

Emerging metrics and mapping of the Internet: A comparative study of Thailand and Norway

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Those studying the Internet and telecommunications industry are confronted with a paradoxical situation when trying to establish comparison metrics based on Internet networking parameters. The size of the gap in understanding between theory and what is actually happening is different for economists, regulators, engineers and other professions. There are many complex problems caused by the on-going changes to the Internet and the subsequent digital convergence when services are provided over the telecom infrastructure (Hallingby et al., 2012). In this paper, we propose that very important aspects are often not covered when analysing the local or national sections of the Internet (Claffy 2008). Issues with the relationship between intrinsic network variables are not fully explored - e.g. QoS, traffic, demand and externality factors such as the type of firms, AS numbers, economic contributions to the national economy. In other words it is difficult to build a fully comprehensive overview of the Internet at a national level, and new methods and metrics are needed.

The authors have completed research applying a collage of qualitative and quantitative methods to provide overviews of the Norwegian and Thai Internet. The methodology used aimed to establish a link between multiple data sources and enhance insight into local Internets. More specifically, we have been able to tie the ownership of autonomous system numbers to firms (Hallingby and Hartviksen, 2012 and 2013). The method was developed in a Norwegian context, in a developed country with high Internet maturity. It was replicated in Thailand in order to test its usability, compare results and promote a discussion of the ways in which Internet topology is dependent on the economic status of a country. The replication and comparison enhances the robustness of the methodology itself, and the discussion of implications for strategy and regulations.

Using this method it is possible to describe firm volume and heterogeneity, as well as relationship between firms, and how this differs from traditional relationships such as assumptions that the Internet is global and flat (Liebenau et al., 2012). The analysis and results for both countries confirm and extend the existence of a significant shift of the Internet logical architecture to a modular, and not only layered architecture (Faratin et al., 2007 and Yoo, 2012). Although research and commercial proposals have tried to show the changes to the service provision and layered model of the Internet, we will describe how our applied method for researching the Internet can describe views of both the layered and modular Internet firms' descriptions.

A modular Internet implies a market with different interdependencies and competition to the layered, and the dynamic forces in the transition phase are strong. Thus firms seem to move strategically between the emerging categories that constitute the modules. We will hint at what firms' motivations are when moving from one status to another, and how competition and cooperation play out.

One of the main results is a verified description of the differences between market dynamics in a pure layered architecture, as opposed to a modular model. The structures reported are present in the growing Thai market, not only in Norway which has next to full Internet penetration. The deviations are however, interesting for how Internet maturity impact Internet structures and thus national variations. The method and results gives a means to improve analysis of the specificity of the local Internet in any market, also in other Asian countries.

The method introduced, and the results provided, are a foundation for discussing economic issues of current Internet. It is also relevant for the current regulatory debates on the nature and definition of Internet companies such as Cogent or Netflix in the provision of high demand Internet services through the telecommunication networks (Liebenau et al., 2013). In addition we expect to contribute to the discussion on net neutrality, and if the understanding of Internet as a layered architecture is sufficient for future regulation of the Internet access market.

1 Introduction

The Internet open architecture and digital service provision is changing, and what it will develop into is still to be seen. There are possible scenarios for the future Internet with proprietary silos of services. The innovative approach to understanding the actual changes to the Internet is to look at the core of traffic load, and the changing balance of traffic relationships (Claffy et al., 2009; Clark et al., 2011; Labovitz and Lekel-Johnson, 2010; Steen, 2012; Shakkottai, 2009 and Valancius, 2011). The core Internet identifier *autonomous systems* – ASs – and enterprises that possess them have proved to be a relevant and effective object of research in order to document and understand 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 (Hawkinson, 1996). It is in the interface

between the ASs that we can study the exchange of traffic and symmetry between the actors.

Faratin (2007) explains how ASs have become more specialized as content and access networks and how traffic has become more asymmetric. These changes impact interconnection relationship contracts due to the heterogeneous incentives. The traditional Internet interconnection regime was simpler in a less complex market, and coordinated a recovery of fixed and variable costs for all actors.

Where a more asymmetric traffic pattern exists, actors have different incentives with regards to keeping traditional regimes and developing new ones. This transformation phase leads to conflicts between actors, as we see for instance in Norway and the Nordic countries (Hallingby and Erdal, 2011; Hallingby and Hartviksen, 2012). There the well-known provider of video content Netflix discussed whether it should compensate the Nordic access-providers – for instance Telenor – for sending traffic into their networks in a clearly asymmetric traffic exchange situation (Vigeland, 2012). Thus, the ongoing Internet transformation is directly influencing economic interests. It should interest regulatory authorities at least from the competition perspective.

Furthermore, the new economic prerequisites that asymmetric traffic load represents at the AS interface, together with the changing bargaining power of the different actors, should interest authorities from a net neutrality perspective. Current net neutrality obligations in for instance Norway (NPT, 2011 and 2012) are based on an understanding of Internet as a layered structure (Labovitz and Lelak-Johnson, 2010) where content providers are the weak part which shall not be excluded from access networks or network layer. The network shall transfer data traffic in an open and non-discriminatory manner regardless of the identity of the sender of content and services. The emergence of more diverse ASs, incentives and interconnection interfaces challenge the simple understanding of a layered Internet and consequences should be thoroughly explored (Friederiszick et al., 2011 and Frischmann, 2012).

The professional content provider minimizes distribution costs and utilizes opportunities to send traffic at no cost into other networks. One result could be impoverished access markets due to indisputable obligations to carry any traffic at any cost. However, the interconnection regimes of today already provide mechanisms to regulate and compensate for asymmetric traffic through private peering, but still lead to conflicts. Recently we have seen that such conflicts between actors are regulated according to competition law rather than net neutrality, for instance when French competition authorities allowed France Telecom to require compensation from Cogent (ARCEP, 2012). Furthermore, actors which host content and provide access within own autonomous system may develop strong market positions that need to be understood and assessed correctly according to competitive power.

A challenge for the whole industry and regulators has been the inability to identify and describe emerging market structures in local markets. New methods are required for describing the Internet, and reporting new emerging structures. Our

starting point of analysis is the emerging topology of Internet based on ASs as suggested by Labovitz and Lelkel-Johnson (2010) and on empirical observations of the Internet. 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.

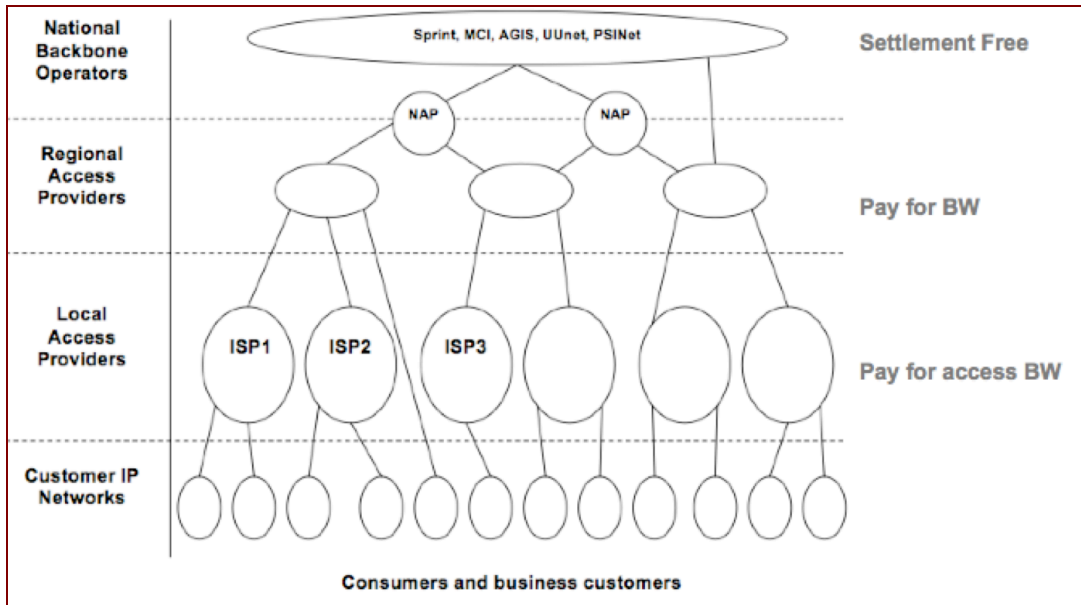


Figure 1. Traditional Internet Logical topology. Sourced from Labovitz and Lelkel-Johnson (2010)

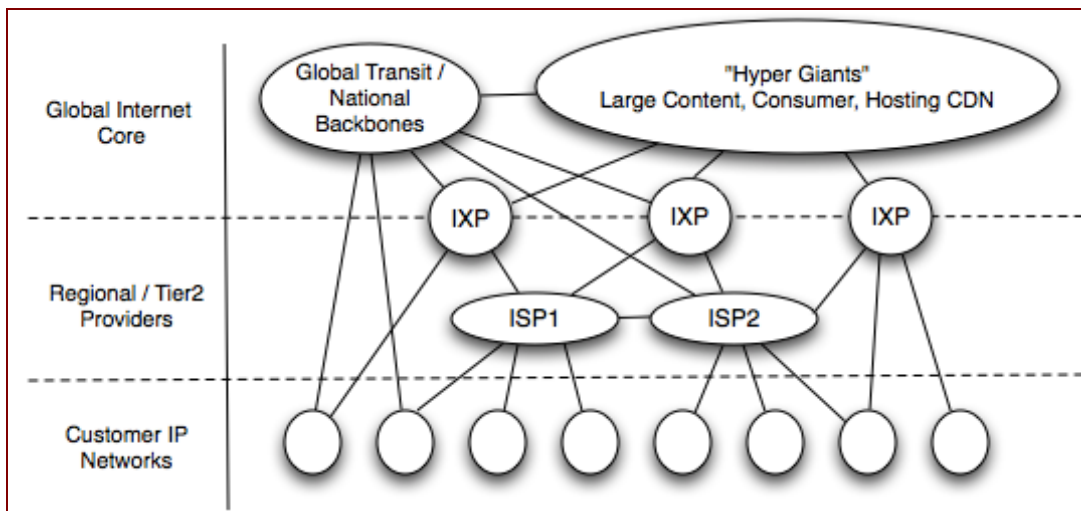


Figure 2. Emerging new Internet Logical topology. Sourced from Labovitz and Lelkel-Johnson (2010)

Figure 2 illustrates how holders of AS numbers more and more seem to be actors at 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 come into play.

Our research has suggested another change to the topology of the mature Internet, with a local Internet, more independent of the global. Due to local requirements for Internet content and applications and higher requirements on Internet access QoS, a local industry will emerge for both content and hosting (Krauss, 2009; Hall et al., 2011; and Hallingby and Hartviksen, 2012). This is a more modular Internet with clear hubs taking on different roles in the total network of ASs. Our method provides us with a deeper insight into the different firms, and enables a discussion of the motivations and underlying driving forces for the industry structure we observe. As such, our research is an investigation into methods to identify and make sense of actors, relationships and motivations in a sub-set of Internet.

Furthermore, we compare markets with different Internet maturity – Thailand and Norway – and investigate if Internet dynamics are influenced by local context such as economy and Internet penetration. This contributes to a discussion on whether there is a local Internet, but also if it is possible to stage our own observations and those of Labovitz and Lekel-Johnson (2010) according to market maturity. All in all, our suggestions for new ways to describe and understand Internet enable a discussion on the potential economic and regulatory issues of a changing Internet topology.

The rest of this article is structured as follows. In section two we explain the method developed and used for the Norwegian market, and the results achieved, which introduces a new perspective on the topology and market mechanisms of Internet. A study of the Thailand Internet is documented in section three, replicating the method and providing results for the Thai market. This is followed in section four by a comparison of the Norwegian and Thai Internet where we discuss whether the results are sufficiently robust for both mature and immature markets, and how they are influenced by Internet maturity. Section five draws the conclusion and comments of this paper.

2 Proposing a methodology to study the emergent Internet: The Norwegian case

The purpose of this article is to illustrate how new methods can be used to build new knowledge about the local Internet and thus enable discussions on Internet strategies and regulations to be based on the real configuration of the Internet. The original purpose of the research 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 there are relevant, publically available data, patterns with significant explanatory power for the market structure, and the existence of local Internets or subgroups 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 (Hawkinson, 1996). ASs are also assigned to juridical entities and subject to a public assignment

regime (Faratin, 2007). One organization might have more than one AS, but for the majority there is a one-to-one relationship between AS and organization. ASs are the basic actors for activity in Internet, and all have some kind of relationship to one or more adjacent AS. The ASs and enterprises that possess them have proved to be a relevant and effective object of research in documenting and understanding Internet.

In Norway, we identified ASs and additional data from many sources. We studied the relationships between the Ass, peering relationships, but also customer-provider relationships, ownership and alliances. The peering relationships were used to analyse how the ASs where interconnected in a graph, information that was supported by the other type of data on relationships. We identified potential belonging resources and allocated them to the ASs in order to consider their stake in such activities; hosting of domains, websites and provisioning of Internet access to end-users. The ASs were assessed according to their type of business, and size of their revenues and market shares were also documented – which again could support or contradict other results. An extensive coding phase led to a large data set where we could look for patterns. We consider our method as inspired and very well explained by the principles of grounded theory (Urquhart, 2013), but cannot claim that we fully fulfil the strictest criteria of the method.

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

Our expectations of the number of IAPs holding AS numbers were somewhat lower than the identified one third of 166 Norwegian ASs. 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, already 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.

Subsequently, the analysis resulted in four categories – or Internet archetypes:

- Internet Access Provider,
- Internet Access and Hosting Provider,
- Hosting Provider and
- Provider of Content, Application, Service.

The four archetypes are categorized along two dimensions. See Table 1 below. The categories were populated with about the same number of ASs.

	Hosting domains/websites for 3rd party	NO Hosting
End-user access provision	Internet Access and Hosting Provider (Balanced ISP)	Internet Access Provider (IAP) (Eyeball ISP)
NO End-user access provision	Hosting Provider (Hosting ISP)	Provider of Content, Application, Service (CAS)

Table 1. Categorization of holders of AS numbers

The categorization was the result of a process of coding, combining, and analysing ASs, additional collected data, identifying characteristics and resources based on reports and interviews. In the Norwegian case, the 166 different ASs seemed to prefer connecting to – or peering with – a few ASs, making these ASs hubs in the Internet in a scale-free network structure (Barabási, 2002). The tendency to act as hubs for other Internet actors was reinforced by the distribution of domains and enterprises in the IT industry not having their own AS numbers – which seemed to prefer the same ASs. This became very clear in graphic illustrations of the ASs and links between them, made possible through the use of the software Cytoscape. In parallel was a clear tendency for some *Internet Access Providers* (IAP) to act only as access providers. They were to a small degree providing transit (in the sense of access to content providers), not hosting domains or websites. This latter group are so-called Eyeball Providers (Hall et al., 2011).

Originally, the hubs were often pure access providers or IT enterprises. Both groups seemed to have extended their activity into transit to, and hosting of, domains and websites. Depending on whether or not they provide access, their current business fall into the categories denoted *Internet Access and Hosting Providers* or *Hosting Providers*, also called Balanced and Hosting ISPs by Hall et al., (2011). The tendency to form hubs was further reinforced by the structure of ownerships and alliances connecting the ASs. Especially the *Internet Access and Hosting Providers* 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 call *Hosting Providers* 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 origin of large shares Internet traffic has been revealed and better understood. These are actors which originate in Norway. Norway is a very open and global economy based largely on oil, energy and fish, and there should be few obstacles to a more international activity. Based on this we deduce that being close to access subscribers and networks is necessary for this type of actor, and that the underlying driver is the ability to provide sufficient Quality of Service within the Internet

network. 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.

A further look into the archetypes reveals that they differ with regards to customers, end-users, products and services, and revenue models. They all have 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, driven by capacity, quality, connection or hosting. 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 (Sandvine, 2013; Cisco, 2012; and ITU, 2011).

In the archetypes and the dynamics between them we encounter 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 Internet in the sense that the specialization becomes explicit by compressing one or more layers (Lessig, 2001). 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; the *Internet Access* and *Hosting Provider* and possibly the *Provider of Content, Applications, and Services*.

However, the archetypes are highly interdependent and 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. Such motivations are described within literature on business ecosystems, for example Iansiti and Levien (2004) and Gawer and Cusumano (2002). 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 (Faratin, 2007 and Clark, et al., 2011). 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 locally, which use global Tier 1 ASs for global activity.

On the other hand we 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, by bypassing the independent layers of Internet. Typically this will mean that *Internet Access Providers* start providing co-location and later hosting of content, websites and applications. Alternatively, the other way around, the provider of hosting services includes Internet access in its product portfolio. The *Internet Access and Hosting Provider* already represents this integration.

Both types of shifts are more likely to happen in a market with substantial demands for local services and more predictable network Quality of Service (QoS). The existence of a vital, local Internet and IT and Internet industry in Norway proves

that there is a market for local services. Based on our analyses of the Norwegian IT industry we find that there is reason to believe that demand for higher requirements on QoS also hold, placing content close to users is one important strategy to meet such requirements. With regards to QoS and closed user groups this has so far been taken care of by MPLS protocols in virtual networks between enterprises (Yoo, 2012). Otherwise best effort and the ability to connect with whom and what you need has been sufficient for most users 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.

Our results reinforce the concept of the emerging Internet introduced by Labovitz and Lekel-Johnson (2010). We suggest that there is a local Internet, serving needs from local end-users and providers of Internet content and applications. This local network is to a large degree self-supporting, yet still complementary to the global Internet. We suggest that such structures will become more prevalent as some requirements for content and services get more advanced and thus more present in mature economies.

2.1 Limitations of method and findings

We started the research reported in this article with the presumption that Internet topology and economy is changing, but we do not how and to what. There has been limited research on the phenomenon, and thus few theories have been formulated. The researchers were experienced and acquainted with the generic telecom industry, but not with the more specific object of interest. As such, fulfilment of some important key features of *Grounded theory* method was actually already present for the researchers as they started out. Their aim was to build knowledge, which can be understood as building theory, but they were not consciously seeing this as theory. They set aside theoretical ideas, both because they did not exist and as a result of being novices into the field. In hindsight, the subsequent result may be described as new theory. We will discuss whether the research process can be meaningfully understood as an example of Grounded theory, or at least be described as heavily influenced by such ideas.

The data were collected from many sources, with continuous search for data, assessment of its relevance, and constructing a patchwork of data illuminating the phenomenon from different perspectives. This can be understood as corresponding to how Grounded theory recommends continuous data collection, analysis and comparison – till “no new conceptualizations emerge” (Urquhart 2013, p 5). The process can be described as two staged, as one theoretical stage led to a new phase with data collection and analysis, concluding in a second theory. Again, the actual research process has many of the characteristics of Grounded theory. The newness is in how the researchers used the method to investigate enterprises, or even more unconventionally, the unique number used to identify a network in the Internet infrastructure. Another new aspect is the multitude of sources on Internet topology, their nature and availability in public sources. The data used were to a large degree naturally occurring (Silverman, 2011), rather than organized interviews.

An indisputable defining criterion for adhering to principles of Grounded theory method is to discuss “how the categories *relate* to each other. Without these statements of relationships, we are not theorizing.” (Urquhart, 2013, p 106, original emphasize). This is the most questionable point of the research in question; to what degree can we call it theory. Although the process of establishing mutually exclusive categories was extensive, the relationship between them may have been be offered less attention.

An additional limitation is that the analyses were based on publicly available data, especially because private peering agreements were hidden from us (Ager et al, 2012). The data are collected from open sources, easy accessible when first identified.

However, an interesting replication of the study has been made in Thailand and has relaxed some of the limitations to the method. Some of the data are also available in Thailand, where this type of analysis makes sense, comparable categories are relevant and similar market dynamics seem to be present. A comparison of the study of Thailand and Norway also sheds some light on what may be the main differences between more and less mature Internet economies.

3 Replicating the method: the Thai case

The method was replicated in Thailand in order to test its usability, compare results and promote a discussion as to how Internet topology is dependent on the economic status of a country. The replication and comparison enhances the robustness of the methodology itself and the discussion of implications for strategy and regulations.

3.1 The Thai Internet access market

Internet penetration was in 2011 more than 30 per cent in Thailand, with 20 Mill Internet users among 67 million Thais (Internet World Stats, 2013). According to Srihirun (2011) the Internet penetration was even higher, and already reached 22 million users in 2010. Srihirun estimated the users at 6.9 million subscribers to fixed Internet, leaving the majority of Internet users accessing Internet from the mobile. It is difficult to get exact figures on mobile Internet use in Thailand from public sources. However, a widespread use of mobile Internet is highly realistic considering a mobile penetration of 122 per cent (CIA, 2013); or as shown by figures from mobile enterprises¹.

There are three large mobile providers in Thailand; AIS, dtac, and True move share the market (Singapore Management University, 2012)². The state owned CAT and TOT hold build-transfer-operate licenses that the other mobile operators operate within. Beyond that, the latter two hold only insignificant market shares.

¹ See also the large mobile operators' figures on mobile subscriptions, a total of 82 million as of April 2013. Last visited 9th April 2012: dtac: <http://dtac.listedcompany.com/highlights.html>; AIS: <http://investor.ais.co.th/en/index.aspx>; True Move: <http://true.listedcompany.com/misc/PRESN/20130325-TRUE-factsheet.pdf>.

² IBID 1

The fixed broadband market is also divided between three large actors: True Online, TT&T and TOT (PPIAF, 2011). The latter two have private ownership while TOT is owned by the state through the Ministry of Finance. TT&T operates within a license given to a wire line company with the same name, but the broadband brand is owned and run independently by Jasmine International.

Operators in Thailand are to obtain a license from the National Broadcasting and Telecommunications Commission - NBTC - and must adhere to a set of industry specific regulations. Most licenses – type one – have been given to operators without their own network, mostly providers of different Internet services. Type three licenses are fewer and given to network operators with networks providing (telecommunication) services to the general public. To our knowledge the Thai Internet is not regulated by principles of net neutrality; there is however, regulation in order to prevent the exercise of market power (NBTC, 2012)³.

3.2 Thailand Internet

To a large degree we were able to replicate the method for studying the Internet in Thailand even though we were limited by our understanding of English but not Thai. We employed open sources to collect the ASs and the ways they were linked as Internet peers. The names of the ASs were not as intuitive as in Norway, sometimes only a street address. Although a cumbersome process, it was possible to link ASs with enterprises. Also, we found relevant data on large web sites and domains, and where these were hosted. For the larger enterprises it turned out to be possible to visit web sites to get an overview of their businesses in English. The same sites informed us about ownership and other constellations, however such information is always difficult to put together as an outsider. It was not possible to obtain public web sites in Thailand with enterprise data such as revenues, ownership and type of business. All in all, less rich data forced us to limit our analysis to the larger actors in Thailand and thus both the results and later comparison is at a high level.

Both mobile and fixed access operators are important players in the Thai Internet market. Our results based on data from 2012 document the broader business of each of these players, as well as a numerous and varied Internet market in Thailand. The enterprises – and the 262 ASs belonging to them – seem to pursue different strategies and market positions. Parts of the market we describe are well known to experts on the Thai Internet industry, especially the large actors and their profiles. Our contribution mainly concerns how the actors' strategies are reflected in their conglomerates of networks and ownership of autonomous system numbers.

The main impression is that the three constellations True Corp, Jasmine and Shin are positioned in the access market as well as hosting and other Internet services. Only True Corp provides both mobile and fixed Internet access, while Jasmine and Shin hold fixed Internet and mobile respectively. Shin is a central host of large

³ NBTC, 2010, Identifying Operators with significant market power in each relevant market and the operators with significant market power to comply with specific measures, No 32/2553, Unofficial Translation, Last visited 2. July 2013, <http://nbt.go.th/wps/wcm/connect/8a5ae2004ff63e4481a1c5abcb3fbcab/2Order-0001-151254.pdf?MOD=AJPERES&CACHEID=8a5ae2004ff63e4481a1c5abcb3fbcab>

domains through its company CSLoxinfo, while both True Corp and CSLoxinfo serve as transit providers to many smaller Internet companies in Thailand. The roles they play are handled by a conglomerate of companies and autonomous system numbers, which was only moderately revealed by our research. Dtac stands out as an actor fully focused on its role as a mobile operator. TOT, although a holder of several licenses, is large but mainly established as a fixed Internet access provider.

Owning company	Mobile access	Fixed access	Hosting	Transit	Int/Nat. gateway	ASs #
Shin	AIS	(Super broadband)	CS Loxinfo	CS Loxinfo	Yes	15
True corp	True Move	True Online	Asianet/ True Internet KSC	Asianet/ True Internet	Yes	15
Jasmine Int	-	TTTB	-	-	Yes	5-7
Telenor	Dtac	-	-	-	No	4
TOT	-	TOT	-	-	Yes	4
CAT	-	-	CAT	-	Yes	6
INET	-	-	INET	-	No	2

Table 2: Distribution of resources among Internet stakeholders in Thailand

True Corp and Dtac stand out as opposites in positions. True Corp is a vertically integrated ICT provider with a broad portfolio across different accesses and hosting, and even offering web services and TV⁴. Dtac is an operator of mobile access, fully focused and without visible – to the researchers – stakes in other sectors. The Shin group is also broadly positioned but lacks a footprint in fixed Internet. Jasmine/TTTB seems to be in a similar position to Dtac but as a fixed operator, and is also more active both with gateways and ASs.

It should be noted that TOT and CAT emerge with a rather focused position in this analysis, based on publicly available data. However, in addition they hold the licences of mobile and broadband access network operators (build-transfer-operate licences), which are transferred over to acting operators. Although the logical networks (IP-addresses) are held by the acting operators, TOT and CAT's positions are as licence holders and controllers of the physical networks. This may add to their influence which, however, was not visible to the researchers.

⁴Confer Wikipedia on True Corp (Last visited 14th December 2012)
http://en.wikipedia.org/wiki/True_Corporation

Looking at the graphic illustrations in Figure 3 and 4 the footprint of respectively the True Corp and Shin group is striking. Based on this we may suggest the presence of two large hubs, and also well-connected alliances.

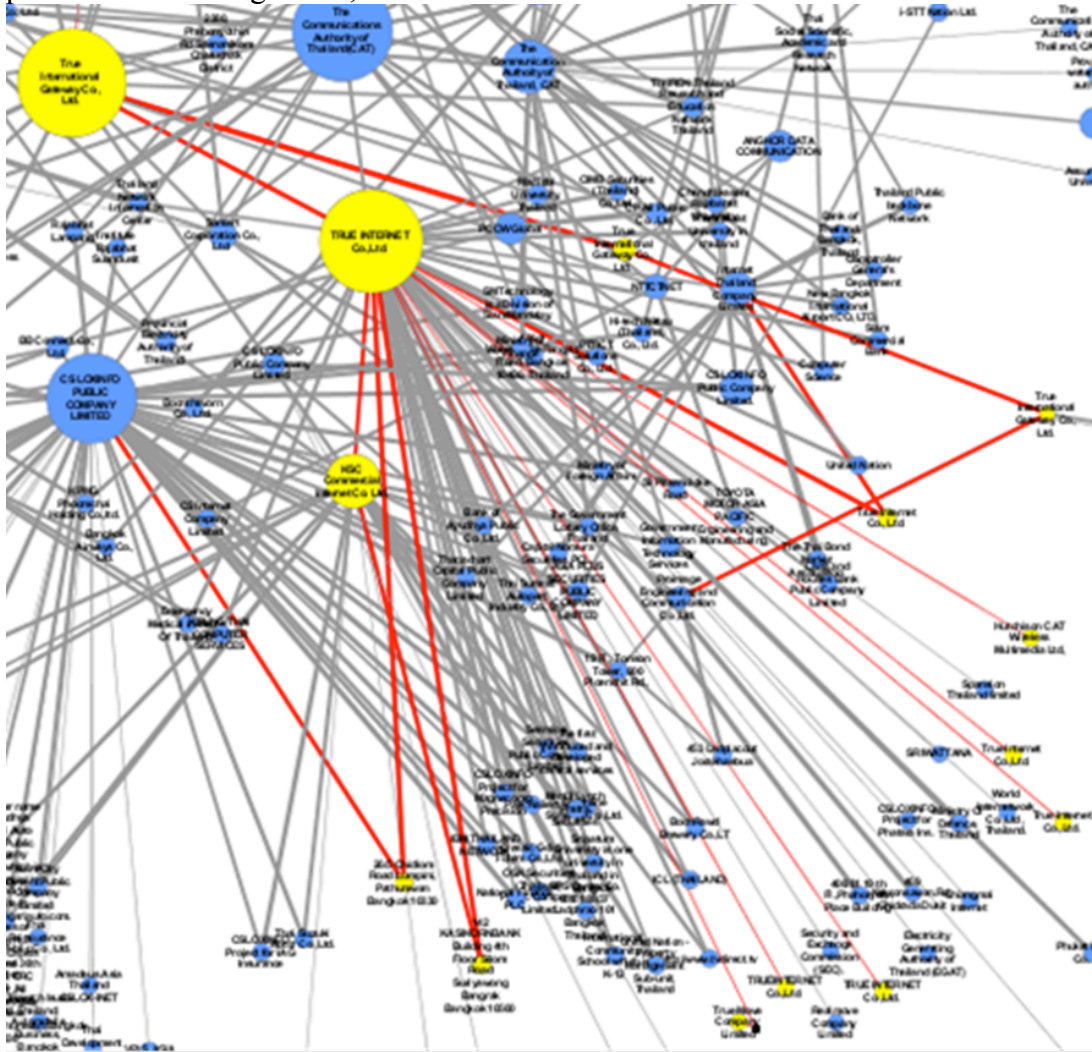


Figure 3. The True Corp conglomerate of interlinked ASs are shown (yellow nodes)

True Corp is the actor with the broadest portfolio in Thailand. The host – Asianet or True Infonet – is central in the group, with all the smaller True enterprises and ASs connecting to it. In addition many external ASs connect to this AS as a gateway to the rest of Internet. The mobile access operator True Move is an AS at the edge providing mobile Internet access to end-users, directly connected to the central host. We were not able to identify which AS that provides fixed access, but suspect one of the edge ASs has this role, again directly connected to the host AS. KSC is a True company established as the actor providing services to the business market. All ASs in the True group seem to connect to one large True international gateway, which also has many external connections. The True Infonet – with the brand name Asianet – is to our knowledge owned 65% by True Corp, and 35% by CAT.

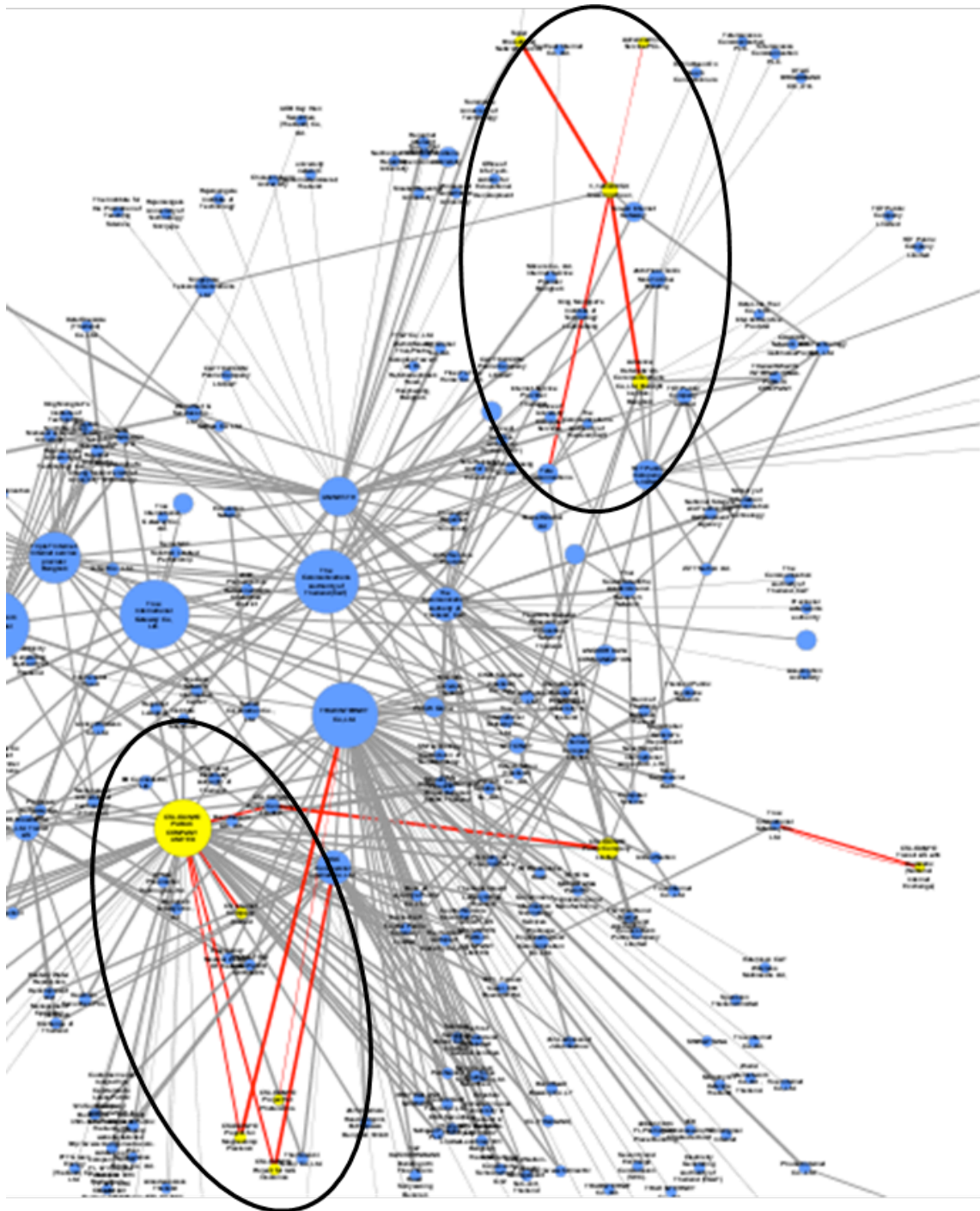


Figure 4. The Shin conglomerate of ASs (yellow nodes)

The Shin group holds 15 ASs, however with a more narrow business portfolio compared to True Group. Looking at how the business is reflected in their network of ASs, the ASs and hence the businesses seem to be less interlinked. We cannot find any direct peering connections between the Advanced sub-group and the CS Loxinfo subgroup. The mobile operator AIS is connected to Internet at the edge, with a transit link into the Superbroadband network, which is a company offering retail ISP services, international and national gateways IP VPNs, VoIP and IPTV. This group is also directly connected to a representative for the owner group Shin:

Singtel in Singapore. Obviously, the Shin group's market share in the fixed market is limited; however the broad portfolio of Superbroadband makes it a strong and complementary partner to the mobile access provider AIS.

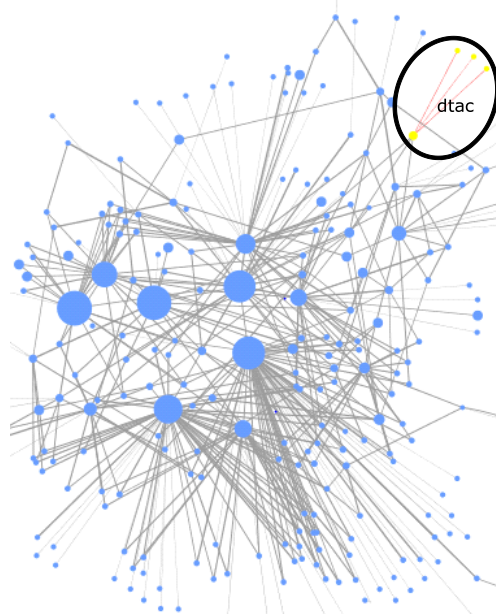


Figure 5. Dtac position in the Thai Internet market. Marked as yellow nodes in the diagram.

In Figure 5 we depict how Dtac is located at the edge of Internet with a small footprint as holder of ASs and without visible partnerships with other enterprises. Neither do the Jasmine group, TOT, CAT and INET stand out as tactically positioned and interlinked within the Internet topology. INET – or Internet Thailand – is an actor that has turned up as a significant host for larger web sites. 49% of its stocks are controlled by the government agencies NSTDA, CAT, TOT⁵. Hosting seems to be the focus of this actor. Based on the data in Table 2 and the belonging figures the different actors fall into three of the suggested four categories of Internet actors; Eyeball ISPs, Balanced ISPs and Hosting ISPs (Hallingby and Erdal, 2011).

	Hosting domains/websites for 3rd party	NO Hosting
End-user access provision	Internet Access and Hosting Providers: <i>True Corp, Shin group</i>	Internet Access Providers: <i>Dtac, Jasmine/TTTB, TOT</i>
NO End-user access provision	Hosting Providers: <i>INET, CAT</i>	Providers of Content, Applications, Services <i>(Not identified)</i>

Table 3. Match of Thai actors into Internet archetypes

⁵ About INET, confer <http://www.inet.co.th/ir/index.php?MainID=7&lang=en> (Last visited 21.12.2012)

Telenor/Dtac, Jasmine/TTTB and TOT are *Internet Access Providers* as they are sole access providers. CAT emerges as a *Hosting Provider* based in our data, although we know they are involved in access through their build-transfer-operate licences and minor mobile operation. INET is a pure *Hosting Provider*. True Corp and the Shin group are *Internet Access and Hosting Providers* with a portfolio including access, transit and hosting. As emphasized above, we were constrained from collecting the same rich data on enterprises in Thailand, as we did in Norway and thus have focused on the larger actors to map the local Internet. The theory built with the Norwegian case, appearing as four archetypes, is an important structure for concluding on structure in Thailand. This both enhances the relevance of the Norwegian study outside this market, but also show how conclusions in another market are vulnerable to lack of data and must rely on support from theories.

We should stress that as of today both a broad and a focused market strategy may be successful and profitable. Our concern is to document how these strategies are reflected in the topology of Internet. The analysis also illustrates how actors in Thailand are already positioned to provide something additional to best effort Internet. The combination of hosted content and services and access provisioning within the controlled networks is a constellation able to provide a predictable QoS.

4 Comparison

Thailand and Norway are different countries according to size of population and GDP per capita, Thailand being more populated and on average less affluent. Mobile penetration is in a mature phase in both countries. However, all Thais are not yet connected to Internet, and Thailand is assessed as a less mature Internet economy than the Norwegian. Based on this we would expect the Internet industry to differ from the Norwegian in both size and structure.

We have brought the UK into the analysis to be able to set the expectations for Thailand based on a country about the same size; however the former has a more affluent economy. The comparison in Table 4 tells us that the numbers of ASs and domains in Thailand are still relatively low, even though the ASs outnumber those in Norway. Based on this and the lower Internet penetration it is fair to say that Thailand is still a less mature Internet economy.

Thus we could expect the Thai Internet to be more similar to the traditional view of Internet as a layered model with mainly *local* Internet access providers with end-users accessing content and applications across the Internet, globally (Labovitz and Lekel-Johnson, 2010). We would not expect the Thai Internet to have developed a significant local Internet activity catering for many of the local content and application enterprises, as we saw in Norway.

However, the nominal high numbers of ASs in Thailand signal an active and advanced Internet industry. In addition to the Internet access providers, we find a local market for general IT and hosting of content and applications. Most interestingly, we find clear indications of the same structures in the market as in Norway, and the archetypes are also present. This could mean that these structures

are developing already in early phases in the local Internet economy, or that the Thai industry is leapfrogging into the market structures and dynamics of more mature markets. Following the logics of scale-free networks (Barabási, 2002) structures with hubs are present already in early phases of a network's evolution.

	Thailand	Norway	United Kingdom
Population	67 mill	5 mill	63 mill
GDP – per capita (CIA)	117. place \$ 10 000	10. place \$ 55 300	36. place \$36 700
ASs	262	166	Ca 2 000 ⁶
ASs/Pop	4	33	32
Domains	Ca 250 000	Ca 800 000	10,24 mill .uk 4,8 mill com.... ⁷
Domains/Population	4	160	240
Internet penetration	30 %	90 %	90 %
Mobile penetration	>100%	>100%	>100%
Internet maturity	Low-medium	High	High
Archetypes	Yes - CAS missing?	Yes	-
Local/global	Global - Local	Local – Global	-

Table 4. Comparison Thailand and Norway

It is also interesting to notice that a fair share of the Thailand Internet seems to be rooted in the national infrastructure, as in Norway. However, to a larger degree than Norway we find international actors hosting smaller national domains (e.g. Worldnet Services, a part of the Hong Kong located Pacnet⁸), as well as the larger Thai websites (e.g. the US Cloudflare⁹). We believe that national content and services will grow in volume and significance as Internet matures, and accordingly the visible international actors may be interpreted as an indication of the market's immaturity. The requirements for Quality of Service on the end-user and content side will be important driving factors for the establishment of a more local industry. Whether the Thai distribution between national and international actors will remain as today, or shift in favour of any of these, remains to be seen. Currently we observe that there is a significant national industry, which is interesting and promising regarding national growth.

⁶ Based on gross number from Hurricane, not confirmed or analysed further. Last visited 10th April 2013:

<http://bgp.he.net/report/world>

⁷ Last visited 10th April 2013: <http://db.nominet.org.uk/page/the-uk-in-detail/>
http://www.webhosting.info/domains/countrv_stats/UK

⁸ The AS 4765 is a Thai company registered with the name World Net & Services, but seems to be branded as Pacnet and directly linked to this Hong Kong located actor.

⁹ The AS 13335 Cloud14-AS is a medium host in Thailand, and belongs to the US company Cloudflare
<http://www.cloudflare.com/>

With more limited analyses of Thailand, and only a taste of the status in UK, the comparison is at a high level. The method as such, however, seems to be feasible and relevant in a context outside the original Norwegian context.

5 Conclusion

In this article we have described the use of new methods to build new knowledge about the Internet, more specifically the local Internet structure in Norway and Thailand. This provides an answer to the need for a more comprehensive overview of the Internet at a national level. The method, with its limitations, has clear indications of being feasible and relevant in markets other than Norway. It is meaningful to map the ASs in a local market, identifying the belonging enterprises and their businesses. However a severe handicap on extending the methodology has been the lack of a full dataset in Thailand leaves us with a high-level comparison. The archetypes established in the Norwegian study are applicable also in Thailand and thus the generic knowledge developed about the local Internet seems relevant in a wider context.

Our findings report on evidence point out to confirm the existence of a local Internet in the Norwegian and Thai market in addition to the global. These local Internets are becoming more heterogeneous and modular compared to the global Internet architecture. We identified four distinct archetypes: Internet Access Provider, Internet Access and Hosting Provider, Hosting Provider, and Provider of Content, Application, Service. The archetypes are positioned differently to carry traffic in future Internet structures, and to negotiate contracts with other ASs and content providers. The specialized Internet Access Provider and Hosting Provider have diverging interests despite being interdependent, and must negotiate new types of contracts that balance their requirements. Internet Access and Hosting Providers are actors that bypass the negotiating challenge by integrating content and access in their own networks, and even make it a quality advantage to control traffic end-to-end. We have found indications of the same structures in the Thai Internet market, as in Norway. Thus, new structures in the Internet topology emerge also in less mature Internet markets, and we suggest that emerging markets may even leapfrog the traditional layered structure.

The interconnection regimes between ASs are about to become more heterogeneous and complex due to more diverse actors with varying incentives (Faratin 2007). Our findings empirically confirm and extend the existence of this heterogeneity both in mature and less mature Internet markets. Our methods and results are answers to the inability to describe specific Internet structures, as well as the evolving structures. Thus, both actors with economic interests and regulatory authorities should be interested in our findings.

In the case of firms it is logical to expect their interest in understanding the structures and changing forces in their markets in order to control cost and find new revenue sources. First, the increasing traffic and traffic asymmetry is a cost concern for all actors and especially for access providers bearing most of the investments and operational costs. As of today cost is driven mainly by a traffic increase outside

their control, The access provider will be interested in what type of actors it is dealing with, and seek to use contractual terms to better control cost driving traffic patterns. On the other hand – the sender of traffic will need to consider how to keep traffic cost low but not impoverish the access networks. Second, passively receiving traffic in access networks leaves no room for assuring quality. Congestion sensitive access network would want to actively manage their interface with other networks to provide predictable quality to end-users. Also content and service providers must balance low cost and service quality, and for some it will be profitable to pay for predictability. The two points made above explain why some actors move into other positions, and other continue to stay as is. To vertically integrate resources in order to regain control over cost and quality may be a solution when it is not possible to negotiate adequate contracts. Thus, the findings of this paper on Internet market structures and dynamics may be of use for important strategic considerations for Internet firms.

Finally, our view is that based on the national evidence collected: global, regional and national regulators, which are bound by law – and through different enabling practices depending of the country - to protect consumers and balance competition, must understand and be able to assess the market power of different Internet actors. There are many implications from the new emerging structures towards business innovation and future sustainability. Focusing only on the issues related to access to networks and price structure without understanding the costs for the provision of digital services is a serious shortcoming for regulators and national and regional level, which is currently affecting the core principles of service provision by creating digital services monopolies. A more modular Internet challenges the basic assumption of the principle of net neutrality – a layered structure. Lack of insight could lead to impoverished access markets or actors with real, but not revealed, market power.

6 References

Ager, B., N. Chatzis, et al. (2012). Anatomy of a Large European IXP. SIGCOMM'12. Helsinki, Finland: 12.

ARCEP (2012, September 2012). "France: First Commitment Decision related to Internet Neutrality issued by the Autorité de la concurrence." Online. Retrieved January, 2013, from http://ec.europa.eu/competition/ecn/brief/04_2012/fr_cogent.pdf.

Barabasi, A.-L. (2002). Linked: The New Science of Networks. Cambridge USA, Perseus Publishing Books.

CIA (2013). "The World Fact Book, Thailand. Last updated 9th April 2013. <https://www.cia.gov/library/publications/the-world-factbook/geos/th.html>". Retrieved April, 2013.

Cisco (2012). Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011-2016. San Jose, California, Cisco Systems: 29.

Claffy, K. (2008). Ten Things Lawyers should know about the Internet. San Diego, USA, CAIDA - University of San Diego: 24.

Claffy, K., Y. Hyun, et al. (2009). Internet Mapping: From Art to Science. IEEE DHS Cybersecurity Applications and Technologies Conference for Homeland Security (CATCH). Washington, USA.

Clark, D., W. Lehr, et al. (2011). Interconnection in the Internet: the policy challenge. 39th Research Conference on Communication, Information and Internet Policy (www.tprcweb.com). George Mason University, Arlington, VA.

Faratin, P., D. Clark, et al. (2007). Complexity of Internet Interconnections: Technology, Incentives and Implications for Policy. Cambridge, MIT Communications Futures Program: 31.

Friederiszick, H. W., J. Kałużny, et al. (2011). Assessment of a sustainable Internet model for the near future. Berlin, Germany, ESMT Business Brief No. BB-11-01. European School of Management and Technology: 16.

Frischmann, B. (2012). Infrastructure - The Social Value of Shared Resources. Oxford, Oxford University Press.

Gawer, A. and M. A. Cusumano (2002). Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation. Boston, Mass., Harvard Business School Press.

Hall, C., R. Clayton, et al. (2011). Inter-X: Resilience of the Internet Interconnection Ecosystem - Full Report. Brussels, Belgium, ENISA: 239.

Hallingby, H. K. and O.-B. Erdal (2011). The Norwegian Internet Economy - a case study - R&I Research Note. Oslo, Norway, Telenor: 52.

Hallingby, H.-S., G. Hartviksen, et al. (2012). Convergence in Action: The New Internet Outsourcing The 19th ITS Biennial Conference 2012, Bangkok, Thailand.

Hallingby, H. K. and O.-B. Erdal (2012). Guide: Case study on autonomous system numbers in Norway - R&I Research Note. Oslo, Norway, Telenor: 31.

Hallingby, H. K. and G. Hartviksen (2012). Internet value creation and capturing – exploring the Norwegian IT industry. Oslo, Norway, Telenor: 38.

Hallingby, H. S. and G. Hartviksen (2013). A quick look into the Internet footprint in Thailand. Oslo, Norway, Telenor: 40.

Hawkinson, J. and T. Bates (1996) Guidelines for creation, selection, and registration of an Autonomous System (AS) -Available URL: <http://tools.ietf.org/html/rfc1930>.

Iansiti, M. and R. Levien (2004). "Strategy as an Ecology." Harvard Business Review: 12.

Internet World Stats (2013). "Asia Internet users, Population and Facebook statistics. <http://www.internetworldstats.com/asia.htm#th>". Retrieved April, 2013.

ITU (2011). Measuring the Information Society. Geneva, Switzerland, International Telecommunication Union: 174.

Krauss, C. (2009). Next Generation Competition - Driving Innovation in Telecommunications. London, Bain & Company: 77.

Labovitz, C., S. Lelak-Johnson, et al. (2010). Internet inter-domain traffic. SIGCOMM'20, New York, USA, ACM Digital Library.

Lessig, L. (2001). The Future of Ideas. The Fate of the Commons in a Connected World. New York, USA, Random House.

Liebenau, J., Elaluf-Calderwood S., Karrberg, P. (2012). "Strategic Challenges for the European Telecom Sector: The Consequences of Imbalances in Internet Traffic." Journal of Information Policy 2: 248-272.

Liebenau, J., Elaluf-Calderwood, S., Karrberg, P (2013). European Internet Traffic: Problems and Prospects of Growth and Competition - White Paper. London, London School of Economics and Political Science 32.

NPT (2012). Det norske markedet for elektroniske kommunikasjonstjenester. Lillesand, Norwegian Post and Telecommunications Authority: 69.

NPT (2011). Telecommunication Markets in the Nordic Countries. Lillesand, Norwegian Post and Telecommunications Authority: 28.

NTBC (2012). "List of licensed telecommunications business. Accesible at <http://apps.nbtc.go.th/license/> (in Thai, translated by authors for analytic purposes)." Retrieved December, 2012.

PPIAF (2011). Thailand rural broadband infrastructure policy project. Final report. Available at http://www.ppiaf.org/sites/ppiaf.org/files/publication/PPIAF-Thailand_rural_telecom_strategy.pdf Bangkok, World Bank: 97.

Sandvine (2013). Global Internet Phenomena Report - 1H-2013. Waterloo, Ontario, Canada, Sandvine: 39.

Shakkottai, S., M. Fomenkov, et al. (2009). Evolution of the Internet AS-Level Ecosystem. Complex Sciences, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, . Berlin, Springer Berlin Heidelberg. 5: 8.

Singapore Management University (2012). "Digital media in Thailand https://wiki.smu.edu.sg/digitalmediaasia/Digital_Media_in_Thailand#Internet_Penetration". Retrieved April, 2013.

Silverman, D. (2001). *Interpreting Qualitative Data: Methods of Analysing Talk, Text and Interaction*. London, UK, SAGE Publication.

Srihirun, P. (2011). *Telecommunications in Thailand*. Presentation on behalf of National Broadcasting and Telecommunication Commission Available at <http://www.itu.int/ITU-D/asp/CMS/Events/2011/ITU-ADB/FinalWorkshop/Thailand-S2.pdf>. ADB/ITU Final International workshop on rural ICT development Krabi, Thailand.

Steen, H. U. (2012). *Coordinating convergence? Competition and conflict between the telecommunications and broadcasting discourses in the standardisation of mobile television in Europe, South Korea and China*. Department of Informatics. Oslo, Norway, University of Oslo: 336.

Urquhart, C. (2013). *Grounded theory for qualitative research. A practical guide*. London, UK, Sage.

Valancius, V., C. Lumezanu, et al. (2011). *How Many Tiers? Pricing in the Internet Transit Market*. SIGCOMM'11, August 15-19, 2011. Toronto, Ontario, Canada.

Vigeland, E. (2012). *Control and Innovation on Digital Platforms - The case of Netflix and streaming of video control*. Centre for Technology, Innovation and Culture. Oslo, University of Oslo: 88.

Yoo, C. S. (2012). *The Dynamic Internet: How Technology, Users and Businesses are Transforming the Network*, AEI Press.