

What Is MOMBASA?

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The growing importance of mobile communication deserves support for host mobility in IP-based cellular networks. But a general problem needs to be solved: An IP address reflects a host identifier as well as the host's current network point of attachment. This IP address is used to establish session between hosts, i.e. in sockets to access network services. A *mobile* host changes its current network point of attachment and the network part of the mobile host's IP address does no longer match the IP network address of the new point of attachment. The assignment of a new IP address – which is topologically correct – enforces that existing sessions (sockets) will be closed and re-opened. In fact, sockets are bound to source and destination addresses. Hence, the re-establishment pertains the mobile as well as a correspondent host communicating with the mobile host and disrupts the communication service. Even frequent changes of the network point of attachment sustains the quality of service.

There exists a number of solutions for the general mobility problem, the most important approaches are *Address translation and indirect routing* (e.g. Mobile IP [7, 8], RAT [10]) and *Host-based routing* (e.g. Cellular IP [1], HAWAII [9]). **MOMBASA (MObility Support – A multicast-BASed Approach)** pursues a different approach. The general mobility problem (separation of identity and location) is solved by multicast. The main idea of *MOMBASA* is to utilize location-independent addressing and routing to support host mobility. In *MOM-*

BASA, each mobile is assigned a multicast group address (which is independent of the current network point of attachment). The mobile host subscribes to the multicast group through its current access point to the network. Handover is performed by multicast operations, namely subscribe/un-subscribe to/from a multicast group. Data packets are distributed via a dynamic multicast tree with branches reaching the current locations of the mobile host on its movement. The branches of the multicast tree grow and shrink, and hence, follow the mobile's location. In comparison to IETF Mobile IP, a multicast approach has some advantages: *First*, re-routing for handover is done in a network node where the path to the old and from the new access station diverge (and not in a software agent in the mobile's home network as in the Mobile IP approach). *Second*, a *handover-specific* signaling and infrastructure is in principle not required, instead multicast is reused for mobility purposes. And *third*, multicast offers inherently mechanisms to minimize the service interruption caused by a handover between access points.

Nevertheless, the utilization of multicast for mobility support poses many challenges. *First*, the today's IP multicast faces a number of open problems – among others: necessity of a global multicast address allocation, lack of receiver authorization and transmission authorization, complexity, scalability problems with respect to the number of multicast groups and with respect to network boundaries (in particular multicast routing protocols interconnecting autonomous systems in the Internet), and finally the lack of reliable transport protocols for multicast. *Second*, a set of challenges come from the usage of multicast for mobility support. One of them arises from the design of IP multicast to be scalable for a very high number of receivers in a multicast group which in turn causes scalability problems with respect to the number of multicast groups. In fact, efficient support for multicast-based mobility requires a multicast scheme with a small number of members in a multicast group which is scalable in the number of groups. Note that this problem exists in fixed IP networks as well.¹

IP multicast as it exists today does not offer all functionalities which are required (Link detection, registration, handoff initiation algorithms) or which

¹ Other challenges are: Multicast state space explosion in routers, signaling overhead on wireless links with small bandwidth, unreliable signaling operations caused by the behavior of the wireless links (mobile hosts which simply disappear, loss of signaling messages, etc.).

are desirable due to performance reasons (Mechanisms to prevent handover oscillation, pre-registration, inactive host handover, buffering and forwarding of packets, paging). Whether or not a future multicast will support all of these functionalities is an open question. In *MOMBASA*, basic multicast functionalities (group creation and release, subscription, un-subscription, data transport) are complemented by mobility functionality (handover initiation, etc.). Which of the functionalities are already provided by the multicast also depends on the multicast protocol and deserves a closer attention. In general, a *MOMBASA* network can be characterized by the following features:

- IP-based network components and protocols, either IPv4 or IPv6,
- Multicast proxy in the access point,
- Network address translation or tunneling for address translation between unicast and multicast addresses,
- Minimal modifications to the multicast protocols,
- Mobility support in the access network, i.e.
 - Locating the current point of attachment of a mobile hosts within the access network,
 - Handover between access point belonging to the same access networks,
- Support of advertisements/solicitations to advertise the availability of access points,
- Support of pre-registrations of mobiles with access points in advance, either by
 - Advertisements interchanged among access points,
 - Third party signaling,
- Support of handover between access points providing different wireless technologies (vertical handover),
- Support of hard and soft handover, predictive handover,
- Differentiation between inactive and active mobile hosts; Provision of a paging service to locate inactive mobile host; paging is multicast-based.
- Buffering and forwarding of packets for predictive handover and paging,
- System behavior can be controlled and tuned by policies (handover type, algorithms for access point selection, paging, buffering, forwarding)

Part of *MOMBASA* is the *MOMBASA Software Environment*, a generic platform for experimentation with multicast-based mobility support in IP-based networks [5]. Basically, it is comprised of software components for mobile hosts, mobility-enabling proxies and gateways. The *MOMBASA Software Environment* can be regarded as a subset of functionality of the general approach *MOMBASA* which has been implemented as prototypes. Moreover, it offers an abstract interface to the multicast, and hence it can be used for different classes and types of multicast. The *MOMBASA Software Environment* is used to proof the *MOMBASA* concept, and to evaluate the performance of multicast protocols with mobility-enhancements. Moreover it offers the capability to compare certain mobility mechanisms with those of other approaches. Finally, the performance of the *MOMBASA Software Environment* is compared with standard Mobile IP, hierarchical Mobile IP, and with a Mobile IP version enhanced by multicast².

In summary, *MOMBASA* is an approach to support host mobility in IP-based cellular networks. It utilizes the capability of multicast for location-independent addressing and routing for mobility purposes. *MOMBASA* can be seen from different perspectives: *First*, as a set of functionality for optimal support of multicast-based mobility; *second*, as a framework of a network architecture and communication protocols to support host mobility in access networks with frequent handover; *third*, as an experimental platform to examine multicast-based mobility utilizing existing and future multicast protocols.

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² Here, a different class of multicast is used: SGM/XCast realizes *multi-destination unicast*. SGM is *not* based on location-independent addressing and routing, and therefore cannot be used as a sole mechanism for mobility support. Nevertheless it potentially improves the performance of Mobile IP and Hierarchical Mobile IP by efficiently distributing user data packets to a set Mobile IP Foreign Agents.

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