Introduction to Budget Based Network Admission Control Methods

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Abstract

In this paper we describe the new concept of network admission control (NAC) and delimit it against link admission control (LAC). Four basically different budget based NAC methods are presented.

1. Introduction

In a connection oriented network layer, admission control (AC) is easily combined with connection state management at each network node. Thus, it is performed link by link like in ATM or in the Integrated Services framework. AC for a single link – we call it *link* admission control (LAC) – can be done by flow descriptor based resource reservation assisted by effective bandwidths or by measurement based AC (MBAC), and it is well understood from research in the ATM context in the 90ies. In contrast, a connectionless network layer like IP does not deal with connection or resource management at the network nodes. Correspondingly, a *network* admission control (NAC) approach is advisable that admits reservations only at dedicated locations, e.g. the borders of a network, without contacting individual routers for admission decisions. We present four basically different NAC approaches that categorize today's NAC implementations and ease their understanding.

2. Budget Based NAC Methods

Budget based NAC methods are descriptor based, i.e. flows indicate a desired resource quantity $f.c$ [1] from an AC instance and are admitted if enough resources are available, otherwise they are rejected. The AC entity records the admitted flows $\mathcal{F}_{admitted}$ for bookkeeping. The type of signalled resources depends on the applied LAC method, i.e. NAC and LAC are complementary concepts.

Link Budget (LB) Based NAC. The capacity $l.c$ of each link l in the network is managed by a single link budget $LB(l)$ (with size $LB(l).c$) that may be administered, e.g., at the router sending over that link or in a centralized database (bandwidth broker). A new flow $f_{new}(v,w)$ with ingress router[2] v, egress router w, and bitrate $f_{new}.c$ must pass the AC procedure for the LBs of all links that are traversed in the network by f_{new} (cf. Figure 1). The NAC procedure will be successful if the following inequality holds

$$\forall l \in \mathcal{E} : l.u(v,w) > 0 : f_{new}(v,w).c \cdot l.u(v,w) + \sum_{f(x,y)\in\mathcal{F}_{admitted}(l)} f(x,y).c \cdot l.u(x,y) \leq LB(l).c. \quad (1)$$

The LB NAC induces states in the core network. In contrast, the following three basic NAC methods manage the network capacity in a distributed way, i.e. all budgets related to a flow can be consulted at its ingress or its egress border router.

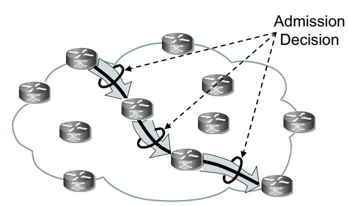

Figure 1. LB NAC.

Ingress and Egress Budget (IB/EB) Based NAC. The IB/EB NAC defines for every ingress node $v \in \mathcal{V}$ an ingress budget $IB(v)$ and for every egress node $w \in \mathcal{V}$ an egress budget $EB(w)$ that must not be exceeded. A new flow $f_{new}(v,w)$ must pass the AC procedure for $IB(v)$ and $EB(w)$ and it is only admitted if both requests are successful (cf. Figure 2).

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1 We borrow parts of our notation from the object-oriented programming style: $x.y$ denotes a property y of an object x. We prefer $x.y$ to the conventional y_x since this is hard to read if the name of x is complex.

2 A networking scenario $\mathcal{N} = (\mathcal{V}, \mathcal{E}, u)$ is given by a set of routers $\mathcal{V}$ and set of links $\mathcal{E}$. The border-to-border (b2b) traffic aggregate with ingress router v and egress router w is denoted by $g(v,w)$, the set of all b2b traffic aggregates is $\mathcal{G}$. The function $l.u(v,w)$ with $v,w \in \mathcal{V}$ and $l \in \mathcal{E}$ reflects the routing and it is able to cover both single- and multi-path routing by indicating the percentage of the traffic rate $g(v,w).c$ using link l.

Hence, the following inequalities must hold

$$f_{new}(v,w).c + \sum_{f \in \mathcal{F}^{ingress}_{admitted}(v)} f.c \quad \leq \quad IB(v).c \qquad (2)$$

$$f_{new}(v,w).c + \sum_{f \in \mathcal{F}^{egress}_{admitted}(w)} f.c \quad \leq \quad EB(w).c \qquad (3)$$

Flows are admitted at the ingress and the egress irrespective of their egress or ingress routers. This entails that the capacity managed by an IB or EB can be used in a very flexible manner. If we leave the EBs aside, only Equation (2) must be met for the AC procedure and we get the simple IB NAC. This idea originates from the DiffServ context. To avoid any confusion: DiffServ is a mechanism for the forwarding differentiation of classified traffic while the IB NAC is just one concept among many others for the management of network resources within that context.

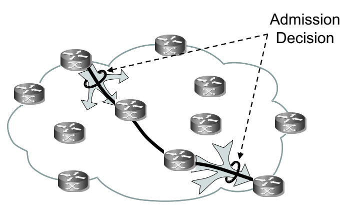

Figure 2. IB/EB NAC.

B2B Budget (BBB) Based NAC. The BBB NAC takes both the ingress and the egress border router of a flow $f(v,w)$ into account for the AC procedure, i.e. a b2b budget $BBB(v,w)$ manages the capacity of a virtual tunnel between v and w. Figure 3 illustrates that a new flow $f_{new}(v,w)$ passes only a single AC procedure for $BBB(v,w)$. It is admitted if this request is successful, i.e. if the following inequality holds

$$f_{new}(v,w).c + \sum_{f \in \mathcal{F}_{admitted}(v,w)} f.c \leq BBB(v,w).c. \qquad (4)$$

In contrast to a physical tunnel, the BBB NAC can be well combined with multi-path routing since the BBBs relate only to the ingress and the egress router of a flow and not to its path.

Ingress and Egress Link Budget (ILB/ELB) Based NAC. The ILB/ELB NAC defines ingress link budgets $ILB(l,v)$ and egress link budgets $ELB(l,w)$ to manage the capacity of each $l \in \mathcal{E}$. They are administered by border routers v and w, i.e. the link capacity is partitioned among $|\mathcal{V}|-1$ border routers. In case of single-path IP routing, the links $\{l : ILB(l,v) > 0\}$, that are administered in v, constitute a logical source tree and the links $\{l : ELB(l,w) > 0\}$, that are administered in w, form a logical sink tree (cf. Figure 4). A new flow f_{new} must pass the AC procedure for the $ILB(.,v)$ and $ELB(.,w)$ of all links that are traversed in the network

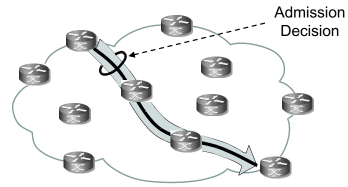

Figure 3. BBB NAC.

by f_{new} (cf. Figure 4). The NAC procedure will be successful if the following inequalities are fulfilled

$$\forall l \in \mathcal{E} : l.u(v,w) > 0 \quad : \quad f_{new}(v,w).c \cdot l.u(v,w) + \sum_{f(v,y) \in \mathcal{F}^{l,v,ingress}_{admitted}} f(v,y).c \cdot l.u(v,y) \leq ILB(l,v).c, \text{ and} \qquad (5)$$

$$\forall l \in \mathcal{E} : l.u(v,w) > 0 \quad : \quad f_{new}(v,w).c \cdot l.u(v,w) + \sum_{f(x,w) \in \mathcal{F}^{l,w,egress}_{admitted}} f(x,w).c \cdot l.u(x,w) \leq ELB(l,w).c. \qquad (6)$$

A BBB covers only an aggregate of flows with the same source and destination while the ILBs (ELBs) cover flows with the same source (destination) but different destinations (sources). Therefore, the ILB/ELB NAC is more flexible than the BBB NAC. The BBB NAC is simpler to implement because only one $BBB(v,w)$ is checked while with ILB/ELB NAC, the number of budgets to be checked is twice the flow's path length in hops. In contrast to the LB NAC, these budgets are controlled only at the border routers. Like with the IB/EB NAC, there is the option to use only ILBs or ELBs by applying only Equation (5) or Equation (6). The concept of ILB/ELB or ILB NAC can be viewed as local bandwidth brokers at the border routers, disposing over a fraction of the network capacity.

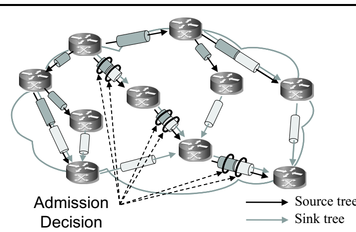

Figure 4. ILB/ELB NAC.

3. Outlook

Currently, we compare the resource efficiency of the presented NAC methods and investigate the impact of various topology and traffic parameters. We also investigate the performance with and without resilience requirements, i.e. if local network outages and the corresponding traffic rerouting are taken into account beforehand to make link or router failures invisible to customers.