Signal Strength-Based Approach for 3G/WLAN Handover on Nokia N900 Devices

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Abstract

Automatic handover between 3G and WLAN networks is typically done when the current network link is going down. In this paper, we explore another possibility: automatic handover to the network which has highest signal level, to ensure steadier connection and faster download speeds. The proposed solution for Nokia N900 device is modular and extensible. Routines to choose the network to connect to can be altered, and it is possible to support another network types besides 3G and WLAN.

Index Terms: handover, 3G, WLAN, received signal strength, N900.

I. Introduction

When multiple access networks are available, such as a public WiFi and 3G carrier, the mobile devices supporting both 3G networks and WLANs could benefit from this situation.

For instance, connection to a WLAN with strong signal can be used when the device is near the public access point, because it it typically faster and cheaper than 3G. However, when the WLAN signal gets weak, 3G network becomes a strongly preferrable option.

As manually choosing access networks over and over again is tedious, some *automatic 3G/WLAN handover* solution is needed. Lots of the research in this area is focused on *Link_Going_Down* (LGD) triggers, which are used to start handover before the current link goes down. The typical solution there is to measure the received signal strength indicator (RSSI) or received signal level of current link, and start handover if the parameter is below some threshold ([2],[3]). Similar strategy can be applied to choosing the “best” current access network.

II. Our Approach

In our approach, received signal level of neighbor networks is periodically measured, and the “best” network (in terms of higher signal level) is selected as the current access network.

A. General Algorithm

Fig. 1 shows the flow of control during best network selection process.

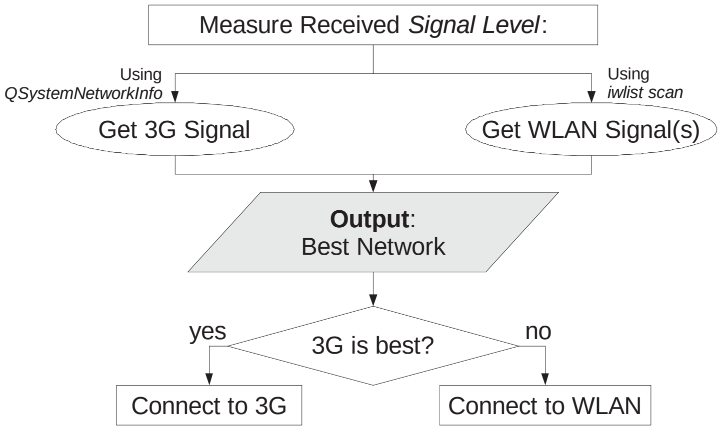

Fig. 1. General Algorithm

1. Neighbor WLANs are detected.
2. The signal levels of 3G and WLAN networks are measured and stored. This is done without disconnecting from current access network.
3. Stored values of signal levels are compared to decide which network is best, and connection to best network is made.

The steps (1-3) are repeated at regular time intervals.

B. Simplifications

To simplify implementation of the algorithm outlined in the previous section, we decided to measure signal level only for a WLAN with a predefined ESSID *defESSID*.

Choosing best network was also done with an extremely simple algorithm (Fig. 2), which did not compensate for different precision and accuracy in signal strength measurement for 3G and WLAN.

```
algorithm Select_Network(defESSID):
    s1 = signal strength of WLAN with defESSID
    s2 = signal strength of 3G
    if (abs(s1 − s2) > threshold and s1 > s2)
        return "Connect to WLAN network"
    else
        return "Connect to 3G network"
```

Fig. 2. Pseudocode for best network selection algorithm

III. ALGORITHM IMPLEMENTATION

A. Components

Our implementation consisted of the following components (Fig. 3).

1. *Switchers*, which perform the handover.
2. *Evaluator*, which measures signal strength and chooses the “best” network.
3. *Monitor*, which periodically calls *Evaluator* to determine the current “best” network. If device is not connected to the “best” network, the corresponding *Switcher* is called.

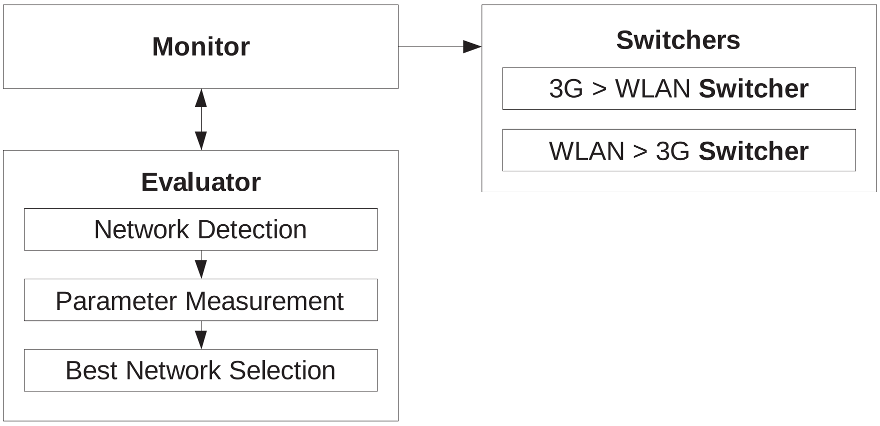

Fig. 3. Implementation Architecture

This architecture allows to modify both supported network types and best network selection procedures.

B. Switcher Implementation

We used Explicit Switching handover scheme (Fig. 4) and adapted mobile node handover scripts from [5].

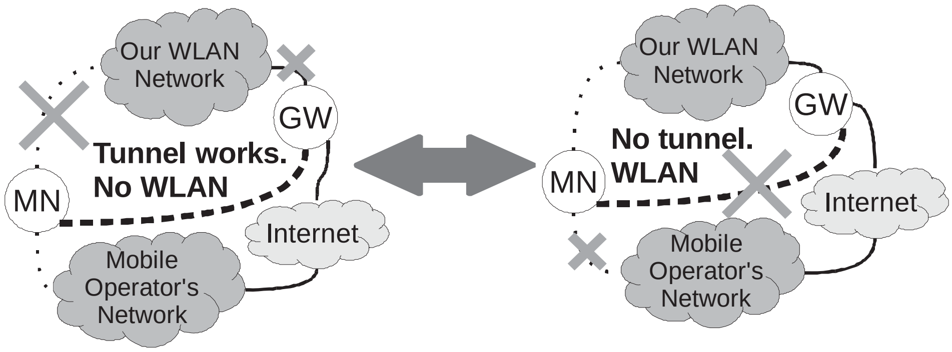

Fig. 4. *Explicit Switching* between 3G and WLAN. Figure taken from [5]

C. Evaluator Implementation

The Evaluator component was implemented as a stand-alone user-mode application called *signalstren*. To implement it, we used Qt Mobility APIs, particularly the *QSystemNetworkInfo* class [1]; and the *iwlist* utility from the wireless-tools package. While *iwlist* utility returned signal strength in dBms (decibels above milliwatt), Qt Mobility API used percentage values. These were converted to dBm using techniques from [6].

signalstren did the following:

1. Read the WLAN access point name from *wireless_name.txt*.
2. Measured & compared signal strengths of both WLAN and 3G networks. (The *threshold* value (Fig. 2. Pseudocode for best network selection algorithmFig. 2) used for comparison was set to 0.)
3. Wrote the answer ("wireless" if WLAN is best, "3g" otherwise) to *aq.txt* file.

D. Monitor Implementation

We implemented the *Monitor* component in a *switch.sh* shell script running as daemon. Its code is shown in Fig. 5.

The *Monitor* script executes the *Evaluator* application each ~5 seconds and examines the *aq.txt* file that contains the type of best network ("wireless" for WLAN, "3g" for 3G). Depending on the contents of *aq.txt*, the *Monitor* launches one of the *Switching* scripts.

```
#! /bin/bash
while true; do
    ./signalstren
    if grep -e "wireless" aq.txt then
        echo "Connecting to WLAN"
        # call script to connect to WLAN here
    else
        echo "Connecting to 3G"
        # call script to connect to 3G network here
    fi
    sleep 5
done
```

Fig. 5. Monitor Implementation in bash

IV. TESTING

A. Mobile Device Configuration

We used a Nokia N900 device for testing our solution. Its configuration is given in Table I.

TABLE I
TEST DEVICE CONFIGURATION

Parameter	Value
Firmware Version	0.2010.36-2
OS Version	Maemo 5 (Fremantle) Linux 2.6.28-omap1
Software Packages	wireless-tools 30~pre7-1.3maemo+0m5[1]
	QtMobility 1.2

B. Mobile Access Networks

We tested our applications for the following mobile networks (Table II). The “SJCE STAFF” WLAN is provided by STPI[2], govt. of India and has an average upload speed of 4 Mbps, and dowload speed of 1.2 Mbps. Its speed varies regularly, and heavily depends on the number of users in network.

For testing 3G connection, we used Aircel’s[3] network.

TABLE II
MOBILE NETWORKS USED FOR TESTING

	"SJCE STAFF" WLAN	Aircel 3G
Paid?	no	yes
Bit Rate(s), Mbit/s	1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, 54	≈3 (download), ≈1 (upload)

[1] From the Nokia Maemo repository: https://downloads.maemo.nokia.com/Packages/
[2] http://www.stpi.in/
[3] http://www.aircel.com/

V. RESULTS

The application has successfully passed the tests. The results obtained are shown in Table III. It can be seen that when the signal level of WLAN network becomes lower than that of 3G network, our application switches to 3G and vice versa.

TABLE III
TEST RESULTS

Signal Level, dBm		Test Result
WLAN	3G (WCDMA)	
−33	−75	Switched to WLAN
−40	−30	Switched to 3G
−70	−80	Switched to WLAN
−80	−75	Switched to 3G

Signal levels for both of the networks are also shown in Fig. 6 below.

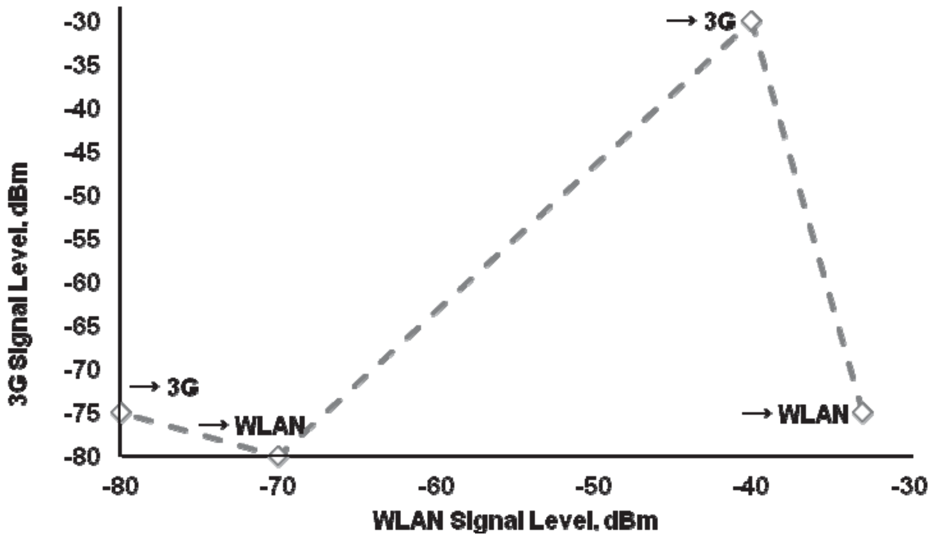

Fig. 6. WLAN vs. 3G Signal Levels

VI. CONCLUSIONS

We have successfully created and tested the signal level-based automatic handover solution. It was designed to permit extension of both supported network types (by creating new *Switcher* scripts) and network evaluation techniques (by changing the *Evaluator* component).

Our solution is freely available from the SVN repository [4].

VII. POSSIBLE FUTURE ENHANCEMENTS

A. Multiple WLANs

At present, our application measures signal strength only for WLAN with a specified ESSID. In the future, it can be enhanced to measure RSS for all WLANs available in the area.

[4] http://osll.spb.ru/projects/sw3g/repository/show/trunk

B. Preventing Continuous Switching

In the current solution, there are no special measures (besides setting *threshold* $\neq 0$) to prevent continuous switching between two networks which have almost identical signal strength. In the future, the basic algorithm can be improved to use two new parameters: *minimum time between handovers* to specify minimum interval between two consecutive handovers, and *minimum time of existence* to consider the network stable enough to switch to.

C. Multi-Parametric Network Evaluation

Signal level is not the only parameter which determines what mobile network is currently the “best”. One of the major parameters to consider is *signal throughput*, which can be measured when connected to a network.

Such parameters as *packet loss, latency* and *jitter* are also very important. In different situations, parameters might have different importance (e.g., network with slightly lower signal level, but significantly lower jitter, is clearly preferrable for VoIP applications).

The *Evaluator* component of our solution could support more complex network evaluation scenarios by using the *network fitness function* ([4],[5]), which is defined as a weighted sum

$$f = \sum w_{1i} RFIP_i^2 + \sum w_{2j} RSIP_j - P, \quad (1)$$

where *RFIP*’s $\in$ [1,5] are ratings of the most important network parameters (Signal Level, Throughput, and so on), *RSIP*’s $\in$ [1,5] are ratings of the less important parameters (e.g. Jitter and Latency), w_{kl} are parameter weights, and P is a static penalty typically applied to non-home networks (which are potentially costly). The *Evaluator* can then choose network with the biggest value of (1) as the “best”.

As there is no “one-size-fits-all” notion of “best” network, the weights w_{kl} will vary according to user preferences and the state of the mobile device (speed, remaining battery charge, CPU load, and so on). The set of weights is called a *weight profile*, e.g. “VoIP profile”, “High velocity profile”, etc. Orthogonal profiles can be combined (e.g. “VoIP + High velocity”).

Implementing multi-parametric network evaluation will be the subject of our future publications.

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