Enabling Coalition-Based Community Networking*

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Abstract: Recent advances in local-area networking capabilities have enabled the emergence of a new class of community-based edge networks. These involve the direct interconnection of machines or local networks between community members. However, such interconnection, or peering, is usually carried out by individuals on an ad hoc basis and requires a level of expertise to configure and maintain. We present a new architectural element for such community-area networks — the *Coalition Peering Domain* — and show why it is needed to better utilise available resources.

1 Introduction

We present here a new architectural element for community-based edge networks; one that involves distributed, collaborative, efforts to share all available resources. It applies to a newly emerging class of community-area networks [1, 2] — where individuals connect together directly, their home and personal-area networks/devices, on an ad hoc basis, forming a local neighbourhood *mesh* or *community network*.

However, there are no rules to facilitate the formation of these community-area networks. Each peering agreement between pairs of community members is unique. We propose that some structure should be added to the ad hoc peering agreements, in a way that encourages collaboration while maintaining local control in a dynamic manner. This is achieved through the formation of a ***Coalition Peering Domain*** wherein there is collaboration between individuals for joint action or mutual benefit.

2 Motivation

Community-area networks have begun to emerge as a result of a growing disparity between data rates available in the wide-area and in the local-area. Although advances in Internet and wide-area technologies have had a great impact on connectivity both for the home user and for the mobile user, their data rates still fall well short of the ever increasing data rates possible in the local-area. Advancing user applications and increasing user expectations have aided to further accentuate this disparity. Meanwhile the increasing availability and the decreasing costs of local-area networking consumer equipment have enabled better support for easy interconnectivity. So, not only do such community-area networking initiatives already exist, but they are likely to stay and continue to grow.

The resulting community networks are essentially multi-homed, with many ingress/egress links from/to the wide-area. Administrative responsibility is distributed across the community, thus they do not represent a single Administrative Domain (AD) that is under the control of a single organisation or entity, but rather a *collaborative* group of such entities. However, the nature of existing ad hoc peering agreements require some form of private, static, addressing and tunneling to be configured placing the burden on individuals and requiring them to have the necessary level of expertise to configure and maintain them. Additionally, although existing mechanisms for addressing and routing are employed by individuals to administer their peering agreements, such mechanisms do not provide an optimal solution. These mechanisms are designed to operate

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best in network environments where administrative responsibility is not distributed. Therefore, they either use a single node as an ingress/egress point for the entire network, thus creating a performance bottleneck and representing a single point of failure; or employ single path source–to–destination routing, thus leaving much of the higher *potential* wide-area data rate unutilised and causing load balancing problems if multiple paths depend on a single node.

There is an opportunity for all community members to benefit from this higher common or aggregated wide-area data rate. This can be achieved by using the local-area connectivity between them as a 'backplane' to distribute traffic across all wide-area links. This is an example where individuals could collaborate for mutual benefit.

3 The Coalition Peering Domain

Figure 1 illustrates a number of collaborative efforts or 'local peering agreements' between pairs of community members. These peerings may be either as simple as links interconnecting different pairs of community members, or more complicated associations controlled through policy defined locally by the community members. As the numbers of such local peering agreements begin to increase and overlap, we can refer to a *coalition* within the community and the formation of a *Coalition Peering Domain (CPD)*.

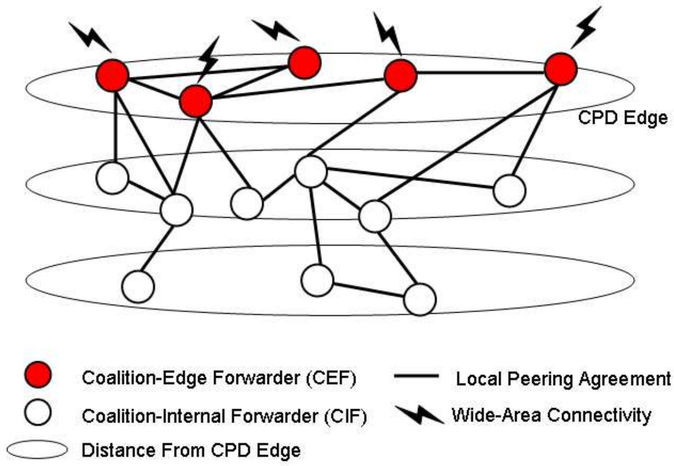

Figure 1: CPD Architecture

Each Coalition Member (CM) may represent an individual with either a single node, or a local network. Coalition members who have wide-area connectivity (or more generically, connectivity outside the CPD) form together the edge of the CPD and act as *Coalition-Edge Forwarders (CEFs)*; they are the CPD ingress–egress points, allocating some proportion of their external connectivity for this purpose. In the simplest case they may forward outgoing packets on their CPD-egress link. However, in a more interesting case they may forward some of these outgoing packets by 'spraying' (distributing) them, across the CPD edge, via their CPD-internal interfaces to other member CEFs within range, who then forward the packets outside the CPD. Thus outgoing traffic is distributed across multiple CEFs, so enabling a higher upstream data rate by aggregating multiple CM egress links. This approach is useful when the local capacity between a number of CMs is greater than or equal to their individual egress capacity to a common remote entity (e.g. the Internet).

Coalition members who do not have connectivity outside the CPD, or who choose not to make available their wide-area capability to other CMs, act as *Coalition-Internal Forwarders (CIFs)*. The forwarding of CPD-internal traffic (that traversing between CMs) may be performed using modified forms of standard inter-domain or ad hoc routing protocols as agreed within the CPD. However, CIFs forward CPD-outbound traffic by directing it towards their 'nearest' CEF for CPD egress. This traffic can be sprayed across the CPD edge by the receiving CEF as described above. Of course, CIFs may also use mechanisms for load balancing and take responsibility for spraying directly to multiple CEFs, depending on the physical connectivity of the CPD.

In this context, coalition members represent a reasonably static group that form peering agreements between each other. It is also possible for such connectivity to be extended to non-coalition members, for example, mobile/roaming nodes. These may peer dynamically with a CIF or directly with a CEF as they pass within radio range.

4 Challenges

4.1 Why not use Existing Routing Mechanisms?

As administrative responsibility is distributed across the CPD, the use of existing EBGP mechanisms [3] would require that each CM be allocated an Autonomous System (AS) number, that each CM be responsible for the correct set-up and configuration of relevant BGP routing and policy, and that each CM be able to maintain and update such configuration as CPD membership evolves. This requires a level of knowledge and expertise that may not be available to all CMs wishing to form a CPD (especially within a neighbourhood community environment). It requires also that the equipment available to the CPD is capable of supporting the relevant protocol and policy systems; this may be infeasible within resource-poor mobile or personal-area network environments. Additionally, by allocating each CM an AS number, the quantity of AS numbers and sets of routing entries grows very quickly even with small-sized CPDs. For example, a single CPD with five CMs will have five sets of routing entries. Another CPD of equal size will have also another five sets of routing entries. So the number of routing entries would grow very quickly and put back-pressure on routing within the core network.

Traditional intra-domain ad hoc routing mechanisms [4] have focused on finding the single most efficient route on a source–to–destination basis where the destination may be either inside or outside the local domain or ad hoc network. This models the domains or ad hoc networks as single ADs that are either disconnected, or direct extensions of a larger infrastructure. This in turn requires them either to discover efficient routes to a very wide set of destinations, or to route towards specific designated domain or network gateways. However, the coalition-based approach focuses on finding a route only to the *edge* of the CPD, after which routing may be distributed across the CPD edge.

4.2 Impact on Existing Infrastructure

Although the CPD architecture provides a means to enable easier collaboration between individual owners of nodes or local networks, while maintaining local control, it is still disruptive to the existing architecture and service provision models. Multi-path routing will have implications for higher layer protocols that rely on the underlying routing infrastructure. Traffic may arrive at its destination with some delay or in an unordered fashion thus causing problems for delay-intolerant applications.

Even though traffic destined for a specific remote destination may be sprayed across the CPD edge, the reverse path still relies on standard routing. This means that individual CEFs may be burdened with a greater volume of return path CPD-ingress traffic. However, the asymmetry of most wide-area connectivity technologies may be sufficient to offset this inequality. Alternatively, the burden for reverse spraying may be placed on either the remote party, or a provider-controlled device located beyond the CPD edge.

CMs need also some mechanism to communicate with each other once they have formed local peering agreements. This implies that some form of addressing scheme should be employed within a CPD. However, addressing is a centralised function that would, in this context, need to be applied to a distributed system. This is a non-trivial task and needs careful consideration.

The formation of local peering agreements between two parties implies a sufficient level of trust between them to reach an agreement in the first place. However, CPDs may depend also on the existence of an independent trust mechanism capable of Authentication, Authorisation and

Accounting, including functions such as the validation of identity, control of local resources, membership and policy negotiation, auditing of activity, and the provision of feedback for trust evaluation.

5 Applications Beyond the Neighbourhood Context

There are a number of applications and scenarios that may benefit from the CPD architecture presented here. The multi-homed nature of the CPD architecture may be especially useful for networks that require a high degree of robustness or survivability in connectivity to the wide-area. Assuming that a CPD is formed with multiple CEFs, should one CEF fail or become disconnected from the wide-area, the CPD as a whole still maintains some wide-area connectivity.

Scenarios involving the co-ordination of evacuations in an emergency, and scenarios involving the co-ordination of aid and relief efforts following a natural disaster are both examples of situations in which a diverse set of devices and communications technologies may be used. The available device resources and connectivity capabilities may be quite limited in some cases. Such scenarios may benefit greatly from the formation of a CPD for the purpose of wide-area connectivity aggregation, allowing better utilisation of the available connectivity to the wide-area.

In fact the formation of a CPD for the purpose of connectivity aggregation can be useful in any scenario where there is some degree of heterogeneity in the available wide-area connectivity, and where the data rates of local-area connectivity exceed individual wide-area data rates.

6 Summary

The formation of community networks is a growing trend. It has been particularly aided by recent advances in local-area network technologies, making them much more affordable and easily available. We have presented an architectural element that would enable groups or communities of individuals to better utilise their wide-area connectivity resources, through collaboration, by using the local-area connectivity between them. This is achieved by adding structure, the **Coalition Peering Domain**, to the otherwise ad hoc community inter-networks residing at the edge of the Internet. The idea proposed may be attractive to both fixed local communities, and groups of individuals willing to collaborate in a long-lived mobile environment (e.g. a meeting room or a train journey).

In conclusion, we take the position that a coalition-based approach would enable individuals to share connectivity resources in a controlled manner, but there are a number of technical challenges that should be researched further.

Acknowledgements

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References

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