Explicit contractual mobility for user roaming

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ABSTRACT
Arguing the reasons why current roaming across different providers is deficient, this paper suggests a new definition of roaming based on the concept of explicit contractual mobility. This enables users to establish explicit business relationships with visited providers in an ad hoc fashion. The functions required to enable this are described in the context of a business plane where no specific roaming model is enforced – users are not wedded to a particular tariff, but only to what they choose and what they pay for. The plane represents a playing field for economic tussles, where current and future commercial roaming models will be realized, and the fittest will survive.

Keywords
Roaming, contractual mobility, business relationships, service innovation, competition, evolvability.

1. INTRODUCTION
In communications networks, roaming is defined as the ability to use any one of many service providers, while maintaining a formal business relationship with just one – the home provider [1, 2]. Only one roaming model is thus provided for: while users roam, their business relationship does not. This definition suffers from two main limitations.

The first exists because, intrinsic to this definition of roaming, users have to be served by the competitors of their home provider in order to experience seamless service. This forces the standardization of services and their control functions across adjacent providers, greatly diminishing the competitive advantage provided by the introduction of innovative new services or functions.

The second limitation is that current roaming allows for user mobility across providers while preventing contractual mobility. Hence, users are unable to explicitly establish business relationships with visited providers as they roam. Instead, they must rely on the existence of a roaming agreement between home and visited provider. This obligatory use of roaming agreements thus introduces a barrier to user’s mobility, created by a perceived mutual self-interest between providers.

Mobile Network Operators (MNOs) and Internet Service Providers (ISPs) set present-day roaming systems in stone by designing them for this roaming definition. This is now spreading unchallenged into the wireless LAN sector and being built into its supporting technology [12].

This is due to the telecommunications industry not considering these deficiencies and choosing to design the roaming capability by extending existing operational support systems to other wireless access technologies.

In contrast with this, we suggest a different definition of roaming, based on explicit contractual mobility, aimed at removing existing limitations. Users are able to use any one of multiple service providers, by establishing with them explicit business relationships in an ad hoc fashion, i.e. on a per session basis, independently of roaming agreements, and through an automated process.

After defining current roaming in the next section, we analyse, in section 3, the deficiencies of its definition and provide arguments for the introduction of explicit contractual mobility, which is then illustrated in section 4. Then, in section 5, in the context of a business plane, we give the functions and architectural properties for systems that support this new roaming definition.

2. TRADITIONAL ROAMING
Originally, the Internet represented a particularly flexible method for interconnecting heterogeneous packet-based networks and sharing their resources. Since its academic origin, it has been influenced by economic and market forces; consequently, it has adapted and has now become a commercial environment upon which many businesses depend.

This unforeseen role is forcing the Internet to face increasing challenges in various domains [8]. In particular, some extensions have broken original architectural assumptions which made the Internet so evolvable. Now, many scientists are re-thinking the Internet architecture within today’s economic and societal context [6].

One particularly important dynamic of Internet evolution is the increasing use of wireless access technologies. Being at the crossroads of two industries, telecommunications and computing, the Internet can play a central role. However, this role particularly exposes the Internet to opposing pressures created by the clashing economic interests of each industry’s players.

Existing and emerging wireless access technologies (e.g. GPRS, UMTS, and WLANs) are bringing to the Internet advantages and opportunities, as well as disadvantages and constraints. In particular, they have made user mobility a central requirement of future developments of the Internet architecture [6].
The notion of mobility can be very broad and issues arising from it varied. This paper considers mobility as a change of network – and thus administrative domain – performed by the user. Both the telecommunications and computing industries have, mostly separately, concentrated their efforts on solving this problem, which raises two kinds of issue:

- communications issues, related to the transfer of information to end-user devices moving between different locations [17],
- business issues, related to the identity of mobile users and the management of business relationships between users and service providers.

The capability that deals with business issues is referred to as roaming and is primarily supported by systems for user authentication, authorization, profile storage, usage accounting, metering and charging.

In the Internet domain, a roaming capability was developed to enable customers of one ISP to use their devices with any other ISP with whom an inter-provider business relationship exists [2, 3, 15].

Similarly, in the domain of cellular networks, a roaming capability has also been developed to enable customers of a particular MNO to use their devices with any other MNO with whom the original MNO had a roaming agreement [1]. In particular, two roaming cases have emerged: the first – consisting of an identity check and settlement procedure – occurs when the visited provider is abroad. The second – additionally involving mechanisms for inter-network seamless switch – occurs when it is in the same country as the home provider. This enabled MNOs to sell full national and international coverage without having to invest in building all of networks themselves.

The above cases show two different roaming situations (Figure 1): one where providers have no overlapping coverage areas (both fixed and wireless) at a location, and one where they do. In the first case, providers do not compete for the same user, while in the second one they do.

**Figure 1. Two cases of roaming**

Given the increasingly wide range of heterogeneous access technologies, we only consider the case where, in one location, many providers’ coverage areas exist.

Surprisingly – perhaps paradoxically – both computing and telecommunications industries have arrived at analogous definitions of roaming – the ability to use any one of many service providers (whether ISP, MNO or others), while maintaining a formal, customer-vendor relationship with just one – the home provider [1,2]. Based on this definition, various international bodies have and are continuing to specify types and scope of possible business relationships, where the roaming user is authenticated and authorized always at the home provider.

3. **DEFICIENCIES OF ROAMING**

This definition of roaming suffers from two major limitations - a fundamental tension between the topological aspects of roaming and service innovation, and an intrinsic absence of contractual mobility that forces users to rely on roaming agreements between providers.

This section illustrates implications of both issues and provides arguments supporting explicit contractual mobility as the underlying paradigm for roaming.

3.1 **The loss of competitive advantage**

Intrinsic to current roaming is that users have to be served by competitors of their home provider in order to experience seamless access and service. This requires services and service control functions to be homogenized across providers.

Nevertheless, user needs and technology evolve with time; and one traditional role of a competitive market is to ensure survival of those services that are the fittest in meeting such needs. As a result, simple topological aspects of current roaming – this service homogenization – are in pathological tension with service innovation.

In today’s world, service providers are realizing – as telecommunications operators did with the arrival of the Internet [14] – that the value of their commercial service propositions is changing locus. In recent times, value has moved from the ‘center’ to the ‘edge’ of the network. Now, with the arrival of seamless mobility, it moves from the ‘communication’ to the ‘business’ plane, where service providers hold business relationships with users and apply their tariffs to those in range.

Services have different values depending on how they are provided, the location, and the time of day; some may only have value if provided in a specific way required or desired by the user. Ultimately, their value is a function of the context in which they are delivered. This forced providers to look for technical and business solutions that accommodate such a requirement.

Their technical response is to cross-deploy services for roaming users, by incorporating control functions of one provider in adjacent providers’ systems. The resulting business approach is then to lock in users through high switching barriers, forcing them to use such services.

However, providers pay a very high price for this achievement. Whereas cross-deploying communications functions is necessary for mobile, seamless communications, cross-deploying functions for the control of business relationships with users (e.g. user authentication, authorization, accounting, metering,
charging, and profile storage functions) is not and, most importantly, introduces deficiencies that limit providers’ scope for service innovation.

Let us consider the case of a provider introducing an innovative new tariff. In virtue of roaming agreements, to apply such a tariff to roaming users, business control functions (e.g. accounting and metering) of adjacent providers must support the tariff. This creates mutual dependencies between control functions of different providers that break the novelty of the tariff.

This process of homogenization of business control functions across competitors culminates in the loss of any competitive advantage created through the introduction of innovations.

This pushes providers to federate in order to maintain competitive advantages (over other confederations). However, the creation of such clubs does not solve the fundamental problem. The local nature of certain wireless access systems (e.g. WLANs) for example makes it unlikely that each confederation will reach global coverage, hence creating the need to include further providers. And, as times change, new factors will create the need to extend the confederation.

If indiscriminately iterated, this process leads to a complete homogenization of providers and the subsequent crystallization of the market. Additionally, when the cost of building these homogenized services becomes higher than the prospective minimum revenue guaranteed from service itself, providers will face stagnation.

Realizing that providers require a method to maintain the competitive advantage of innovation, we assert that explicit contractual mobility responds to such a need. In the past, providers have discounted the possibility of users establishing explicit business relationships with visited providers while roaming. This would remove any inter-provider dependencies related to business control functions, allowing providers to innovate without having to share their innovations with others.

Users with contractual mobility stay with a provider because of its innovative services, rather than high switching barriers or inertia to change. For providers, this should have more value than an approach assuming to lock in users indefinitely.

Overall, users with contractual mobility bring advantage to the whole market, enabling providers to innovate and giving the incentives to do so. In addition, a system based on such a paradigm would see an increased pace of innovation compared to today’s.

3.2 The necessity of roaming agreements

Current access networks are primarily characterized by a horizontal communication model [16], where heterogeneous networks – both wireless and fixed – converge into a common platform that meets different service requirements and allows roaming users seamless access to services. To achieve this, interfaces and functions for seamless inter-provider roaming are being specified.

This convergence has fostered new business opportunities, but it has also accelerated the conflict of economic interests between players in traditionally separate industries. However, whereas technology systems typically show predictable behavior and evolution, market players do not.

Clark et al. [9] point out how the dynamic management of these evolving interests has historically been the essence of successful societies. These societies are structured around the ‘controlled tussle’, regulated by mechanisms such as laws, societal opinion and shared values. These mechanisms ensure that the tussle is not too strong – because that creates paralysis – and that it is not too weak – otherwise the size of the whole market would be smaller than its potential.

Similarly, we argue that the future of communications networks will increasingly be defined by tussles that arise among players with clashing interests.

In contrast with this, the industry opted for a definition of roaming that does not consider the unpredictability of the outcome of economic tussles.

Based on the obligatory use of roaming agreements, current roaming systems assume an intrinsic absence of contractual mobility, where only one roaming model is allowed – users have to rely on their home provider having roaming agreements with visited providers. Such a model does not allow users to change provider (i.e. tariff) when visiting a different network. As this has been encoded in designs and standards for roaming, a circumstantial model has become the only model.

Consequently, roaming that is neither flexible nor open enough to allow for variation results. The evidence is that the telecommunications industry is simply extending to all access systems the use of roaming agreements.

Developments, such as roaming exchanges, cope with the combinatorial explosion of inter-provider business relationships, but do not change the underlying definition.

Although valuable for facilitating the establishment of roaming for new providers, roaming agreements impede flexibility – which would offer improved user benefit – because they do not allow users any choice or verification of the control imposed by providers. As a result, the obligatory use of roaming agreements represents a barrier to user’s mobility, created by a perceived mutual self-interest between providers.

A roaming definition that would remove this limitation is one where users establish business relationships with visited providers in an ad hoc fashion, without having to rely on roaming agreements. This makes technology and business innovation more likely to increase
user’s demand. And more innovating providers lead to an increased overall market size.

4. CONTRACTUAL MOBILITY

In the light of the previous arguments, a roaming capability should neither force the homogenization of services, nor use of roaming agreements. Instead, it should be flexible, automated and neutral to any roaming model, to cope with the unpredictable outcome of economic tussles.

We suggest a definition based on explicit contractual mobility, where users are able to choose and use any one of multiple service providers, being able to establish ad hoc business relationships with them [10, 11].

An ad hoc business relationship between user and provider is established:

• on a per session basis,
• independently of inter-provider roaming agreements,
• and in an automated fashion.

Therefore, users willing to purchase a single communication session must be able to request the establishment of a business relationship just for the duration of a session. Whether or not to maintain many long-term business relationships or to re-establish a new short-term relationship each time is up to the user; the essence is that roaming systems have to support the establishment of relationships at the finest granularity, the session.

In addition, this establishment has to be accomplished on a one-to-one basis, so that the successful establishment of a business relationship does not depend on any factors outside the control of the user and visited provider. Hence, there are no third party dependencies (e.g. roaming agreements) that affect users’ roaming ability and scope.

And finally, these abilities have to be automated in order to simplify possibly complex tasks for users and ultimately overcome their inertia to undertake changes.

4.1 Contractual mobility in ad hoc networks

In the current economic downturn, many are addressing the need for technological innovation. In general, we would assert that any innovation-enabling mechanism is desirable, regardless of the market situation. Reed [18, 19] identifies the approach of ad hoc networking as a possible way to address this problem.

One essential element of contractual mobility is to allow for the establishment of ad hoc business relationships. This is therefore one example of how enabling a new roaming capability provided through contractual mobility could in this case enable users to be serviced by other users (instead of providers). The economic models applicable to ad hoc networking would be different from the traditional one, but the roaming systems, if based on contractual mobility, would be the same. This demonstrates the flexibility of contractual mobility in not embedding any model.

5. DESIGNING A BUSINESS PLANE

The functions that enable explicit contractual mobility identify a class of distributed systems providing operational support to the management of ad hoc business relationships between roaming users and providers. We refer to this class of systems as the business plane, an abstraction representing one way of structuring these functions and describing their properties.

The plane, sketched in Figure 2, provides for the following functions:

• Users are reachable by providers and other users even if they hold no business relationship with any service provider (reachability).
• Users are aware of all providers in range and their service offers (i.e. service descriptions and associated tariffs). Hence, a function for providers to distribute their offers to users in range is provided (offer dissemination).
• Users are able to automatically assess different service offers and select the one that best matches their preferences. Hence, a function is provided for the selection of service offers of providers in range against buying preferences and application requirements. This offer selection is available for both sender and receiver, so that payment for sessions can be apportioned differently depending on users preferences and providers’ constraints.
• Users are able to establish ad hoc business relationships with providers in range. This is accomplished through a number of functions:
  • The verification of the identity of roaming users (authentication). Such verification can be achieved on a one-to-one basis or possibly through intermediary parties.
  • The verification of users’ rights to use the desired service (authorization). Such verification can be achieved on a one-to-one basis or possibly through intermediary third parties.
  • The measurement of network resources utilized by users (accounting). The function allows the metering party to exchange accounting information with the charging party.

Note that ‘ad hoc networking’ and ‘ad hoc business relationships’ make a different use of the term ad hoc.

2 A detailed description of these functions is outside the scope of this paper; we refer to [11] for a more complete discussion.
The simultaneous management of many business relationships with different providers, without experiencing any switching barriers.

- Providers are able to remotely re-configure metering capabilities of adjacent providers’ systems in order to introduce innovative new tariffs and without having to publish the novelty of their tariff.

![Figure 2. Functions of the business plane](image)

5.1 Architectural properties

The business plane changes the traditional perception that users have of business relationships with providers. It in fact introduces a common policy interface acting as intermediary role between users and providers, whose task is to mediate their business relationships (Figure 3).

![Figure 3. Introducing an intermediary role](image)

On a per-session basis, this interface accepts requests from the user for the purchase of communication sessions (e.g. a multimedia call, a web browsing session). The request includes application and user requirements, so that the interface can select the best offer of providers in range. Then, it decides how to purchase the session. Depending on whether it already has a business relationship established with the chosen provider, the interface decides whether to establish a business relationship for the duration of a single session, many sessions, or whether a relationship already exists and therefore the purchase is implicitly agreed.

This modus operandi breaks the establishment of user-provider business relationships in two stages, intermediated by the policy interface; this allows users not to be any longer wedded to particular tariffs or service offers, but only to what they get and what they pay for and allows providers to choose their preferred commercial model to provide roaming.

A first implication is that the business plane is neutral to specific roaming models. The plane is not designed for a single model, but for a variety, so that changes do not break existing architectural hypothesis. Its functions ensure that roaming agreements are not the only way of providing roaming. Functions can in fact be arranged or used in many ways to create each time a different roaming model. The plane is hence intended to be a playing field for economic tussles, where existing and future commercial models will be realized, and the fittest will survive.

Although this proposal seems to herald far more intense competition in the market, these functions do not necessarily need to be commercially structured into an open roaming model. A second implication is in fact that providers can still realize a roaming model based on roaming agreements by arranging the functions of the business plane in a closed fashion. For example, a home provider can decide offer selection policies, constraining users to select providers with which the home one has a business relationship. Alternatively, it can choose whether applying its tariffs to users on visited networks, or let them have visited providers’ tariffs applied.

The essence is that building closed models from open parts allows these to be re-arranged later in different ways, as market and technology evolve. Open components, in fact, allow for different uses, ways of communicating with other systems, and re-combination. Hence, functions of the business plane can be re-combined both in closed and open models, depending on the outcome of economic tussles, fully realizing the potential of the market. The result is a system able to evolve as technology, economic circumstances and understanding change, without introducing any constraints or breaking architectural assumptions.

A third implication is that the business plane is user-centric because designed to empower users with control and choice: control because users can have direct control on the functions required to manage relationships with providers; and choice because users are able to express preferences about providers and relationships with them.

5.2 Why a plane?

The term plane is used to underline that the business aspects of networks should be separate from and orthogonal to communications aspects (related to the simple transfer of information from source to destination).

This design choice has two implications. First, it ensures that specific issues of one plane do not to interfere with those of the other one, and can be therefore solved independently from it. Second, if a separation between mechanism and policy of a function can be achieved, then policies of the business plane can run mechanisms of the
communications one. Therefore, communications mechanisms can allow business policies to determine some of their behaviors or configurations without being knowledgeable or even aware of the rules in the policies.

5.3 Standardization issues

When positioning the business plane in the context of existing standards developed by the telecommunications and computing industries (mainly through 3GPP and IETF), we realized that the roles of the two industries were conflicting. It is surprising – but retrospectively understandable – that both have solved the same problem, through analogous definitions of roaming, but different sets of systems.

Although the telecommunications industry had recognized roaming as a key requirement since the origins of cellular networks – the computer industry did it only more recently – the development of roaming is not solely an issue of cellular networks.

Instead, it is part of the whole packet-switched network interconnection work area. In fact, an important common link amongst many access systems is that they are all packet-switched networks. Except for the wireless nature of some of them, these networks are suitable for being interconnected using IP. Therefore, their interconnection requirements – including mobility and roaming – fall within the Internet architecture.

6. CONCLUSIONS

This paper argues that the current roaming definition is inadequate. The forced service homogenization across providers and the obligatory use of roaming agreements represent two serious limiting factors for the evolvability of services and the communications market.

Asserting that any new Internet architecture should consider a different definition, we suggest a requirement for explicit contractual mobility for roaming: users can explicitly establish ad hoc business relationships with providers on a per session basis, independently of roaming agreements, and in an automated fashion.

In explicitly separating out the communications elements of networks from those that support business functions, we also define a business plane. This is responsible for describing the distributed systems needed to provide users with contractual mobility. The component systems of the plane are designed to unlock the commercial environment for services. This provides a playing field for economic tussles, where existing and future commercial models can be realized, and the fittest will survive.

Having defined research scope [11] and architecture, and developed a prototype, we found that, although nothing was intractable, the task is complex. Other attempts to provide similar functions are the Personal Router [7], INDEX [4] and TDP [13] projects.

Unsurprisingly, we also found that the main issues are not technical, but commercial. Because of its strong business implications, explicit contractual mobility may be perceived by incumbents as disruptive to their short-term revenue targets. Open questions, such as why incumbents would allow contractual mobility, and why would they deploy capabilities not aimed at generating short-term revenues, are only partially answered and urge a convincing response from the scientific community.

7. REFERENCES