

## Customer Supplied Clinical Network WLAN Test Report

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### **Philips patient monitors in a LANCOM WLAN infrastructure**

**Objective:**

To test the integration of Philips patient monitors into a LANCOM WLAN infrastructure and to check the required functionality.

**Participants:**

LANCOM

- Wolfgang Kriegisch (Customer Project Manager)
- Thorsten Müller (Field Application Engineer)

Philips

- Julius Kalbhenn (Solution Architect Patient Monitoring)

## **Setup:**

The test took place at LANCOM in Würselen, Germany.

The test installation featured a latest-generation Information Center monitoring system that was connected to the patient monitors via WLAN. Two access points were used for the roaming tests, with one set up in the room and another set up in the corridor.

## **Test environment:**

The test environment contained a very large number of SSIDs and different access points.

A sample of the channels in the 2.4-GHz band as displayed by inSSIDer can be seen in Figure 1.

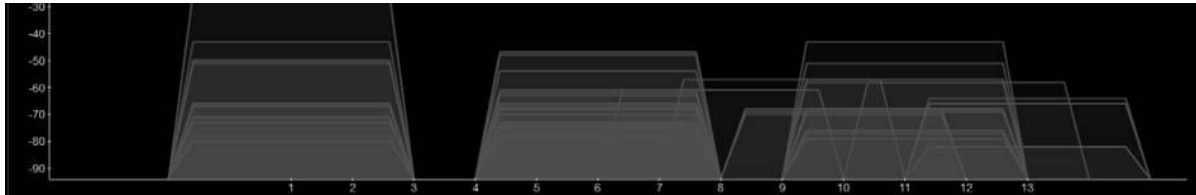


Figure 1

## **Equipment:**

### LANCOM

AP: 2 x LN-830acn with LCOS 9.20.0717RU4  
Controller: WLC-4006+ with LCOS  
9.20.0717RU4, router with DHCP type 1781EF+  
Gigabit switch: GS-2310P FW: 3.22.0003

### Philips

#### MX400

SN: DE35105674  
Software-Rev. L.01.10  
WLAN Rev. B.00.01, FW-Rev. B.00.26

#### MX40

SN: US09688306, US09688310, US09688311, US09688312  
Software-Rev. B.06.16  
WLAN Rev. WL3

#### X2

SN: DE83619502  
Software-Rev. K.21.39  
WLAN Rev. B.00.01, FW-Rev. B.00.26

#### Philips Intellivue Information Center iX

Revision B.02.06

## Test in layer-2 topology

- Operation with 802.11a/n
  - 20-MHz channel bandwidth:
    - Authentication using WPA2-PSK:  
Performed without problem
    - General behavior:  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
    - Network load (WLAN) with large amounts of data (simulated with iperf)  
Data transfer simulated bi-directionally between two clients using WLAN. No disconnections occurred.
    - Roaming behavior  
The systems displayed a good roaming behavior.

Additional test with the FastRoaming setting in the LANCOM controller. It was confirmed that the Philips devices do not support this setting. This is described in the CSCN Guide from Philips.

- 40-MHz channel bandwidth
  - Authentication using WPA2-PSK:  
Performed without problem
  - General behavior:  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
  - Network load (WLAN) with large amounts of data (simulated with iperf)  
Data transfer simulated bi-directionally between two clients using WLAN. No disconnections occurred.
  - Roaming behavior  
The patient monitors displayed a good roaming behavior with roaming times mainly < 500ms.

Random sampling of the data recorded with OmniPeek shows an increase in the retry rates for all of the tests conducted so far. Analysis reveals that over 20% of the packets were repeat transmissions. For this reason, we switched to 802.11a with a 20-MHz channel bandwidth.

- Operation with 802.11a
  - 20-MHz channel bandwidth
    - Authentication using WPA2-PSK:  
Performed without problem

- General behavior:  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
- Network load (WLAN) with large amounts of data (simulated with iperf)  
Data transfer simulated bi-directionally between two clients using WLAN. No disconnections occurred.
- Roaming behavior  
Roaming times slightly longer by approx. 500ms and brief interruptions to the real-time ECG were evident on the central monitoring system.  
MX40: The curves view was gap free thanks to the backfilling function of the MX40.  
X2: Here it was apparent that data were missing as the X2 has no backfilling function.
- Retry rate  
The static endurance test and the roaming test with two MX40 PWMs showed a clear improvement in the retry rates. After 20 minutes in the static test, only 4.5% of the packets consisted of resent data. An improvement to the rates was also evident in the roaming test.

In general, the Quality of Service (QoS) setting is recognized by the controller and the devices are set to the correct QoS level.

- Operation with 802.11ac
  - It is not possible to operate the patient monitors while they are permanently set to 802.11ac. The monitors do not connect to the network.
- Operation with 802.11a/n/c
  - The system automatically selects a channel bandwidth of 40 MHz
    - Authentication using WPA2-PSK:  
Performed without problem
  - General behavior  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
  - Roaming behavior:  
Roaming times averaging approx. 250 ms
  - Retry rate  
WLAN packet analysis for the X2 and MX40-1/-2 shows a retry rate of about 15%. This is acceptable for operation and did not result in any drop-outs in the trend at the Information Center

- Operation with 802.11a/n/c
  - Automatic channel bandwidth, channel 48 and 112 selected
    - 802.1X authentication:  
Performed without problem
  - General behavior  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
  - Roaming behavior  
MX40-3 and MX40-4 use PEAP and MSCHAPv2 and displayed similar roaming times as with WPA2-PSK between 200ms and 500ms. X2 with TTLS MSCHAPv2 is significantly slower at 1.2 – 2 seconds. Switching to PEAP and MSCHAPv2 brought a slight time improvement of about 1 second per roaming event. The MX40-1 set to TTLS and MSCHAPv2 took about 2 seconds for the first roaming event, and subsequent roaming events took about 250ms per roaming.  
  
The real-time ECG at the Information Center has noticeable data gaps due to roaming.  
MX40: The curves view was gap free thanks to the backfilling function of the MX40.  
X2: Gaps in the data were apparent because the X2 has no backfilling function.  
None of the devices lost their connection to the Information Center.
- 20-MHz channel bandwidth, channel 60 and 108 selected
  - 802.1X authentication:  
Performed without problem
  - General behavior  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
  - Roaming behavior  
Roaming times were widely scattered between 200ms to 2 seconds  
The real-time ECG at the Information Center has noticeable data gaps due to roaming.  
MX40: The curves view was gap free thanks to the backfilling function of the MX40.  
X2: Gaps in the data were apparent because the X2 has no backfilling function.  
None of the devices lost their connection to the Information Center.

- Retry rate  
Running this test with three MX40s and the X2 produced retry rates of approximately 15%.
- Operation with 802.11a
  - 20-MHz channel bandwidth, channel 40 and 48 selected
    - Authentication with 802.1X was performed without problem
  - Roaming behavior  
The roaming times varied between 200ms and 400ms. This partly led to brief interruptions of the curve at the Information Center. There were no disconnections.  
MX40: The curves view was gap free thanks to the backfilling function of the MX40.  
X2: Gaps in the data were apparent because the X2 has no backfilling function.
- Retry rate  
Running this test produced retry rates of approx. 6.5% with the three MX40s and approx. 23% with the X2.

The load caused by Wi-Fi clients with higher data rates did not cause any problems with any of the setups described above. All connections to the Information Center remained intact and there was no data loss.

- 802.11b/g operation
  - Authentication by WPA2-PSK was performed without problem
  - General behavior  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
  - Roaming behavior  
Roaming times were widely scattered between 0.2 – 2.4 seconds. This partly led to brief interruptions to the real-time ECG at the Information Center. There were no disconnections.  
MX40: The curves view was gap free thanks to the backfilling function of the MX40.  
X2: Gaps in the data were apparent because the X2 has no backfilling function.
- Retry rate  
WLAN packet analysis for the X2 and MX40-1/-2 shows a retry rate of about 14%. This is acceptable for operation and did not result in any drop-outs in the trend at the Information Center

The load caused by Wi-Fi clients with higher data rates did not cause any interruptions of the connection. Roaming times were about 1 second. All connections to the Information Center were consistent.

- **802.1X authentication**  
Performed without problem. The devices were configured with PEAP or TTLS with MSCHAPv2
- **General behavior**  
The Philips patient monitors all connected to the wireless network. The connection is stable within the static setup, there are no interruptions, and data transmission to the central monitoring system works as intended.
- **Roaming behavior**  
Roaming times were between 0.25 – 1.8 seconds. This partly led to brief interruptions to the real-time ECG at the Information Center. The X2 repeatedly disconnected during the roaming operation, which resulted in a break of 30 – 40 seconds in the data stream, and there were significant gaps in the curves display.  
The MX40 did not disconnect. The short gaps in the curves were closed by backfilling.

Time constraints meant that the effects of load caused by Wi-Fi clients with higher data rates could not be tested.

### **Test in layer-3 topology**

Setup:

The Information Center was patched into a different subnet

192.168.2.0/24

Wi-Fi clients were in 192.168.1.0/24

The devices provided by LANCOM did not permit the necessary multi-cast traffic to be routed between the Information Center and the clients. The patient monitors did not connect to the Information Center.

➔ A layer-3 setup is not possible with LANCOM infrastructure.

## Conclusion:

The infrastructure provided by LANCOM supports the general functionality on a layer-2 basis. Performance was significantly better in the 5-GHz band, which is probably due to the heavy utilization of the 2.4-GHz band. This confirms the recommendation issued by Philips to operate their patient monitoring systems in the 5-GHz band.

The data loss caused by roaming was within acceptable limits and meets Philips requirements of continuous monitoring. At this point a distinction should be made that the MX40 in combination with the PIIC iX Information Center Rev. B.02 with the backfilling function minimized or completely filled the gaps. This function is not provided by other patient monitors, which would lead to corresponding gaps in the data.

When operating authentication as per 802.1X and PEAP/TTLS, the X2 had problems with its roaming behavior in the 2.4-GHz band and disconnections were the result. In the case of on-site validation, this would prevent the approval of the patient monitoring system.

As recommended in the Philips document "IntelliVue Network Specification", operation with a LANCOM infrastructure is best suited with 802. 11a in combination with WPA2-PSK authentication.

There are clear limitations with L3 routing. This could not be implemented with the infrastructure provided by LANCOM, as multicast traffic could not be routed.