Mobility Management and Traffic Engineering Support in MPLS-LTE Networks

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Summary
Mobile IP presents some deficiencies over dynamic mobile environment. For this reason, extending the MPLS capabilities to wireless access networks has gained many researchers interests now days. Some researches in network resource management have been devoted to provide bandwidth guarantees and prevent network congestion. However, most of them rely on load balancing to avoid network bottlenecks, tailoring on the other hand longer and costly paths. They ignore that longer paths can badly affect on both quality of routing, and usage efficiency of their network infrastructure. This paper presents a new Routing Algorithm for mobile MPLS traffic engineering. The approach is an improvement of the well-known bandwidth constrained routing algorithms since it compromises between network load balancing, reducing path length, and minimizing path cost. Our proposed TE (Traffic Engineering) algorithm has been evaluated. Simulation results show that it outperforms the most recent algorithms under a wide range of workload, topology and system parameters. Simulations also show that our proposed algorithm gives good results in reducing rejected requests.

Key words:
MPLS, Mobile networks, handoff, QoS, traffic engineering, routing LSPs.

1. Introduction

Future wireless and mobile networks are expected to provide IP-based coverage and efficient mobility support with end to end Quality of Services (QoS) requirements.
Service providers, driven by the growing consumer interest in Smartphone, dongles, and net books, increasing number of mobile subscribers, growing of bandwidth demands, are quickly moving to Long Term Evolution (LTE) technology. LTE supports all-IP Radio Access Networks (RAN) architecture and involves two network mobility ranges that are Micro mobility and Macro mobility.
Micro mobility: also called intradomain mobility in the process of mobility over a small area. Usually, this means mobility within an IP domain with an emphasis on support for active mode using handover, although it may include idle mode procedures also. Micro mobility protocol exploit the locality of movement by confirming movement related changes and signaling to the access network.
Macro mobility: also called interdomain mobility or global mobility, is the process of a mobility over a large area. This includes mobility support and associated address registration procedures that are needed when a Mobile Host (MH) moves between IP domains. Interdomain handovers typically involves macro mobility protocols .
Mobile IP (MIP) is the current standard for supporting macro-mobility in IP networks, which provides transparent mobility by hiding the change of IP address when the mobile host moves between IP subnets, thus providing a good framework that allows user to roam outside their home network. However, it has some deficiencies in supporting fast handoff and seamless mobility in handoff intensive environment.
In order to remove such deficiencies as frequent registration and triangular routing, and to suit the needs of service providers and the operating system in term of QoS, it is too interesting to combine LTE technology with Multi Protocol Label Switching (MPLS). In fact, MPLS can ensure connection availability between two endpoints with QoS guaranteed by a Service Level Agreement (SLA). In MPLS, each packet is presented with a label. The label is the only information used to determine the packet's next hop. MPLS simplifies the forwarding process by means of label swapping. Other advantage of MPLS includes the ease of creating paths and supporting traffic engineering via Constrained Based Routing (CBR).
These notable benefits of MPLS have inspired some studies on the use of this technology in wireless infrastructure. In view of this, reference [1] proposes a scheme to integrate the mobile IP and MPLS. This scheme, called mobile MPLS, aims to improve the scalability of Mobile IP data forwarding process by removing for IP-in IP tunneling from Home Agent (HA) to Foreign Agent (FA) using Label Switched Path (LSP). Such a scheme suffers from non applicability to micro-mobility (intra domain) as the scope of Mobile IP is more shifted toward the global mobility.
H-MPLS [3] and several other schemes [4 – 8], try to ameliorate the performance of Mobile MPLS by using different architectures. However, all these studies propose

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micro mobility schemes without treating routing optimization process.

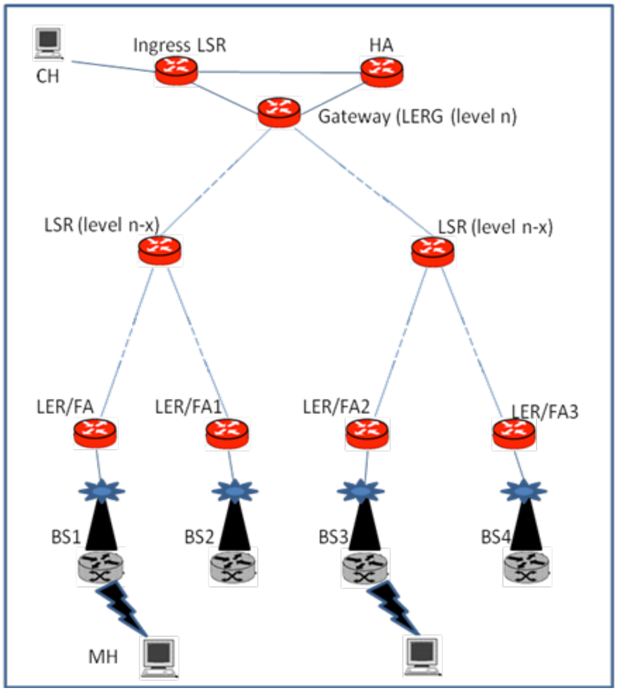

Fig 1. Topology of the considered mobile MPLS network

To overcome these limitations, we propose in this paper a new Global Mobile MPLS called GM-MPLS. Our proposal has the advantage to support a route optimization process to gain more QoS in term of bandwidth, avoiding network bottleneck and reducing path length .

In the following section, we first present the general routing problem. In section 3 we define key ideas of our routing algorithm. Section 4 presents the pseudocode of the proposed algorithm. Finally, we conclude by giving a brief idea on our future works in section 5.

2. General Routing Problem

Determining the route taken by real time Internet applications, like voice over IP [9] forms the most dealt problem recently in network resource management process since it involves resource provisioning decision on the scale of the entire network. QOS based routing is of critical importance in achieving such applications with high speed and efficiency. QOS routing problem is involved in several constraints, such as, delay, jitter, packet loss rate, bandwidth and cost.

In this section, we discuss routing algorithms for traffic requiring bandwidth guarantees. The goal of the routing algorithm is to find a feasible path from the LER/FA and the LERG if one exists, and to select one that achieves efficient resource utilization if more than one path is available. The most commonly used algorithm for routing LSPs is the shortest path routing [10]. In the shortest path routing, the path with the least number of links between ingress and egress nodes is chosen. The routing algorithm keeps track of the current residual capacity for each link and only those links that have sufficient residual capacity for the new flows are considered. The shortest path algorithm is very simple, but it can also create bottleneck for future flows and lead to severe network under-utilization. Our motivation for a new routing algorithm arises from the needs of service providers of an approach that can compromise between several TE objectives to support usage efficiency of the network infrastructure.

In our proposed approach, we have considered the following TE objectives: Distributing network load, minimizing path length and reducing path cost. We present, in next paragraph, the basic ideas of the proposed algorithm.

Before this, let's define some notation to be used. A network can be modeled as a graph $G(V,E)$, where V is a set of all nodes representing routers, E is a set of edges representing connectivity between nodes. Each link is bidirectional, i.e. the existence of a link $e = (u, v)$ from node u to node v implies the existence of another link $e' = (v, u)$ for any u, v in V . Any link e in E has a TE metric called *TEML*(e) which defines measures we want to optimize.

The setup request for a path i is defined by a triple r(si, ti, Bi) where si specifies the ingress router, ti specifies the egress router, and Bi specifies the amount of bandwidth required. We assume that path setup request arrives one at a time and there is no prior knowledge of future requests. The objective is to find a feasible path for each request.

3. Keys Ideas of the Route Computation Algorithm

We present in this section the basics ideas of an algorithm for dynamic routing of bandwidth guaranteed. Traditional routing does not take advantage of any knowledge about the traffic distribution or ingress-egress pairs, and therefore can often lead to severe network under-utilization. Algorithms of load balancing, if they exist, they select paths with high number of hops count to avoid network congestion. For this reason, compromising between network load balancing and reducing route hops count will be the most efficient solution for the network infrastructure.

- Distributing network load: for distributing network load, we define a link load parameter $l\_load(e)$ for the link e as follow:

$$l\_load(e) = \frac{reserved\ \ bandwidth\ \ on\ \ e}{total\ \ reservable\ \ bandwidth\ \ on\ \ e}. \quad (1)$$

To conserve load balancing we suppose that the TE metric on each link *e* belonging to the graph *G* is defined as the following:

$$TEML(e) = f_e(l\_\mathrm{load(e)}). \quad (2)$$

Where f_e is a positive objective function that it will be formulated later.

The TE metric for a path *i*, called *TEMP(i)*, reflects the cost of path *i* and it is defined as follow:

$$TEMP(i) = \sum_{e \in E \cap i} TEML(e). \quad (3)$$

- Reducing routing cost: we assume that network usage cost is solely dependent on the cost of the paths being used. Thus, the TE objective of minimizing network cost is directly translated to the problem of minimizing path cost. Path cost is a static metric and depends directly on its component links costs. Static metrics help in maintaining network stability under high load condition. We denote Cost(e) the cost of link e. we define Cost(e) inversely proportional to its bandwidth capacity.

$$Cost(e) = \frac{1}{l\_capacity(e)} \quad (4)$$

Where *l_capacity (e)* the bandwidth capacity of the link *e*.

We formulate now the function f_e as:

$$f_e = l\_load(e) \times Cost(e) \quad \forall e \in E. \quad (5)$$

Therefore, *TEML(e)* is reformulated as follow:

$$TEML(e) = l\_load(e) \times Cost(e) \quad \forall e \in E. \quad (6)$$

- Minimizing path length: to minimize path length, CSPFHopCount assigns a weight equal to 1 for each link. We will exploit this fact to formulate our objective function f_e.

$$f_e = l\_load(e) \times Cost(e) + 1 \forall e \in E. \quad (7)$$

4. Keys Ideas of the Route Computation Algorithm

We present in this section the pseudo code of the route computation algorithm. The algorithm will return the path taken by an LSP from the source to the destination minimizing the objective function. So, we use the well-known Dijkstra scheme and adapt its formulation to our need. Our route computation algorithm is detailed in Figure 2.

1 **Route-computation-algorithm procedure(G(V,E), r(*si*, *ti*, *Bi*))**
{
2 Compute the link weight, TEML(e), for all e in L according to equation.
3 Eliminate all links that have residual bandwidth less than *B* and form a reduced network topology with remaining links and nodes.
4 Use Dijkstra algorithm to compute the shortest path in the network using TEML(e) as weight of link.
5 Route the request from *si* to *ti* along this bandwidth constrained least cost path and update the residual capacities of the network.
}

Fig. 2. Pseudo Code of the Route Computation algorithm.

5. Conclusion

This paper addresses a framework of mobility management and traffic engineering for Mobile MPLS networks, called Global Mobile MPLS (GM-MPLS). The proposed scheme has the advantage to involve two ranges of network mobility, that are micro mobility and macro mobility, to provide excellent solution to the problem of mobility support in wireless environment.

We have presented registration procedure and discussed handoff techniques: inter LER and intra LER handoff. These techniques reduce considerably the number of lost packets due to movement of MH in mobile MPLS network. We have also proposed a new routing scheme to support traffic engineering. The algorithm satisfies meeting QoS requirement of bandwidth, efficient usage of network infrastructure, by providing network load balancing and reducing path length. Thus we can conclude that our solution improves the overall performance of the mobile system

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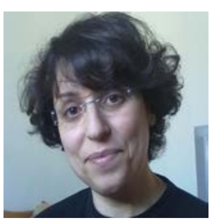

Afaf Mustafa KOTTI was born in Sfax, Tunisia. She received his engineer diploma in Computer Engineering and Master degree in new technologies in computer systems from the Ecole Nationale d'Ingénieurs de Sfax (ENIS) in 2003, and 2004 respectively. She received his Ph.D in information and telecommunication technologies in 2011. She was been an assistant at University of sciences of Monastir (FSM) in 2010. Then an assistant Professor in Higher institute of Applied Sciences and Technology in September 2011. And since September 2012, she is an assistant Professor in King AbdulAziz University. His interests include traffic engineering and quality of services in mobile IP/MPLS networks.