].

Another aspect of development, is that it is sequential. Each step of development is followed by a new step. These steps may be taken within the same organisation, or by crossing organisational boundaries, or by restructuring and creating new organisations. At the core of this process are the entrepreneurs, who organise new ventures. Partly, development is characterised by serial entrepreneurs or portfolio entrepreneurs [36–38], i.e. the entrepreneur who moves from one start-up to the next and creates a number of new ventures. The process of entrepreneurship may also be regarded as sequential, in the sense that potential entrepreneurs observe what other entrepreneurs do and base their own startups on what might be learnt from the experiences of previous entrepreneurs. In this way the process is cumulative; each new step in the development provides a contribution to change the context in which new firms are started up.

Furthermore, firms 'participating' in the development, may go through internal changes more or less continually, which from one point of view may be regarded as temporary coalitions [39]. This perspective may partly be illustrated by the firms involved in this case, based on many combinations of members of the 'pizza gang', combinations that have even changed during the lifetime of the firms.

Processes of spin-offs or spin-outs are often regarded as an important mechanism of cluster evolution [25,31,40]. New businesses are often developed while the founder is still working in an existing organisation or institution, and the new organisation is launched when the founder(s) leaves this organisation. This case shows that the phenomenon of spin-outs is significant. The majority of firms that members of the 'pizza gang' founded, may be regarded as spin-outs, either from the university-based institutions where they initially were employed or were students, or from Oslonett or some of the companies followed. However, the importance of the 'link' between the 'incubator' organisation and the spin-out organisation may vary a lot depending on the extent to which the new organisation is based on knowledge and other resources found in the 'mother' organisation.

## 10 Summary

According to current theory on innovation systems and cluster evolution, knowledge is the most important resource in the economy, and learning is the most important process, as stated by Lundvall during the early 1990s [7]. This understanding of innovation systems has been followed up by a number of researchers [6,18,19,41,42]. One aspect of cluster evolution is covered by the concept of collective learning [25,43,44–46], i.e. there is a broader process going on in which actors contribute in different ways to the process of learning, for instant through entrepreneurial processes.

Thus, the formation of new firms provides a significant contribution to the evolutionary process. Each entrance of a new firm, and each step of development in an existing firm, may be regarded as a contribution to the evolution of the system as a whole. From this perspective, each new step is based on previous events and adds new knowledge to the system.

The case presented in this paper gives some indication of how diversified this process may be. Although the focus is on a narrow field of technological development, a number of actors have been involved, partly in competition, partly in collaboration and partly in complementary roles.

Based on the perspective of collective learning, the nature of 'success' may be reflected on. While the common understanding of success is often related to profit and growth at the firm level, the perspective of cluster evolution leads to a focus on 'performance' and 'success' at an aggregate level, i.e. it is the development of the business community as a whole that is of interest. From this perspective, 'failures' at the individual level in terms of closures and bankruptcies may provide an important contribution to the process of collective learning, as 'success' at the individual level. The point is to what extent mechanisms in the local economy facilitate sharing of knowledge and experiences, and in this way create a process of collective learning.

Given that the capitalist system is not working as a predictable mechanical clock, but is highly unpredictable [35], the role of small firms (as well as larger firms, although they may take somewhat different approaches) is to take risks, test out new ideas, develop new knowledge and thereby contribute to processes of learning. It is about a process of trial and error, about making experiments in which the outcome is unpredictable. This calls for the ability to adapt and be flexible. A characteristic feature of the system is that of flexibility at the system level, from which evolution may be regarded as a constant process of recycling and transfer of resources between different business concepts. As Bahrami and Evans indicate, "the short life cycle of many high-technology firms may be helpful for sustaining the long-term innovative capability" [47].

### **Acknowledgement**

We are grateful to an anonymous reviewer for valuable comments on the paper.

### **References and Notes**

- 1 The story of Oslonett and the development that followed is written on the basis of brief interviews with 16 of the 18 persons behind the company. (In addition to the 16 that established the company in 1991, another two persons were invited to take part in 1994.) Supplementary information has been obtained through public databases and web pages.
- 2 Frostad, R. and Thomsen, M. (2001) *Dot-konk. Historien om det kommersielle internett i Norge. (Dot-bankrupt. On the commercial internet in Norway)*. Oslo, Hegnar Media AS.
- 3 RITTS (2000) *Summary Report*, Oslo business region 2000.
- 4 RITTS is the acronym for Regional Innovation Technology Transfer Strategies and Infrastructure, a EU-funded programme.
- 5 Spilling, O.R. and Steinsli, J. (2003) 'Evolution of high-technology clusters: Oslo and Trondheim in international comparison', *Norwegian School of Management BI*.
- 6 Edquist, C. (1997) 'Systems of innovation approaches – their emergence and characteristics', in Edquist, C. (Ed.): *Systems of Innovation. Technologies, Institutions and Organizations*, Pinter, London and Washington, pp.1–35.
- 7 Lundvall, B.A. (Ed.) (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter, London.

- 8 Nelson, R.R. (Ed.) (1993) *National Innovation Systems: A Comparative Analysis*, Oxford University Press, Oxford.
- 9 Camagni, R. and Capello, R. (2000) 'The role of inter-SME networking and links in innovative high-technology milieu', in Keeble, D. and Wilkinson, F. (Eds.): *High-Technology Clusters, Networking and Collective Learning in Europe*, Aldershot, Ashgate.
- 10 Maillat, D. (1995) 'Territorial dynamic, innovative milieu and regional policy', *Entrepreneurship and Regional Development*, Vol. 7, No. 2, pp.157–165.
- 11 OECD (Ed.) (1999) *Boosting Innovation: The Cluster Approach*, OECD, Paris.
- 12 OECD (Ed.) (2001) *Innovative Clusters: Drivers of National Innovation Systems*, OECD, Paris.
- 13 Porter, M.E. (1998) 'Clusters and the new economics of competition', *Harvard Business Review*, November–December, pp.77–91.
- 14 There seems to be a significant convergence between the different concept which are applied in the analysis of territorially confined economic systems, like agglomerations, industrial districts, regional innovation system and cluster, cf. Spilling and Steinsli (2002, forthcoming).
- 15 Garnsey, E. (1998) *The Genesis of the High Technology Milieu*, University of Cambridge.
- 16 Keeble, D. (1989) 'High-technology industry and regional development in Britain: the case of the Cambridge phenomenon', *Environment and Planning C: Government and Policy*, Vol. 7, pp.153–172.
- 17 Keeble, D. and Wilkinson, F. (Eds.) (2000) *High-Technology Clusters, Networking and Collective Learning in Europe*, Aldershot, Ashgate.
- 18 Maskell, P., Eskelinen, H. et al. (1998) *Competitiveness, Localised Learning and Regional Development. Specialisation and Prosperity in Small Open Economies*, London and New York, Routledge.
- 19 Eliasson, G. (2000) *The Role of Knowledge in Economic Growth*, Stockholm, KTH.
- 20 Schumpeter, J.A. (1934, 1996) *The Theory of Economic Development*, London, Transaction Books.
- 21 Autio, E. (1995) 'Four types of innovators: a conceptual and empirical study of new, technology-based companies as innovators', *Entrepreneurship & Regional Development*, Vol. 7, No. 3, pp.233–248.
- 22 Based on these two dimensions Autio suggested the following four categories of innovators 1) application innovators (established technology, established market), 2) market innovators (established technology, emerging market), 3) technology innovators (emerging technology, established market), and 4) paradigm innovators (emerging technology, emerging market).
- 23 Aldrich, H. (1999) *Organizations Evolving*, Thousand Oaks, London, Sage Publications, New Dehli.
- 24 Isaksen, A. (2001) 'Regional clusters between local and non-local relations. A comparative European study', Paper prepared for the IGU Conference on 'Local Development: Issues of Competition, Collaboration and Territoriality', Turin July 2001.
- 25 Keeble, D. and Wilkinson, F. (1999) 'Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe', *Regional Studies*, Vol. 33, No. 4, pp.295–303.
- 26 Keeble, D. and Wilkinson, F. (2000) 'High-technology SMEs, regional clustering and collective learning: an overview', in Keeble, D. and Wilkinson, F. (Eds.): *High-Technology Clusters, Networking and Collective Learning in Europe*, Aldershot, Ashgate.
- 27 Kuijper, J. and van den Stappen, H. (1999) 'Clusters and clustering: genesis, evolution and results', in Oakey, R., Durning, W. and Mokhtar, S-M. (Eds.): *New Technology-Based Firms in the 1990s*, Paul Chapman, London, pp.105–121.

- 28 Wintjes, R. and Cobbenhagen, J. (2000) *Knowledge Intensive Industrial Clustering Around Océ*, Maastricht, MERIT – University of Maastricht.
- 29 Audretsch, D.B. (2001b) 'The role of small firms in US biotechnology clusters', *Small Business Economics*, Vol. 17, pp.3–15.
- 30 Dahlstrand, Å.L. (1999) 'Industrial dynamics and ownership changes – incubation and acquisition of small technology-based firms', in Johannisson, B. and Landström, H. (Eds.): *Images of Entrepreneurship and Small Business – Emergent Swedish Contributions to Academic Research*, Lund, Studenlitteratur.
- 31 Dahlstrand, Å.L. (2000) 'Large firm acquisitions, spin-offs and links in the development of regional clusters of technology-intensive SMEs', in Keeble, D. and Wilkinson, F. (Eds.): *High-Technology Clusters, Networking and Collective Learning in Europe*, Aldershot, Ashgate, pp.156–181.
- 32 Oakey, R.P. (1999) 'United Kingdom high-technology small firms in theory and practice: a review of recent trends', *International Small Business Journal*, Vol. 17, No. 2, pp.48–64.
- 33 Vatne, E. and Taylor, M. (2000) 'Small firms, networked firms and innovation systems: an introduction', in Vatne, E. and Taylor, M. (Eds.): *The Networked Firm in a Global World, Small Firms in New Environments*, Aldershot, Ashgate, pp.1–16.
- 34 Ramström, D. (1975) 'De mindre företagen i ett dynamiskt perspektiv. (Small firms in a dynamic perspective)', in Ramström, D. (Ed.): *Små Företag Stora Problem (Small Firms, Big Problems)*, Stockholm, Norstedts, pp.156–169.
- 35 Metcalfe, J.S. (2000) 'Restless capitalism, experimental economies', in Durning, W., Oakey, R. and Kipling, M. (Eds.): *New Technology-Based Firms at the Turn of the Century*, Amsterdam, Pergamon, pp.4–16.
- 36 Rosa, P. and Scott, M. (1996) *Portfolio Entrepreneurs: Some Empirical Evidence on the Multiple Ownership or Control of SMEs, and its Implication for Our Understanding of Start-up and Growth*, RENT X – Research in Entrepreneurship, Brussels.
- 37 Spilling, O.R. (1998) 'Om entreprenørskap (On entrepreneurship)', in Spilling, O.R. (Ed.): *Entreprenørskap på Norsk*, Bergen, Fagbokforlaget.
- 38 Westhead, P. and Wright, M. (1998) 'Novice, portfolio, and serial founders: are they different?', *Journal of Business Venturing*, Vol. 13, No. 3, pp.173–204.
- 39 Taylor, M. (1999) 'The small firm as a temporary coalition', *Entrepreneurship and Regional Development*, Vol. 11, No. 1, pp.1–19.
- 40 Cooke, P. (2001) 'Clusters as key determinants of economic growth', in Mariussen, Å. (Ed.): *Cluster Policies – Cluster Development?*, Stockholm, Nordregio, pp.23–38.
- 41 Asheim, B.T. (1996) 'Industrial districts as 'learning regions': a condition for prosperity', *European Planning Studies*, Vol. 4, No. 4, pp.379–400.
- 42 Asheim, B. (2001) 'Localised learning, innovation and regional clusters', in Mariussen, Å. (Ed.): *Cluster Policies – Cluster Development?*, Stockholm, Nordregio, pp.39–58.
- 43 Capello, R. (1999) 'Spatial transfer of knowledge in high technology milieu: learning vs. collective learning processes', *Regional Studies*, Vol. 33, No. 4, pp.353–365.
- 44 Lawson, C. and Lorenz, E. (1999) 'Collective learning, tacit knowledge and regional innovative capacity', *Regional Studies*, Vol. 33, No. 4, pp.305–317.
- 45 Longhi, C. (1999) 'Networks, collective learning and technology development in innovative high technology regions: the case of Sophia-Antipolis', *Regional Studies*, Vol. 33, No. 4, pp.333–342.
- 46 Longhi, C. and Keeble, D. (2000) 'High-technology clusters and evolutionary trends in the 1990s', in Keeble, D. and Wilkinson, F. (Eds.): *High-Technology Clusters, Networking and Collective Learning in Europe*, Aldershot, Ashgate, pp.21–56.
- 47 Bahrami, H. and Evans, S. (1995) 'Flexible re-cycling and high-technology entrepreneurship', *California Management Review*, Vol. 37, No. 3, pp.62–89.