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a Case Study of the Norwegian Internet

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CONVERGENCE IN ACTION:
A CASE STUDY OF THE NORWEGIAN INTERNET

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ABSTRACT

The conceptual framework for understanding the logical Internet is based on the construction of a horizontal, layered architecture, which differentiates between physical-, data link-, network-, transport-, and application layers (1). This is different from the telecommunication networks model where a new service traditionally used to require a new network architecture to be established (2). However, the digitalization of services and products offered over the telecom infrastructure allows us to observe an emergent phenomenon of increased vertical integration on the Internet as well as the creation of further service specialization opportunities for telecom operators and users (3). We propose in this paper that this development and

change in the way services are provided, leads to a new type of Internet – an addition to the current best effort Internet.

This paper presents the case study of the Internet in Norway, analysing 166 of the approximately 40.000 independent AS numbers registered worldwide as catering for end-to-end services. The paper categorizes the Norwegian AS numbers according to size and type of services.

Through our analyses two major groups of actors can be identified, each of them seeking to gain strategic advantage from the current Internet traffic growth: 1) Content providers and hosts seek to have a highly reliable network access with a minimal set of traffic or transmission costs. One action is to acquire AS numbers and use settlement-free peering agreements for distribution of their traffic, which is possible in traffic exchange regimes rooted in symmetry, slowly becoming asymmetric; 2) Internet access providers (IAPs) seek to take control over incoming traffic growth by hosting content within their own network and thereby to rebalance traffic and create new revenue streams with content hosting and premium end-to-end connection on-net. Our findings support the hypothesis that Internet is becoming both more vertically integrated and converged, and more specialized or modularized (4).

Keywords: convergence, modularity, Internet, Internet outsourcing, Norway, autonomous systems

INTRODUCTION

The motivation of this research is to provide further insight on the changes happening to the overall Internet and the local Internet through the study of the changes on the autonomous system (AS) number distribution in Norway. An AS is a connected group of one or more IP prefixes run by one or more network operators, which has a single and clearly defined routing policy (5). Over the last five years a number of people and organizations involved in the monitoring of the Internet (6, 7, 8) have reflected on the changes leading to the emergence of walled gardens (9), modular Internet (10), new stakeholders such as over the top services (OTT) etc. A number of socio-technical characteristics (e.g. new service provisioning, new business models and consumer demands, etc.) signal for a clear change to the established logical Internet topology known as “best effort” or the layered model. (11).

The many Internet bystanders observe the trends that the traffic increases, the mobility of the users’ access to Internet services increases (as opposite to the fixed access to the Internet from the early stages of development), as well as consciousness of the quality of service provision and measurement required to satisfy such demand (12, 13). The pressure on the Internet telecom providers is coming from the digitalization of products and subsequent opportunities for convergence in the whole value chain. In the first instance the emergence of an OTT service like Skype’s Voice over IP (VOIP) have put telecom operators in direct strain due to their competition effect on the traditional telecom revenue streams (14). Later the OTT phenomenon brought many new players such as Netflix and other Internet TV services suppliers, and together with the experience of YouTube they have created even more demand for bandwidth from the Internet core (15).

These changes are producing conditions and strategies for commercial and network convergence enabling business integration of many Internet stakeholders (e.g. Cable providers as ISPs and media transport and content creators). The aspect that users are exposed to digital services enabling “live” experiences which are bandwidth hungry (e.g. multimodal digital integration and distribution of services in real time) and the

rise of software platforms exclusively for digital services (e.g. Apple, Google, advertisement), promote new innovation and pricing structures. Software providers – whether they are Microsoft, SAP or Oracle or local SW providers – are slowly starting to distribute digitalized services over the Internet relying on cloud or network hubs. However we have not yet seen how large the cloud computing industry will grow (16, 2), and if they will be able to provide the capacity, quality performance and security that users require. As a result of these trends and changes, new business models for the Internet and the Telco industry may imply that digital services are provided with predictable performance in more than one layer as composed services based on their functionality.

How do we transfer these trends to understand, at a more local level, what is happening to the Internet and develop the case for discussing a new type of Internet? In the first instance we show the existence of a Norwegian Internet that is localized, providing services that generate demand and supply dynamics. On the other hand we have been able to identify the formation of hubs of companies using AS numbers as a way to improve their opportunities to offer digital services within the Norwegian community.

The Norwegian Internet case study does matter to understand what is happening to the overall Internet. Norway, due to its advanced status from a technological and societal point of view, has the data resources to provide a full comprehensive map of its Internet – which is not the case with many other countries in the world. Hence the analysis presented in this document using the AS numbers identifying enterprise strategies is not only relevant but also novel in its approach to the study of the Internet.

RELATED RESEARCH

The study of the Internet changes is not a new science, and the monitoring tools and protocols are not standardized (17). Since its creation and due to the original purpose of the Internet – primarily designed as a military command communication tool for a dystopian post-nuclear future – the monitoring (e.g. systems, protocols) has always existed. The principles of load balancing and equilibrium peering and the close attention from Regional Internet Registries (RIR), are the foundations of such monitoring (18) and (19). Additionally technical reports on traffic from major vendors such as Cisco, or backbone providers such as Akamai provide interesting insightful ideas on the total volume of traffic in the Internet (e.g. 20, 21).

The modern Internet, which has been accelerated by the increased convergence of digital services with the use of the physical infrastructure, requires intelligent tools to monitor what is actually happening as trends. Many of the tools used either focus on the traffic monitoring only, or rely on one or two main sources of information (e.g. broadband connections vs. mobile connections (20, 22)), while others only focus on the quality of service (e.g. the majority of the IPTV reports (15, 23)). Complex issues on the role competition and regulation tussles with the study of demands are novel aspects to be revised in the near future by researchers (24).

However the data already available report permanent increases of traffic and analyses indicate a trend for further growth. The literature review for this paper revealed many traffic studies done by institutions such as MIT, CAIDA, etc. or sourced from specialized conferences in the field such as SIGCOMM on related issues (25), which give a partial view on the emergence of the issues described in the introduction of this paper. The different studies revised are partly conceptual, partly empirical and often

interpreted in a policy or regulatory context. In the case of Norway, the traffic data and subscription data strongly support the traffic trends as identified from the global available data (26).

However the innovative approach to understand the actual changes to the Internet is to look at the core of traffic load, and the changing balance on the traffic relationships (27, 28, 11, 23, 6). Figure 1 implicitly assumes that holders of AS numbers in Internet are "network operators" at the lower layers, and has then re-layered them into a hierarchy based on geography.

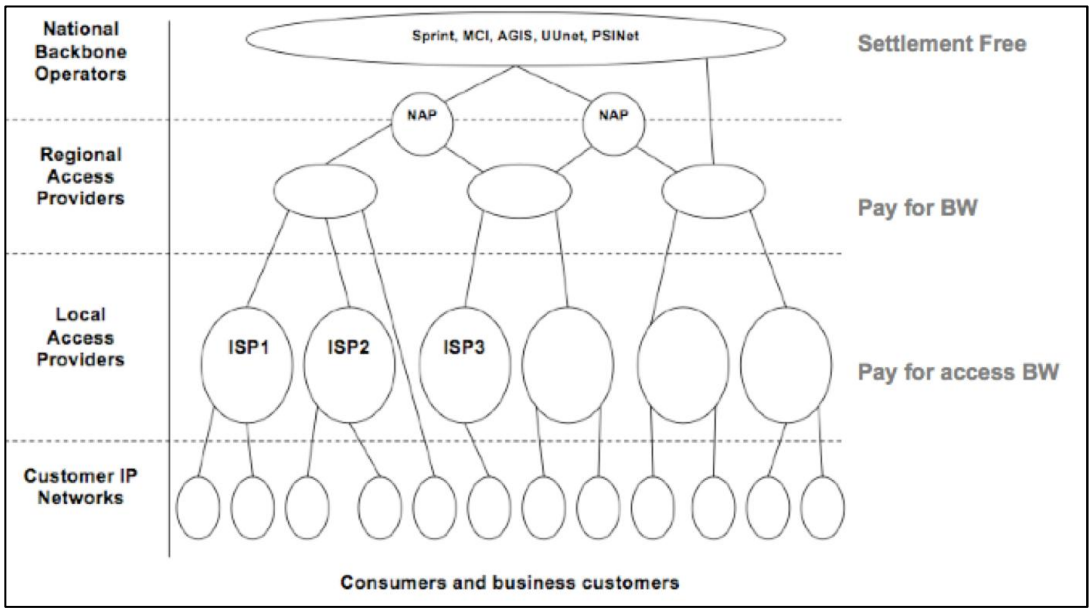

Figure 1. Traditional Internet Logical topology (Sourced from (11))

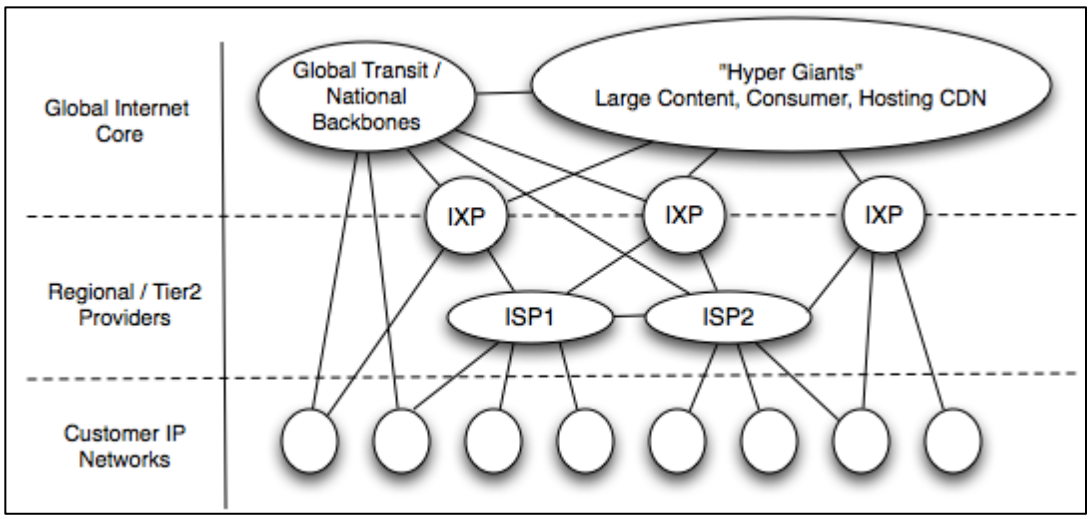

Figure 2. Emerging new Internet logical topology (Sourced from (11))

Figure 2 illustrates how holders of AS numbers more and more seem to be actors on all Internet layers; network, content and services, hosts etc. It is a trend observed at both the global and regional level, and can be read as a change from a strict hierarchical routing to a more flattened routing characterized by both public and private peering. Hence both the traditional Internet layers as well as the geographical hierarchy are at play.

The issue of this paper is how companies are dealing with rebalancing the control of traffic routing; i.e. among companies at the core of the backbone of the Internet; regional and local access providers, and content providers and hosts. This effect is analysed in the case study described below. We find the presence of emerging new topologies such as AS numbers specialized on the service level as well as on the network level, and AS numbers seeming to vertically integrate different layers due to functional requirements such as quality performance, privacy requirements etc. These represent respectively a specialization and modularization of Internet, and a vertical integration across the layered Internet, which may be understood as a modularization along QoS requirements. We also observe a vital regional Internet topology co-existing with the 3-tiered model. The observations capture both patterns that we suspect are in their infancy as well as more mature.

THE CASE STUDY AND METHODS

As explained in the introduction this research is a study of the Internet, limiting it to Norway. And we can conclusively say that **there is a Norwegian Internet**. The original purpose of the study aimed to focus on an Internet subgroup, potentially limiting it to Norway, but without knowing if such a phenomenon existed. Furthermore, the researchers did not know if they could find data on Norwegian Internet actors and the quality of the data. Our enquiries have shown that the Norwegian Internet is quite significant, in the sense that we find many local actors interacting locally. This is despite the fact that Norway in general is a very open economy resting on global industries such as oil, energy and fishery industries.

The study comprises two phases, each of which has used different looking glasses into the Internet economy of Norway as described below:

In the first phase we addressed AS numbers as the objects of research to identify and understand the actors of Internet. An AS number is a unique identifier of a collection of connected Internet Protocol (IP) routing prefixes under the control of one or more network operators that presents a common, clearly defined routing policy to the Internet. ASs are also assigned to juridical entities and due to a public assignment regime (29). One organization might have more than one AS, but for the majority there is a one-to-one relationship between AS and organization. The ASs were identified through several different sources, and filtered down to a Norwegian list. All ASs have some kind of relationships to one or more adjacent ASs, and they are the basic actors for activity in Internet.

The relationships between the ASs were our next research object; of course the peering relationships but also customer-provider relationships, ownership and alliances. Then we identified potential resources and allocated them to the ASs; domains, websites and access customers. We further categorized them according to the type of business they were into, and also identified the size of the revenues. Based on this we looked for patterns that could tell us something about the working mechanisms of the connected system they make up. The data has not been easily available. However, limited to Norway we have used our knowledge about the Norwegian Internet industry to qualify that we cover a substantial share of the Norwegian Internet. This first phase motivated us to look further into the IT industry active in the Norwegian Internet, as about one third of the holders of ASs were IT enterprises.

In the second phase we used available data from public sources in Norway, filtering out the relevant IT enterprises through applicable NACE categories. Hence the research object was the IT enterprise. The records are available with additional

information such as revenues, number of employees etc. We started adding information to the records, first by denoting if they were of Norwegian or foreign origin and possessed an AS number.

So far we have analysed only the Norwegian enterprises in detail. We chose to look further into two groups; those IT enterprises that possessed an AS and those with revenues higher than NOK 50M in 2010. Even with this delimitation we covered a large share of the total Norwegian IT industry. We coded the IT enterprises in our dataset according to certain characteristics, starting by forming an idea of the type of IT services they were providing. We have also looked into end-users and customers (those who are paying for the services).

The end-users have been coded according to whether they are open or closed user groups. Typically open user groups use open services with potentially many users interchanging with anyone (e.g. social networks). Closed user groups use services where some authority decides who are allowed to have access and use the service (e.g. accounting software). The structure of customer relationships has been denoted according to whether the IT enterprise has a direct relationship to end-users or rather as a subcontractor to the party with direct relationship to the end-user (B-B/C or B-B-B/C). We have also considered the level of sharing of hosting resources; whether they are public, semi-public or fully private. This categorizing was inspired by Forrester's Cloud Computing Taxonomy, which has become an industry standard for denoting types of hosting (30).

In addition we have denoted whether the IT enterprises are retailers, or develop their own software. We further identified if they provide Internet access, and if they possess their own physical network. Based on this systematic tagging of the different enterprises we were able to distinguish between five main categories of IT enterprises, providing a deeper understanding of the business and their motivations as actors in the Internet economy.

MAIN FINDINGS

THE CASE FOR THE EXISTENCE OF THE NORWEGIAN INTERNET

Through our coding we have identified 166 Norwegian ASs, belonging to 157 organizations. Only one third is what we call traditional Internet access providers (IAP), or often called Internet Service providers (ISP). Another third is a mixed group with e.g. private wide area networks, content providers and private or public initiatives. The final third is enterprises that we categorize into the IT industry, anything from IT outsourcing to software as a service and other types of Internet applications.

Our expectations to the number of IAPs holding AS numbers were somewhat lower than the identified one third of 166 Norwegian ASs. One reason is that the size of the population of Norway (around 5 million) should indicate a relatively lower number. Another reason for our expectations is that 80-100% of respectively the fixed and mobile broadband market in Norway is dominated by only 10-20 enterprises (31). In the same way, the number of ASs *not* being IAPs was also unexpectedly high. However, we did expect to find that some IT enterprises have started to route their own traffic.

Holding one third of the total Norwegian ASs, the IT industry holds a significant share of the Norwegian Internet. Some of these IT enterprises provide access included in their IT offering, but many do not. These enterprises use autonomous system

numbers to route their own traffic into the Internet, and make their services efficiently available for their end-users. Hence, these facts about the constitution of Internet enhance our understanding of Internet not only as an access network but also a distribution network for the IT industry. We know that the IT industry in Norway has outgrown the telecommunication industry, and is growing at a higher pace. The comparison is an analysis of data on enterprises within relevant NACE codes sourced from the Statistics Norway (32). This reinforces the significance of the new constitution of Internet.

The large IAPs are mostly incumbents, or originally Norwegian currently with Nordic owners. The IT enterprises with AS numbers are mostly Norwegian, and a few Nordic with strong Norwegian operations. Looking at the revenues in the IT industry as a whole, two thirds of the enterprises are Norwegian, and the rest is large foreign enterprises typically providing SW or SW implementation and consulting. Of course, including the total numbers of IT actors, Norwegian SMEs outnumber foreign enterprises. The large foreign IT enterprises have an AS number from their origin country covering their requirements. The Norwegian AS numbers are linked up to the global Internet through a handful of important international actors (Tier 1s) such as Level 3 and TeliaSonera.

There are some limitations to the findings in our study. The ability to generalize is restricted although we believe that the findings are still interesting and may illuminate the market situation also in other regions. The validity of the variables chosen – such as control and distribution of domains as an indication of strategy direct – will need to be further refined. In addition, the data are based on publically available data and especially private peering agreements are hidden from us (25). All in all we still believe that our rich and qualitatively oriented approach give deep and broad insight into the issues discussed.

MODULARISATION OF NORWEGIAN AUTONOMOUS SYSTEMS

Within the Norwegian AS numbers, the 166 different ASs seem to prefer transit to – or peering with – a few ASs, making these ASs hubs in the Internet. The tendency to being hubs for other Internet actors was reinforced by the distribution of domains and enterprises in the IT industry not having their own AS numbers. In parallel it was a clear tendency that some IAPs were only access providers. They are to a small degree providing transit (in the sense of access to content providers), hosting neither small nor high-volume domains or connecting the IT industry. This latter group are so called Eyeball ISPs (33). We do not fully adhere to the tail ISP and the expectation this abbreviation raise, but acknowledge the established vocabulary within the community.

The hubs, which turned out to originally being both IAPs and IT enterprises, seemed to have large activity with regards to transit and hosting. Depending on whether or not they provide access, they fall into the categories denoted Balanced or Hosting ISPs (33). The tendency to form hubs was further reinforced by the ownerships and alliances connecting the ASs. The Balanced ISPs were clearly positioned to host application and services within their AS routing domain, thus providing Internet access customers with intra AS routing to these services.

The ASs we may call Hosting ISPs were those most hidden to our – and our community's – general knowledge. Their critical position as hosts for many large society and business mission critical services, the active peering policies and source of Internet traffic has been revealed. Again they are Norwegian, and based on this we induce that being close to access subscribers and networks is necessary for this type of actors. This is reinforced by the fact that we find very few large Norwegian

Websites and providers of services over the Internet that host their services with non-Norwegian actors, i.e. Amazon is not common as a host in the Norwegian market.

Based on the analysis of the different Norwegian ASs it is possible to establish four arch types along two dimensions (see Table 1 below); 1) providing Internet access – or not, and 2) providing hosting of domains, websites etc. – or not. Three of these arch types are in accordance with the ISP types mentioned above; the Eyeball, Balanced and Hosting ISP. In addition we have identified one arch type that neither provides access nor hosts anything but its own content; the Content, Application and Service (CAS) provider. The four arch types were populated with about the same number of ASs. A further look into the arch types reveals that they differ in many ways, e.g. customers, end-users, products and services, and revenue models. They have all different challenges in a changing and dynamic market, but share an interest in establishing revenue models that can carry the belonging costs. They also share the risk of ending up carrying an unfair share of the Internet costs: capacity, quality, connection and hosting. A higher growth in the large IT industry and the stagnating Telecommunication and Publishing market are important underlying forces leading to the dynamics in the market and between the arch types. Behind these dynamics is the increased demand for network capacity, especially due to the rise in video consumption. This is something described in available traffic data trends reports (13, 21, 34). One solution – forced on many traditional ISPs – has been to become significantly more cost efficient, but this is not a sustainable situation.

	Hosting domains/websites for 3rd party	**NO Hosting**
End-user access	IAP and Hosting (Balanced ISP)	Internet Access Provider (IAP) (Eyeball ISP)
NO End-user access	Hosting (Hosting ISP)	Content, application, service (CAS)

Table 1. Categorization of holders of AS numbers

In the arch types and the dynamics between them we can read at least two strategies that may generalize into more basic shifts of Internet. On one side we may see a shift to an even more modular (compressing one or more layers) Internet in the sense that the specialization becomes explicit (35). The layered Internet implicitly understands the ASs as a homogenous group that controls the physical Internet and access at the bottom of a hierarchy. On top of this is the content consumed in Internet, which is supposed to freely flow end-to-end through the physical and logical network layer. The dynamics caused by risks with costs and revenue balance may drive autonomous system numbers into specializing on access and content respectively, i.e. the Eyeball and Hosting ISP (and possibly the CAS provider).

However, they share a mutual motivation to cover the costs, and find a simple interface to allocate both costs and revenues to the best of both parts. This means to move away from the settlement free peering agreements, to agreements between ASs that incorporate the costs through some type of paid peering, see also (26). Such agreements will necessarily have implications for both types of AS customers, and seem already to exist on a regional level between lower tier AS numbers, using global tier 1 actors for global activity.

On the other hand we may see increased vertical integration in the form of ASs handling the risk factors by internalizing the source of the challenge, across the

layered Internet. This is where we speak of the Internet becoming more modular in the form of vertical integration, through bypassing the independent layers of Internet. Typically this will mean that an IAP starts providing co-location and later hosting of content and websites and -applications. Or the other way around, the provider of hosting services includes Internet access in its product portfolio.

Both types of shifts are more likely to happen in a more local market, with higher demands for more predictable network Quality of Service (QoS), and semi-closed user groups. We have already argued that the first requirement is in place. A more local market will retain the competitive advantage of local actors, confronted with global competition. Based on our analyses of the Norwegian IT industry we find that there is reason to believe that the latter two requirements also hold. With regards to QoS and closed user groups this has so far been taken care of by MPLS protocols in virtual networks between enterprises (2). Otherwise best effort and the ability to connect with whom and what you need has been within the Internet context, including a global connectivity. However, with increasing traffic and more mission critical services provided over the Internet this might require changed contexts, especially for the business critical services.

MODULARISATION OF THE NORWEGIAN IT INDUSTRY

The finding that one third of the ASs in Norway can be categorized into the IT industry attracted our curiosity, alongside the need to find out more about demand for QoS and different user groups. We will see that the analysis of this industry further confirms observation of the strategic behaviour that leads to an increasingly modular Internet. In general the IT industry (IT industry, not including hardware neither telecommunication) has grown at a higher rate in Norway in the period 2003-11 than the telecommunication industry, 8.7% compared to 2.6% (results from the analysis of data from Norwegian Census Bureau (29)). In 2007 the IT industry bypassed telecom and is by 2011 about 30% larger. With this tremendous growth as a background we observe that the IT industry by 2011 possessed a large proportion of the Internet resource *autonomous systems*.

Our sample of 258 IT enterprises constitutes 86% of the total IT market in Norway. Included in this is 69 international enterprises accounting for one third of the market, however these international enterprises were not included in the coding and analyses. According to NACE codes, the identified international firms with business in Norway seem to be about software development and consulting, i.e. fewer delivering operating services. Based on the Norwegian firms in our sample we identified five main categories of IT enterprises. One of them is *Consulting* companies, i.e. companies focusing on adaption and implementation of software. They do not tend to possess AS numbers and are less network dependent, and hence out of our focus on network QoS and closed user groups. The other four categories are characterized by whether they develop or operate software, and whether they deliver their services to predefined (by others), closed user groups, or as open self-services. In addition we observe how they differ according to whether they are wholesale enterprises or retailers with a direct customer relationship to their end-users; so called business-to-business, or business-to-business-to-business/consumer. Enterprises such as Google and Facebook are not included in our analyses, as they are not reporting revenues in the Norwegian market. Of course these enterprises are large also in Norway, both when it comes to popularity and traffic, but out of scope in this study.

The enterprises that deliver they services to predefined, closed user groups are split in two subgroups; the ones – *IT services* – that develop software themselves (and other types of applications and services); and those – *IT operations* – who do *not* develop services software, but typically operate standard software (both large as Microsoft

and smaller, local software providers) on behalf of an enterprise which is their customer.

	Predefined, closed user groups	**Open self-services**
Software (CAS) development	IT services	Internet services
Software (CAS) operation	IT operations	Internet operations

Table 2. Categorization of network dependent IT enterprises

The latter group is often a retailer for the former and has an intimate and direct customer relationship to the end-user. The customer has typically outsourced its IT function to the *IT operations*. The *IT services* may also have direct customer relationship and operate themselves. The on-going development towards providing software as a service (cloud computing) increases the opportunity to bypass the retailer – i.e. the *IT operations*. These two categories are the traditional actors in the IT industry, and in our data the oldest and most consolidated segments. Obviously, the software and applications operated by either the *IT services* or *IT operations* will be providing mission critical services over Internet to customers that need to keep control of access. For the call-centres using software delivered as a service, outages and delays when talking to a customer are not acceptable. Hence network QoS parameters such as redundancy and low latency to predefined users are critical. We observe that the *IT operations* tend to hold autonomous system numbers more often than the *IT services*. This might be both a signal of the strong role they have had as the actor ensuring service delivery, and of the position they intend to build in this field.

The typical Internet companies are often perceived as providing open self-service content, applications and services, but also here we see that there are two subgroups; the *Internet services* and the *Internet operations*. The category *Internet services* is characterized by providers that have developed the services themselves, offering it to end-users on a self-service basis with little service access restrictions. The *Internet operations* typically operate the services on behalf of the former category. They are a wholesaler, and truly a business-to-business-to-business/consumer enterprise. Neither the *Internet services* nor *Internet operations* adhere to the same requirements on network QoS as the IT services/operations, but are based on the best effort regime of Internet. However, the *Internet operations* which run services on behalf of another enterprise hold autonomous system numbers to a larger degree. This seems to be a part of the professional role they intend to play, efficiently connecting end-users and services.

While the *IT operations* is a retailer, the *Internet operations* has a wholesale role in Internet, however they both represent a form of specialization based in being close to the users on respectively the sales and delivery side, and the pure delivery side. The *IT operations'* position is threatened by being by-passed by *IT services* that prefer to sell and deliver directly to the customer themselves, internalizing such processes. The Internet concepts of delivering software as a service and self-service opportunities increase this threat. Hence there are strong converging forces that may lead to an Internet more specialized and modularized according to the Internet layers. On the other hand we observe that the typical *Internet service* provider tends to outsource the operation of the service to specialized *Internet operators* where the operations are locally based, i.e. another form of re-specialization and modularization of Internet. In

the long run, the degree to which a local sales force close to customers, and operations close to local access networks are needed, will decide the speed and degree of this convergence and re-specialization. Also within this field we observe convergence and modularity both in the form of internalizing of processes formerly handled externally, i.e. vertical integration, and specialization leading to modularity in the form of separate individual complex actors with accepted and sustainable business interfaces.

SUMMARY AND CONCLUSIONS

From this study we can affirm that the dynamics at the core of Internet lead to (at least) two new type of actors: content providers and hosts, and IAPs that also may host content. This represents on the one hand a specialization and modularization of the Internet. On the other hand it is a convergent, more vertically integrated Internet across all layers which may be understood as a modularization along QoS network requirements. This happens at a local level within Norway. We have further found that currently many Internet and IT services are hosted locally, i.e. the delivery of these services to end-users is taken care of by local hosts in either of the two categories. The delivery takes form as the well-known retail relationship model, or a wholesale model which is a less described concept. Especially the retail model is exposed to QoS requirements. Thus, we argue that there will be a need for network QoS, as a result of the increased provisioning of mission critical software as a service. Even providing services based on best effort Internet may require some assurance of network quality. As long as such quality requires local presence in some way, we may see more of the different forms of modularity in a local market – either as vertical integrated units or further specialization.

We provide an insight into Internet through a descriptive analysis of the status in Norway. Our empirical data indicate the emergence of a different Internet than generally assumed, and may serve as a meaningful contribution to discussion on both predictions and guidance for the way further. However this is just the beginning of a new Internet era which requires further research in order to understand the relationships between the AS number holders and their partners.

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