

# Characterizing the usage of a large municipal WiFi network

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This study focuses on characterizing the usage of a large municipal WiFi network panOULU provided via a public private partnership in the city of Oulu in Northern Finland. The network comprises of the campus networks of four public organisations (City of Oulu, University of Oulu, Oulu Polytechnic and VTT Technical Research Centre of Finland) and the panOULU subscriptions provided by three telcos (DNA, Elisa and Netplaza). To a user the subnets appear as one large uniform WiFi network under the SSID panoulu, which provides open and free wireless internet access to the general public on equal terms. As of August 2008 the panOULU network totals about 800 WiFi access points having different backhaul connections to the panOULU backbone, including xDSL, Ethernet, Flash-OFDM and IEEE 802.11a. The different subnets are connected to a central switch so that the access points reside in the same geographically large layer-2 network.

Of the four campus networks the City of Oulu's OukaWLAN is of special interest, as it spans a wide range of public service points and areas, such as city center, market area, city's offices, libraries, schools, health stations, sports facilities, community centers, camping area, youth centers, city hospital, and elderly service centers. About 90 of the 350 access points in the OukaWLAN provide outdoor coverage, which will be further expanded by a WiFi mesh network of 60 access points currently being installed in the city center and selected areas.

In OukaWLAN of special interest are also the mobile hotspots available in panOULU buses and Hailuoto ferry, for example. The WiFi access points in these vehicles are connected to the panOULU backbone using the @450 Wireless Broadband network based on the Flash-OFDM technology in the 450 MHz frequency band. The WiFi access points run a VPN client that builds a VPN tunnel over the @450 Wireless Broadband network to the panOULU DHCP, for the purpose of allocating clients with addresses from the same panOULU IP address space as stationary access points. This way a client will experience no problems with roaming between the mobile and stationary panOULU hotspots.

The panOULU subscriptions provided by telcos include both a standard business subscription for the subscriber's own production use and one or more WiFi access points for the purpose of providing an open and free panOULU hotspot in the subscriber's premises for customers and visitors. Typically, a panOULU subscription is realized with an xDSL connection and two VLANs, the other for routing the traffic of the business subscription via the telco's uplink, and the other for routing the traffic of the panOULU hotspot via panOULU's uplink. A wide range of organisations have acquired a panOULU subscription to enhance their customer service and competitiveness, including Oulu Airport, Oulu Cathedral, a private hospital, a sports complex, major bank, major department store, pubs and restaurants, and media and IT companies.

A number of tools have been developed and deployed for monitoring the usage of the panOULU network and for supporting the various R&D activities conducted in the network. A centralized management and monitoring system has been developed in-house for access point maintenance and for collecting various statistics on the usage of the panOULU network. The monitoring system uses

the DHCP log, the syslog data generated by the access points, arping for probing whether an access point or a client is alive, and a proprietary 'pandaemon' for computing session statistics.

An advanced network analysis system has been deployed for capturing and analysing packet data. Three types of probes are deployed. A high performance core probe captures headers of all packets in panOULU central switch into a ring buffer. A remote probe can be deployed for collecting packets from a desired network node and a WiFi probe for collecting WiFi packets at a desired location. The packet streams originating from different subnets are VLAN tagged with a separate switch, to allow provider or subnet specific analysis. The panOULU central switch processes typically 500 million packets every day. As 100 header bytes are captured of each packet by default, the 1 terabyte ring buffer in the core probe suffices typically for 20 days. Capturing of the payload data of devices with particular MAC addresses can be triggered separately. The packet data is analyzed with the Tia analysis tool provided by Clarified Networks. Tia facilitates exploring individual events such as atypical traffic patterns or volumes, illustrating the causal relationships of multiple flows, visualizing relationships between different panOULU users, and exporting the packet data to other tools, for example.

The poster provides a set of rather simple analysis examples. The network usage has been growing steadily so that 8585 devices used the panOULU network in August 2007. Typically 30-40% of the clients using the panOULU network in a given month are new, i.e. they have not used the panOULU network before. They are either WiFi devices used by new people visiting Oulu or new WiFi devices acquired by local panOULU users, we can not tell. In any case, the statistic speaks in favor of the argument used by many municipalities providing these kinds of open and free visitor networks that the network enhances attractiveness, competitiveness and productivity. One interesting trend is the increasing usage of the network by WiFi handsets, although a clear majority of the clients are still PCs furnished with Windows OS. Recently, the proportion of WiFi-equipped phones and internet tablets manufactured by Nokia having used the panOULU network has risen to over 20% of all clients.

User profiling with data from Jan-Aug 2008 reveals few interesting details. 79% of the 25939 clients had a "home AP" at which they spent most of their time. 1.1% were 'heavy' users which used the panOULU network on at least every other day on average. 52% were 'one-time' users which used the network during one week at most, which also speaks in favor of the importance of the network for visitors. About 4% of the 1.4 million sessions were mobile under a given criteria. Most active 10% of users generated about 90% of the 50 million online minutes. While average usage per client was 54 sessions and 1959 online minutes, the median usage was 125 sessions and 58 minutes. Acknowledging the fact that the median includes a number of short failed or accidental sessions with no real usage, the typical client logs in for a short session to check email, for example.

Future work includes a more detailed analysis of the different applications used in the panOULU network. Further, access point activity analysis will be carried out to determine the service points and locations where this type of municipal wireless network offering is useful. The more challenging tasks include a rigorous analysis of the economical and social impact of the panOULU network.