Community Building over Neighbourhood Wireless Mesh Networks

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Next generation networks. *Always Best Connected.* Heterogeneous Environments. All keywords for the long sought fourth generation (4G) network paradigm. However, as these trends are discussed in industry and academia, we are witnessing new trends in communications, where examples as the explosion of peer-to-peer applications, increased security and privacy concerns, community and social networks come easily to mind. These examples have all a common aspect: communications stem from the user, and its social life, and exploit user-owned resources: hardware, software and information.

This vision reflects the duality of human life: the egocentric activities of a social animal, where all actions are balanced between the immediate self-interest of the user, and its need for social contacts – the gap bridge by communications.

This paper addresses a user-centric vision for future 4G networks. Users poll their resources to build communities, promoted by self–and common–interest. In this context, users will be responsible for both the creation of the communication network and for the service provision on top of it, bringing to the community not only their human presence, but also their computing and networking capabilities, leading to a “social image” of the user. In this article, we highlight and exploit this fact in order to provide social incentives that will encourage users to share their resources and cooperate.

The participation of users at these different layers (physical, access, network, application) leads to a conceptually complicated game theory problem. Traditional incentive mechanisms, treating users as rational economic agents, are impractical both in terms of theoretical analysis and implementation. By relying on neighbourhood on-line communities, the required social environment for the proposed incentives to be effective is in place, and can be efficiently deployed. In such a dynamic wireless environment, self-organizing wireless mesh networks...
(WMN) could play a decisive role towards the user-centric vision on 4G ubiquitous access, exploiting the large amount of unutilized connectivity between users’ access points. Social relations will encourage users to participate in the formation of the envisioned neighbourhood WMN, and will generate the necessary information to ensure that the underlying network is formed among trusted (and interested) users, sharing resources, content or Internet connectivity, and support mobile applications.

In this article, we argue that the support of neighbourhood online communities is both an objective to strengthen the social capital between people living in the same neighbourhood (and close the gap between virtual and physical communities) and a driving force towards the creation of neighbourhood self-organizing WMN. Our goal is to provide some basic principles and directions for their design. In the first two sections we discuss wireless mesh network initiatives and demonstrate the need for end-users to cooperate at all layers of the corresponding system architecture. In Section 3 we review incentive mechanisms proposed in the literature for each of these layers. Then, in Sections 4 and 5 we analyze in depth the role of neighbouring communities in motivating users to participate and ensuring a secure and trustworthy network creation respectively. In Section 6 we propose a “cross-layer” approach to provide the necessary incentives for resource sharing. Finally, in section 7 we draw our main conclusions.

1. The technology – user rules!

4G networks will provide a converged environment for technology and service provision. Wireless communications are an essential aspect of this environment. From the user point of view, this is specially encouraged by the low cost of the 802.x standards. The IEEE 802.11 standards family (known as Wi-Fi) and the corresponding equipment are now common in households, due to their very attractive characteristics in terms of cost, capacity, and ease of deployment and use. The upcoming 802.16 (WiMax) promises to follow a similar path, at the same time that 802.11 also promises higher bandwidths and coverage.

Over the last years, different initiatives have been trying to exploit the advances of WiFi technology to offer ubiquitous Internet access, mostly under the form of wireless hotspots - free or commercial. Aggregators (such as Boingo) allow their customers to have access to a large number of hotspots all over the world, increasing their overall value. This approach relies on wired access through the users household, and on centralized company control, increasing access costs, and withdrawing control from the users. Interestingly, wireless mesh networks provide an attractive means to reduce costs, since only some of the wireless routers that form the network must have a direct connection to the Internet. Both university projects (e.g. MIT’s Roofnet, Rice University’s TAP) or town initiatives (e.g. Athens Wireless, Paris Sansfil, etc.) have started along these lines, building city-wide WMN with directional antennas (wireless backhaul networks) offering added value services and/or free Internet access. Other municipalities (e.g. Philadelphia, San Francisco, and more) have also started with the deployment of “WiFi blankets” (Municipality WiFi), but there is growing criticism as to what extend this is a feasible scenario for the moment, both economically and technically.

Nevertheless, such wireless infrastructures can provide connectivity with significantly less cost than wired solutions in many cases (e.g. in remote and secluded areas, like small islands or mountains).

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1 See for example http://news.com.com/Cities+deploying+Wi-Fi+face+challenges/2100-7351_3-6066746.html.
This cost issue is not a major factor when exploiting user-owned infrastructure, i.e. the already available home users’ wireless access points, most of them already associated with broadband connections. Interestingly, there are both research and commercial efforts made towards enabling peer-to-peer communities of users sharing Internet access through their wireless access points for mobile use [1][2]. Moreover, the existence of numerous wireless access points in urban areas has brought closer the wider vision of Nicholas Negroponte, five years ago, for a “WiFi ‘lily pads and frogs’ broadband system, built by people for the people”[3], neighbourhood self-organizing WMN, according to Microsoft [4]. That is, in addition to providing a wireless (one-hop) link towards the Internet users can form wireless mesh networks with their wireless access points in dense environments, which could further facilitate people’s access to the Internet (playing the role of a wireless backhaul network). However, this is not their only potential value: among many others, they could also provide additional network capacity (e.g. for content distribution or games), enable the sharing of other resources such as storage (e.g. for backup services) and content (file sharing or caching), support social and collaborative applications strengthening the physical neighbourhood communities, and offer services to mobile users and/or peer-to-peer applications.

The interest in forming a neighbourhood wireless network can depend on the expansion of the wired Internet. If the wired Internet is available everywhere and non-congested, users might not have an obvious incentive to participate in a wireless architecture, since even “neighbourhood-oriented” services could be supported through the Internet (e.g. [5]). Nevertheless, even in this extreme case, neighbourhood WMN have a specific value, obviously related to privacy and trust issues, but other psychological factors are relevant. We will return to this point later in Section 4.

Finally, WMN deployment can be seen as an intermediate step towards more general ad-hoc, user-centric (including mobile users) environments. As members of a community live in the same neighbourhood, the level of trust could be considered high –even without having to meet physically. Moreover, investment on this collaborative communication can be considered worthwhile, since users always remain in their vicinity. In this context, neighbourhood WMN could play an additional role towards the 4G vision [6] by making people experience and exploit this type of communication.

An important differentiating feature of neighbourhood WMN compared to the wired Internet is the need for users to actually contribute to their creation and operation. This means that, – explicit or implicit– incentives should be in place in order for them to participate and contribute their resources, not only for the formation and efficient operation of the network, but also for the successful deployment of the applications that will run on top of it. Notice that the problem of cooperation is very similar in the case of mobile ad-hoc networks. The main difference in our case is that the conditions are suitable for the creation of on-line communities thanks to the geographical proximity, implicit social relations, and reduced costs (due to the lack of constraints on battery consumption).

2. The need for cooperation at different layers

In our vision, a user participating in a neighbourhood WMN is a “node” at different layers of the system architecture (physical, access, network, application, and social), as depicted in
Figure 1. Suitable incentives for cooperation should be provided at all these layers to guarantee the efficient operation of the system.

At the physical and network layers, terminals are usually assumed to comply with a predetermined protocol which prevents them from antagonizing and pursuing their own benefit in an autonomic fashion. In certain cases though, the interaction has a game theoretic nature and desirable behaviours emerge in the context of an antagonistic framework [7][8]. Power control is such an example. If energy consumption is not an issue (as in our case), then it is hard to discourage the terminals to use the maximum transmission power as they seek better link quality and more bandwidth, in which case they may diminish bit rates because of excessive interference. Another example is the inter-frame gap time between packet transmissions in WiFi. Nodes that do not use the specified minimum time (but a smaller one) could achieve higher rates at the expense of users who follow the protocol. In these cases, selfish behaviour will lead, to degraded overall network performance, at the benefit of a single user. Incentives are required for promoting adequate user behaviour. Although traditionally this relies on technology hardware constrains, as increasingly complex transmission mechanisms are considered for wireless communications, with more and more configuration possibilities (such as software defined radio, link-layer security, or opportunistic radio), the need for explicit cooperation (and thus incentives) at the physical layer becomes essential.

Figure 1: The different layers of required user cooperation

At the network layer there is an even clearer need for explicitly agreed cooperation, and for incentives to promote this. In a WMN, users’ available bandwidth will be reduced if they forward packets belonging to other nodes. This is a traditional problem in mobile ad-hoc networks (facing stringent resource constrains), and led to a significant research work regarding the provision of suitable and trustable incentives for cooperation (e.g. [9][10][11] among many others).
At another level, when users participate in a peer-to-peer application (such as file sharing, backup services, or grid computing) they will need to contribute additional resources (e.g. content, storage, CPU cycles, etc). But, ideally, they would prefer “free riding” on the contributions of their peers by consuming available resources and services without contributing anything themselves and thus avoiding the corresponding costs [12]. Similar issues hold even in the case of on-line communities where users’ active participation is of critical importance; in this context “lurking” is the term used to describe users that consume information but do not contribute.

Finally, additional incentive issues arise when users should contribute themselves to the implementation of the required management functionality at different layers (e.g. build routing tables and reply to service queries). Clearly, the need to take into account all these different decisions and potential selfish strategies makes the design of suitable incentive mechanisms in a neighbourhood wireless community a very challenging task. Moreover, relying on the limited skills of normal users concerning the tampering of software or even hardware is not safe, since hacked versions could be made easily available in the Internet and be used without main requirements (e.g. kazaa hack, “fast” browsers). This means that, even if a “protocol” was defined and implemented in the corresponding software (e.g. in the case of power control), incentives to steer people to follow this protocol would still be necessary.

### 3. Incentive mechanisms and the human perspective

One way of defining an incentive mechanism is to consider it as a system rule, whose goal is to influence participating agents to behave in a certain manner, by rewarding (or punishing) them according to their actions. For example, in a traditional market, a price is a monetary reward for production and a punishment (a charge) for consumption. The designer’s task is to decide on the mechanism to compute and set “prices” in order to reach a specific goal.

The two most common objectives considered in economics are social welfare maximization (also called economic efficiency) and fairness. The social welfare maximization approach considers two, in general private, user metrics (namely utility and cost for consuming and contributing resources, respectively). It aims at maximizing the total utility minus the total cost, assuming participation is rational (i.e. agents seek to maximize their own benefit: their utility minus their cost). On the other hand, the fairness approach treats all agents in the same way either by principle, or by acknowledging the inability to convey more information. Although the choice between these two objectives is controversial across several disciplines such as political philosophy, sociology, and economics, the selection of an approach rather than another is not always due to economic considerations. The complexity of computing optimal prices in many economic problems and/or obtaining the required information, the difficulty of implementing micro-payments in a distributed system and the mental burden that they may require from the user, are some of the reasons why pricing mechanisms proposed in the literature for addressing many of the aforementioned problems [11][9][2] are not implemented in practice despite their nice theoretical properties.

As a result, alternative solutions [12] are usually favoured, such as simple fixed contributions [2] or reciprocity, which treat all users as equals. For example, reciprocity dictates that all users should contribute the same amount of resources they consume. But although this is a theoretically simple incentive mechanism, its enforcement is not trivial in a distributed
environment, since it requires the existence of some kind of virtual currency, except in few cases where a direct exchange of resources is possible (e.g. BitTorrent). Nevertheless, it still puts a significant mental burden on users, and can discourage altruistic behaviour, which seems to play an important role in the context of p2p applications.

Acknowledging the above issues, reputation mechanisms [14], originally introduced in distributed marketplaces (such as eBay), have been considered promising incentive mechanisms in the context of all types of p2p applications providing a more qualitative (than quantitative) way to reward/punish good and bad behaviour. More specifically, a user’s reputation could be seen as a way to aggregate his past behaviour into a single value. This value is in general a function of the individual users’ ratings based on the corresponding user’s observed behaviour. Then rewarding users with high reputation (e.g. giving them priority) and/or punishing those with low reputation (e.g. denying service to those below a specific threshold) would ideally the suitable incentives for users to maintain high values of reputation and thus behave correctly. However, the “freedom” offered by this approach in terms of rewards and punishments makes it difficult to evaluate formally the outcome of a specific mechanism, since there is currently no final theoretical framework for their analysis. The complexity of the problem may explain why a plethora of reputation mechanisms have been proposed for several incentive strategies [15].

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Incentives</th>
<th>Users’ decisions</th>
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<tbody>
<tr>
<td>Pricing</td>
<td>Charges/payments for consumption/contribution</td>
<td>Level of consumption and/or contribution</td>
</tr>
<tr>
<td>Entry fees</td>
<td>Fixed contribution, fair resource allocation</td>
<td>Participate or not</td>
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<tr>
<td>Reciprocity</td>
<td>Consumption=contribution</td>
<td>Level of consumption</td>
</tr>
<tr>
<td>Reputation</td>
<td>Resource allocation based on past behaviour</td>
<td>Level of contribution - Quality of Experience</td>
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Table 1: Incentive mechanisms for resource provisioning

An important dimension to the problem is the reliability of the reputation values: these values have to be computed correctly (i.e. based on truthful ratings). This is particularly critical when users may easily create a new identity/pseudonym and when information regarding the effort exerted by a user as a function of the outcome of a transaction is hidden. So, the fact that users are treated both as selfish agents who wish to maximize their net benefit and as in charge for sustaining collaboration (having to rate other peers and rewarding/punishing peers according to the rules of the reputation mechanism) create complex theoretical games.

The mechanisms above (summarized in Table 1 above) assume that humans behave rationally, which is actually highly debatable. There are many cases where people seem to actually contribute “for free” (e.g. in p2p file sharing applications some peers provide a huge amount of content although no explicit incentive mechanisms exist), or at least, their reward is not apparent if considering only typical economic assets. The main motivation for such an

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E.g. in an ad-hoc network, when a packet does not reach its destination it is not straightforward for the sender to decide which intermediate node was responsible for this failure.
“altruistic” behaviour relies on more subtle rewards. Four main social motivations are mentioned in the literature [16]: community spirit, feeling of influence and/or importance, social status, and shared emotional connections. However, they cannot be provided explicitly and most importantly they require a social environment—a community—in order to be generated and assessed. In reality, they directly reflect social aspects of humankind: the way people interact with each other and create relationships, how they represent themselves, the feedback they receive concerning their popularity and activity, the elasticity in deciding which part of their activity is public or private.

We propose the provision of such social incentive mechanisms in order to encourage people to share resources and services. The stronger the community ties, the less “strict” the corresponding incentive mechanisms need to be at the resource level. This is the cornerstone of our neighbourhood WMN concept. And in cases where the community as such is not enough for discouraging selfish behaviour, its existence would still create a suitable environment for providing additional social rewards related explicitly to resource sharing (see Section 6), fundamentally “cross-layer” incentive mechanisms. All the discussions above concerned a single “cooperation layer”, but the concepts could be implemented across the multiple views in Figure 1. Before analyzing in more depth this cross-layer approach we start by proposing some basic characteristics of communities (and a corresponding network creation procedure) that we believe will play an important role for the bootstrapping of the system.

4. User participation

In user-centric environments, all the services that are to be offered (including the network) rely on the contribution of infrastructure and resources from the users themselves, which will therefore expect a clear benefit from their participation. In the following, we analyze the basic features this kind of community environments should exploit, starting from those that are less dependent on the future evolution of telecommunications.

The most important differentiating characteristic of wireless neighbourhood communities, when compared with Internet communities, is the de facto physical proximity between participants. This is a property exploitable by applications; in the case of social applications for example, physical proximity adds value to the potential acquaintances thanks to the ability to transfer them into the real world as well, but also thanks to the increased level of trust and intimacy between people living in the same neighbourhood.

However, trust is not obviously granted even for people living in the same neighbourhood and privacy issues still exist. We could say that privacy is related to the reluctance to disclose personal information to strangers, and trust to the reluctance to interact with them (either because of disagreements with their actions or because of the perceived level of their commitment). These same issues also exist in mobile ad-hoc networks where they are much more restrictive due to the dynamicity of the relationships formed. On the other hand, the more permanent relations on a neighbourhood WMN, makes any privacy disclosure much more critical than on transient mobile environments.

Neighbourhood WMN provide a more realistic framework for the deployment of reputation-based mechanisms since relations are long-lived (compared to the highly dynamic nature of ad-hoc networks where it is not easy to build trust—“there is not enough time”). The
potentially available location information could further assist towards strengthening the notion of identity and thus increase the level of trust and making reputation mechanisms less vulnerable to whitewashing and sybil attacks [17][18]. Additionally, there is an existing social context (e.g. in our environment people could know each other from real life or through physical meetings arranged through the on-line neighbourhood communities built).

In the context of on-line community applications, two different concerns exist regarding privacy: personal information stored in central databases of companies vs. personal information travelling “in the air”. While it is not easy to be protected from the former, for the latter it is always possible to use secured communications with trusted people (see next section). WMN nevertheless do not require central databases, since the infrastructure self-organizes in a distributed manner.

Besides the practical benefits of self-organization, the neighbourhood WMN approach could also offer an important psychological advantage compared to centrally-managed solutions since it could be seen as a “natural” extension of everyday social interactions, retaining the feeling of independence. In addition to its psychological effect this independence could also be materialized in the design of the communities itself. In particular, users have the ability to configure the community forming and management functionality to suit their own needs providing them the required level of control and increasing this way the overall generated value and satisfaction. Moreover, since the users of a neighbourhood WMN are themselves responsible for all layers of communication, they are capable of implementing effective and cost-efficient solutions to various challenging networking problems such as security support, spectrum management, or mobility. In this later case, for example, users could enjoy free mobile access inside their community network (and all corresponding provided services, e.g. Internet access), which could be an important incentive for them to participate and support its operation: while in his neighbourhood, the user would be “always best connected”.

In addition to the above general characteristics a number of specific services and/or applications can provide additional motivations to people to participate. These could be categorized as follows:

- Real life neighbourhood activities (e.g. decision making, organizational activities, announcements, etc.)
- Socializing, neighbourhood games.
- P2p resource sharing (e.g. camera-view sharing, content, etc.)
- Information/expertise sharing
- Security support, with a digitally safe-environment, able to supervise both the digital and the geographic neighbourhood.

Finally, we should stress that building communities over a neighbourhood WMN could be seen also as a goal for 4G networking (rather than the means) since the value they provide may be significant (especially nowadays where virtual interactions have started threatening the physical and social ones): the fact that the communities will be supported by users themselves should be exploited in order to strengthen their relationships and the community spirit rather than be seen only as a vision that could be reached by using incentive mechanisms.
5. Network creation

Once users have decided to participate in our communities, they will have to actually follow the agreed community rules (known as doctrine [19]), including media access and network setup. This will establish the communication between community members. That is, they should create links with their neighbouring nodes and define their “next-hops” to forward queries or to reach specific destinations. Of course, in this context the notion of a link is artificial due to the broadcast nature of the medium; the creation of these links actually corresponds to an agreement between involved parties to use the same media access rules and participate on the same network.

Typically, we expect routing tables to be created automatically according to network performance criteria. However, users might sometimes be reluctant to allow any link to be formed mainly because of associated costs and/or trust issues. As a consequence, we propose mechanisms to build the required trust at the community level, and from here the system will automatically handle the required interactions at the network layer to set the “already trusted” community members as a network on itself.

We could say that a community is characterized by its doctrine, consisting of the collection of all different possible member roles, membership rules and requirements, incentive mechanisms, and privacy or security parameters. In this case, when network creation is treated as an inherent part of a community’s activity, the creation of a link corresponds to a community “join” and is subject to the doctrine set by each community (e.g. certain communities could define “physical” limits or a minimum amount of resource contribution or require an invitation from a member, etc.). Additionally, such links could belong to different types (e.g. “testing”, “trusted”, etc.) and have a differentiated treatment according to personal ratings in the community (see Figure 2). Different treatments could correspond to different levels of trust (enforced through the exchange of cryptographic keys), different behaviour in case of congestion (i.e. priority given to the more trusted ones) or in terms of propagation of service queries. Note also the physical proximity and long-lived relationships imply users need to rely in each other, and punishments as “node isolation” will be quite effective.

It will be beneficial for users to be part of trusted links, and the cross-layer approach to incentives will promote also appropriate behaviour at the higher levels. Moreover, this approach would ensure the maximum possible connectivity without making sacrifices in terms of trust, and could additionally provide the suitable incentives for users to behave according to the community doctrine at the social level. Thus, under this community-aware network creation, a “zero level” community would be implicitly created with some standard functionality: allow users to access available communities, and freely create their sub-communities (in the same way flickr and myspace, for example, enable users to create their own groups with their specific participation and operation rules).
Figure 2: Different types of links depending on level of trust

The overall network created would finally be a WMN. This can potentially lead to distributed or hierarchical solutions (based on the concept of super-peers [20]), depending on the environment. In some cases (e.g. wireless access points provided by a municipality), the use of some centrally managed elements could even be assumed. Hierarchical solutions (which require some users to play the role of super-peer) are particularly attractive, since they simplify community management. Many users would wish to play this role mainly due to social visibility. In this sense, providing explicit social incentives to these users will be enough, regardless of the increased costs to support the community’s operation. Furthermore, super-peers will also have a broader view on the network’s operation, higher resilience to network events, faster information retrieval and higher potential of finding better services and resources.

6. Cooperation and resource provisioning

We will now provide some insights on how to link the social activity of users together with the required cooperation and resource provisioning at the lower layers (the main interactions between the different layers are summarized in Figure 3). Note that unlike human societies, in the Internet, social interactions are restricted by the human-computer interface. To this end, there has been extensive research in the field of Computer Supported Cooperative Work (CSCW), where recently the term social software has become established (extending the scope from collaborative work environments to more general communities) and many successful on-line communities owe their success to clever details incorporated in their software to reward cooperative behaviour (see [21] and references therein).
Notably, what is new in our context is the underlying network in which users participate with their own devices, their natural ability to self-organize, and the de facto proximity between them. The characteristics of this new environment can be exploited and incorporated in the system built to support the envisioned neighbourhood communities. Our goal here is not to propose specific solutions, as critical details depend on particular social contexts. However, we address the means for the different communities to define their own doctrines and try to capture the most important rules of such doctrines.

**Physical and access layer**

For this layer we propose to encode the desirable cooperative behaviour into the design of the corresponding protocols, but configurable by the community doctrine (the . In this case, deviation from these protocols will be detected by the neighbouring nodes and considered as misbehaviour; these users should be punished through an appropriate change of the status of the corresponding links as described above.

In addition, specific social punishments could be used to further discourage misbehaviour. Such punishments can harm explicitly one’s social image (e.g. by means of a “black list” visible to everybody, warning messages, or even a dishonourable characterization). Alternatively, they could affect his privileges and/or position in the community (e.g. limit his ability to browse the complete graph of his social network).

**Network layer**

At the network layer, the principal service is packet forwarding. Reciprocity mechanisms seem to require users to serve the same amount of traffic as the one they inserted in the network. However, users have incomplete information concerning the nodes which forward their packets more than one hop away, which makes the enforcement of such a mechanism difficult to implement. Another problem with this approach is that nodes at the edge of the network will not be able to accumulate the necessary “credit” in order to satisfy their needs.

A cross-layer approach can give chances to these edge nodes to provide other kind of services in exchange, belonging possibly to different layers. So, a user’s contributions at the application layer can provide him with network services, like packet forwarding or connectivity (e.g. when mobile) or the opposite, a user’s contributions at the network layer can give him priority and good quality for an application layer service.

Similarly with the case of physical and access layer, an alternative approach is to give social incentives but in this case it is important for such incentives to be positive rather than negative since we wish to encourage resource sharing rather than detect and punish misbehaviour. Notably, this choice of perspective could play an important psychological role [22].

So, concerning mesh infrastructure investments, users should be rewarded (instead of punished) according to their contribution in terms of social image and position in the community. But this is not necessarily correlated with its resource contributions at the network layer. This means that users should have a distinct status or reputation related to their behaviour at the network layer. To this end, we propose the introduction of a new type of social relationship “my network neighbour” (and “my neighbourhood community”) which will be valid only between physically connected users, and required for network setup. Then
additional incentives concerning the per-usage contributions could be applied in the context of these communities.

Figure 3: Cross-layer incentive mechanisms

**Application layer**

Depending on the application, users could exchange all types of resources (from storage space to Internet access) and, as at the network layer, resource provisioning should be treated as a positive act. So, similar mechanisms should be used with the only difference that now the interactions are not limited by the network topology (but they depend on it).

In this case, specific solutions are even more dependent on the specific environment and the corresponding resources entailed. As a result, freedom should be given to communities to self-organize and configure the corresponding mechanisms to suit their own needs.

**Social layer**

At the social layer, all standard mechanisms discussed in the context of social software [21] apply. But, additionally, one should exploit the specific environment in order to further increase their effectiveness. To this end, the ability of users to physically meet should be taken into account and possibly formalized in the software design (e.g. provide the means to set rendezvous points, account for the participants, reward users based on their participation, etc.). This ability should be also exploited to promote socializing which is particularly attractive in this context (e.g. socializing games exploiting the actually physical topology as for example random walks from people’s apartments)

Additionally, the fact that people may exchange different types of resources as proposed above should be incorporated into the community’s interface and social interactions. This fact
could further strengthen the community spirit creating feelings of solidarity and independence towards the wired Internet infrastructure.

7. Conclusions

Communities are an increased guiding line for future networks. Their social nature reflects human communication needs, and seem particularly adequate as a basis for future user-centric communications, based on wireless technologies. In this context, communities span from the physical layer until the higher social layers, reflecting human interests, and creating self-organizing wireless mesh networks (WMN).

Social relations will encourage users to participate in the formation of the envisioned neighbourhood WMN, and will generate the necessary information to ensure that the underlying network is formed among trusted (and interested) users, sharing resources, content or Internet connectivity, and support mobile applications. For this end, cross-layer incentive mechanisms are nevertheless required, using either reward or punishment strategies at different levels, reflecting the current user (node) behaviour towards the community.

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9. References


