NXP Basestation Site Scanning proposal with AISG modems

Advanced Systems White Paper

by Jaijith Radhakrishnan

There are a number of connectivity issues associated with cellular base stations that can increase the cost of operation. Prior to commissioning, the tower is typically given a visual inspection to ensure connectivity. The inspection, which involves verifying connectivity for the antenna line devices (ALDs) and the base station controller (BSC), requires the presence of a field technician and, because data is usually gathered visually (and not electronically), can be prone to error. Some connectivity faults are difficult to detect with the eyes alone, and it's possible for the technician to miss a connection.

Once the tower is operational, connectivity problems can be hard to identify from the operations and maintenance center, and equipment may have to be brought offline to debug the issue. Over time, connectivity can deteriorate, due to damage to the ALDs and other tower equipment. Connectors and cables can't really be assessed accurately with a quick visual inspection, so detailed and time-consuming onsite inspections may be needed to keep things running. Also, complex problems may require multiple site visits to resolve.

Making connectivity information available, via an electronic process, to a central operations and maintenance center, would save having to send personnel to the site and could reduce the possibility of errors. At present, however, there is no industry-defined method for automatically scanning device connectivity. The Antenna Standards Interface Group (AISG) mainly addresses equipment failure, with methods for tuning ALD parameters to make network operations *more efficient, but these methods don't currently address the connectivity between devices in the tower. Creating a system for remote scanning of connectivity would most likely require a joint effort from base station and ALD manufacturers, as well as network operators. One such system, currently under consideration, is called Site Scan.*

Site Scan is a reliable, scalable method that makes it possible to verify base station connectivity remotely. As an electronic process, Site Scan can be initiated automatically and, under normal conditions, can be performed at any time without affecting tower operations. Site Scan gathers connectivity information and detects improper or inconsistent connections. Any irregularities are flagged for further diagnostics. Site Scan can also detect the kind of damage that can occur over time, so there is less need for periodic visits to the tower for preventive maintenance. Site Scan provides a new way for the operations and maintenance center to gather connectivity data remotely and, as a result, promises to have a significant impact on the overall cost of network operations.

This paper describes how primary and secondary devices support Site Scan, and outlines the scanning sequence used to trace connections. It also explains how connectivity information is stored, and suggests ways to use the Site Scan information to diagnose and debug issues.

Device requirements for Site Scan

Site Scan assumes the AISG modem can respond to any port in the device or that there is one modem connected to each port. In a cellular tower, the scan can be initiated by the BSC or by a remote request from the operations and maintenance center. This scan can be performed in real time, while the base station is operational. This is because the scan is performed using the AISG commands at AISG or a custom carrier frequency that doesn't interfere with RF communication. To evaluate connectivity, the tower devices need to know how many ports they have and which port is responding to the current command. All responses are evaluated in real time using a scan sequence. This means the BSC doesn't have to have any device or connectivity information to perform the scan. The only requirement is that each device, including the BSC, must know how many ports it has. This Site Scan procedure can be performed at any time after the device is initialized and all addresses have been assigned. To evaluate connectivity, the AISG bus must be configured as a point-to-point connection. This can easily be done by reconfiguring the transmit and receive lines. Note that, to perform Site Scan, the modems must be configured in bypass or repeat mode. Details are given below.

A. All the ports of the secondary and primary devices need to be AISG-enabled

This includes RF and AISG ports. To electrically trace connectivity, point-to-point access of all the ports is needed. This requires additional features on each device but the final cost is lower than compared to traditional on-site maintenance. Having AISG-enabled ports means all devices are capable of receiving or sending AISG messages through their ports. Devices are also aware of which port is used for communication.

B. Secondary devices should be able to configure the ports in Site Scan repeater mode

At startup, all secondary devices act as normal AISG devices and can run the regular AISG protocol. During Site Scan, the base station may be required to configure secondary devices in ‘repeater mode' to communicate with other device ports. The configuration can be performed with minimal hardware features. This feature is important for secondary devices that have a pass-through AISG connection configured as a multi-drop bus. The following example shows the two modes of connection on a TMA.

Figure 1 shows TMA connectivity during address scan and normal AISG operation.

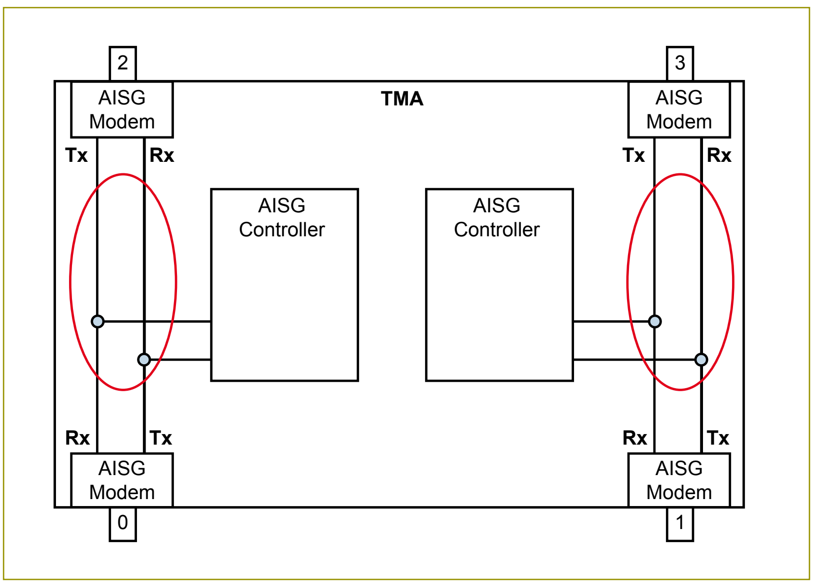

Figure 1 TMA connectivity during address scan and normal AISG operation

The diagram shows only AISG-related connectivity for a TMA with AISG uplink connection for a system which has integrated AISG antenna. Shown the connectivity of normal AISG operation, including address scan mode. RF connectivity is not shown. This is a multi-drop bus and many devices are connected to the same bus. The TMA is a [secondary] device. The [primary] device BSC is connected to the port ‘0’, and RET may be connected to port ‘2’.

The diagram shows two AISG controllers but a single controller can do the job. The number of repeater combinations increases as the number of ports the increase. An easy configuration uses only two ports in repeater mode, as shown in Figure 2.

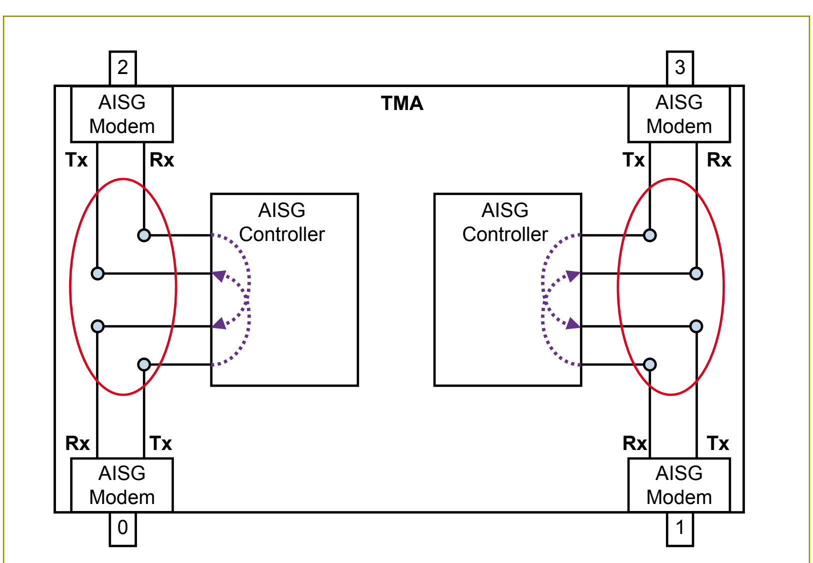

Figure 2 TMA connectivity during Site Scan repeater mode

The diagram shows only AISG-related connectivity for a TMA in “Site Scan” repeater mode. RF connectivity is not shown. This is point-to-point bus connectivity. The secondary device responds to commands addressed to it, or repeats the command/response to the other port. The purple arrow indicates either the crossed Tx and Rx connectivity or store-and-forward from Rx to Tx.

This is a point-to-point connection, referred to as a repeater mode connection in the rest of this document. In this mode, the repeater ports exchange the commands and responses. Commands and responses received from port ‘0’ are repeated to port ‘2’, and vice versa.

C. All Site Scan-enabled devices know the number of ports they have and their attributes

Using connectivity information and the attributes of these ports, the central operations and maintenance center can run various diagnostics.

D. All Site Scan-enabled devices need to support commands related to Site Scan

All Site Scan enabled primary devices shall support additional commands for the Site Scan. All secondary devices need to understand and respond to primary commands.

E. The scan initiator must know the intended connectivity of the devices

Site Scan can be initiated from the BSC or from the central operations and maintenance center. To evaluate connection problems, such as open or wrong connections, the scan initiator must know the intended connectivity of the tower. This is cross-checked with actual connectivity to evaluate intended connectivity or to find bad/wrong connections. Alternatively, a set of rules can be maintained and the scan can check for rule violations. For example, a rule could be “RF output port should not be connected to another RF output port” or “TMA port and antenna port need to be in same band of operation.”

Site Scan command sequence

The concept of Site Scan can be explained using a simple example. (The example can be extended to support more complex systems.) The example uses a base station controller (BSC), tower mounted devices (TMA), and an antenna or remote electrical tilt (ANT/RET). The concept device IDs are indicated in each figure. All ports, devices, and layers are named with numbers starting from ‘0’. For the device ID, the first digit indicates the layer and the second digit is the device's position in that layer. For example “device_id_10” is the first device on the second layer. The device ID is for reference only and does not match the ID of the AISG device.

Figure 3 gives the key for reading the diagrams that follow.

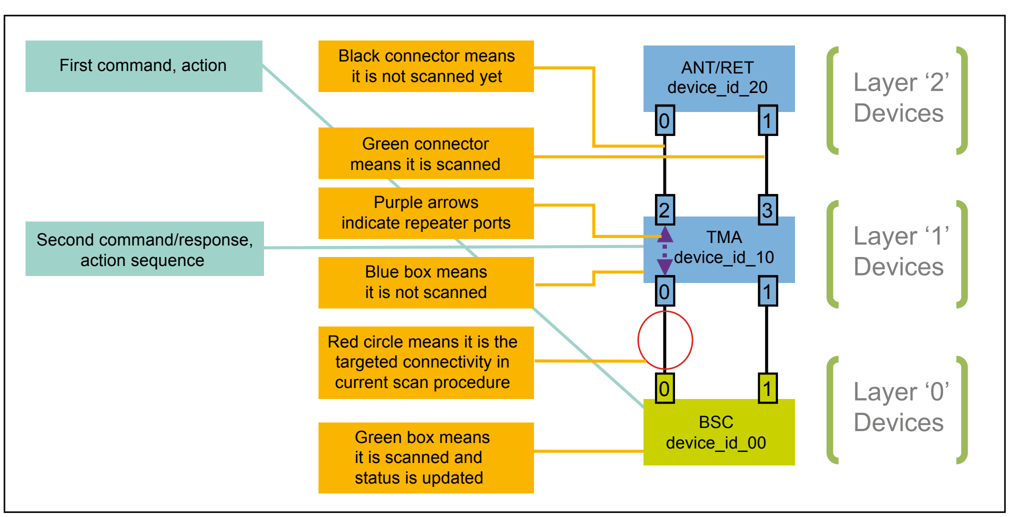

Figure 3

Figure 3 Key for reading diagrams

Site Scan can be initiated by the primary device (BSC) and can be triggered by the following events:

- Self starting based on any algorithm or periodically
- Remote request from operations and maintenance

The following diagrams give the sequence for Site Scan.

Figure 4 Site Scan command sequence (1)

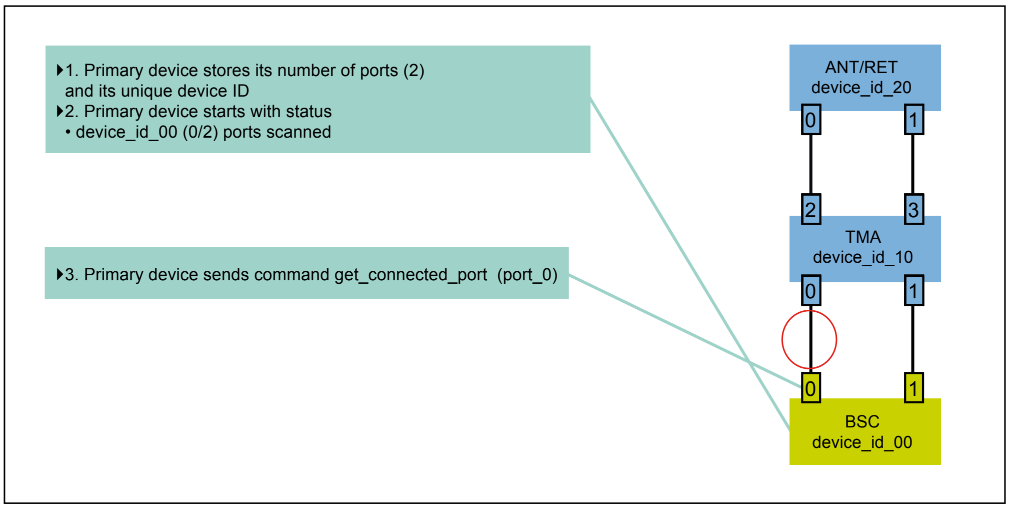

Figure 4

Figure 4 Site Scan command sequence (1)

Figure 5 Site Scan command sequence (2)

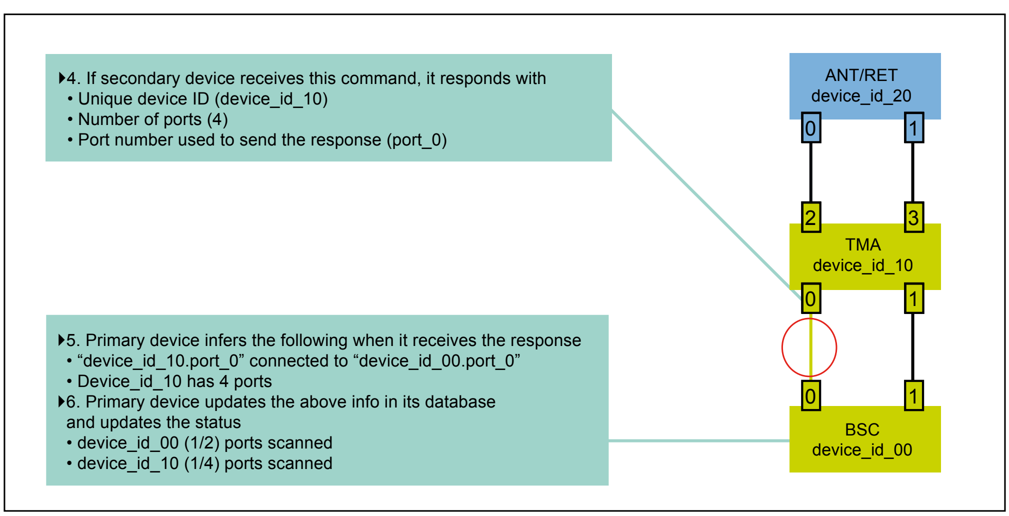

Figure 5

Figure 5 Site Scan command sequence (2)

Figure 6 Site Scan command sequence (3)

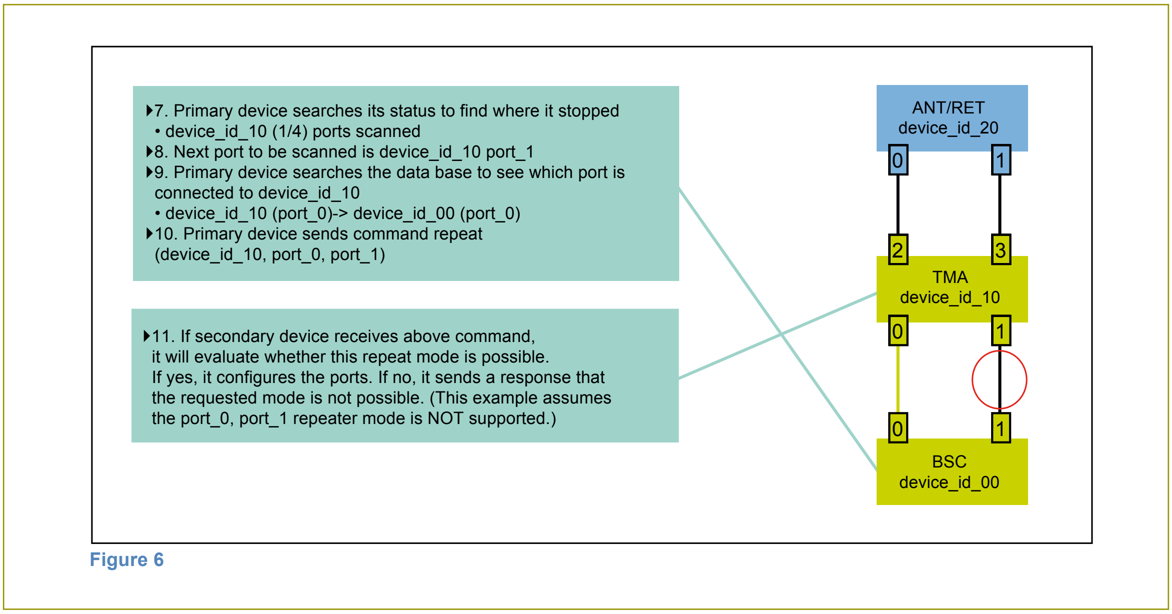

Figure 6 Site Scan command sequence (3)

Figure 7 Site Scan command sequence (4)

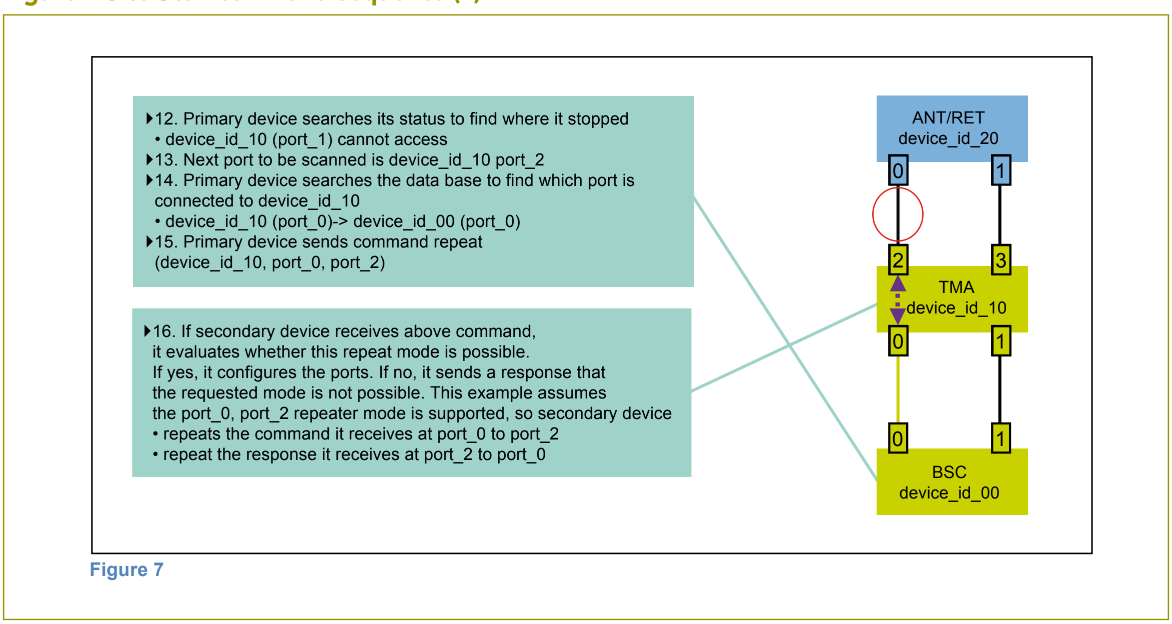

Figure 7 Site Scan command sequence (4)

Figure 8 Site Scan command sequence (5)

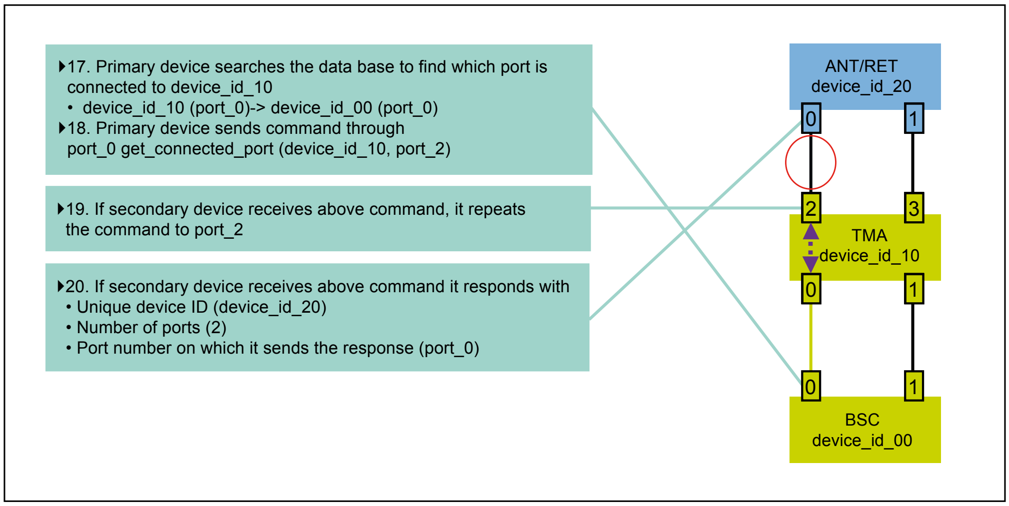

Figure 8

Figure 8 Site Scan command sequence (5)

Figure 9 Site Scan command sequence (6)

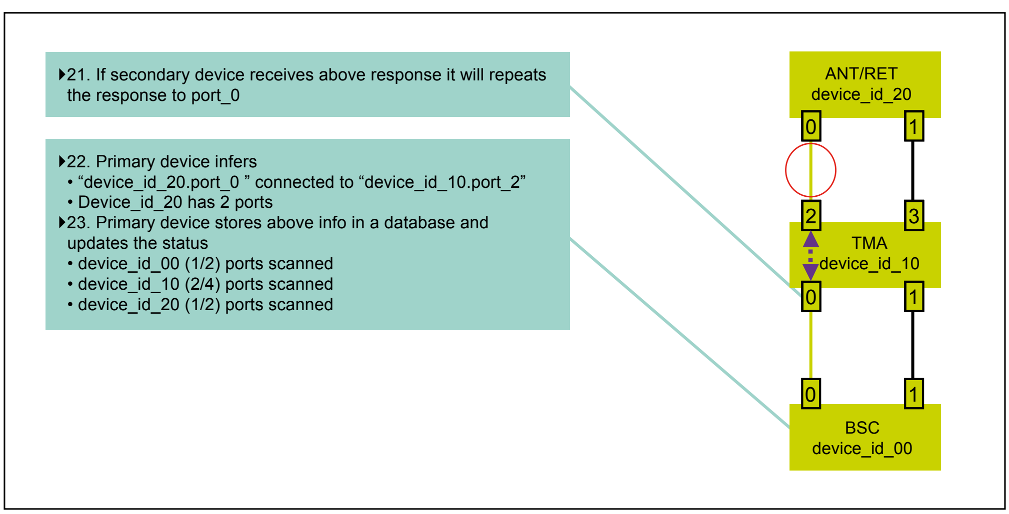

Figure 9

Figure 9 Site Scan command sequence (6)

Figure 10 Site Scan command sequence (7)

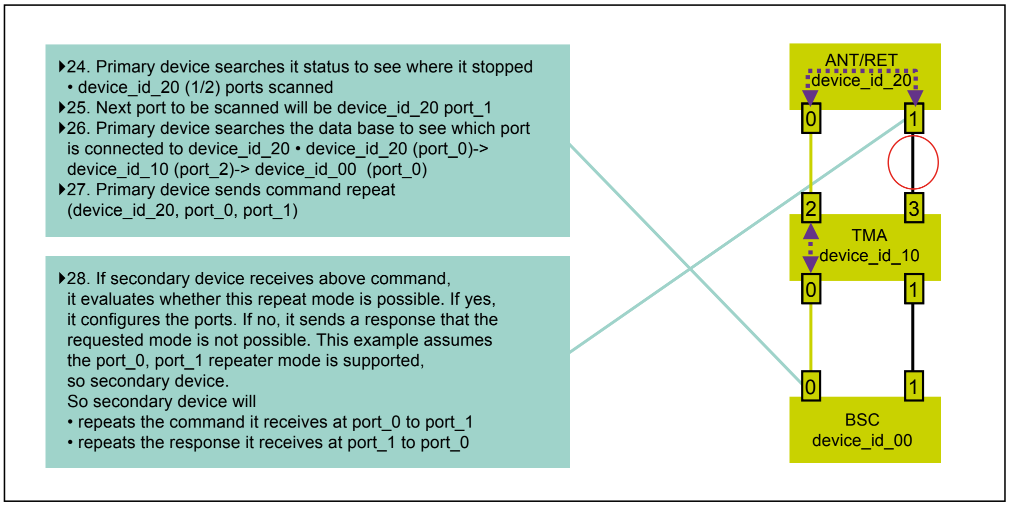

Figure 10

Figure 10 Site Scan command sequence (7)

Figure 11 Site Scan command sequence (8)

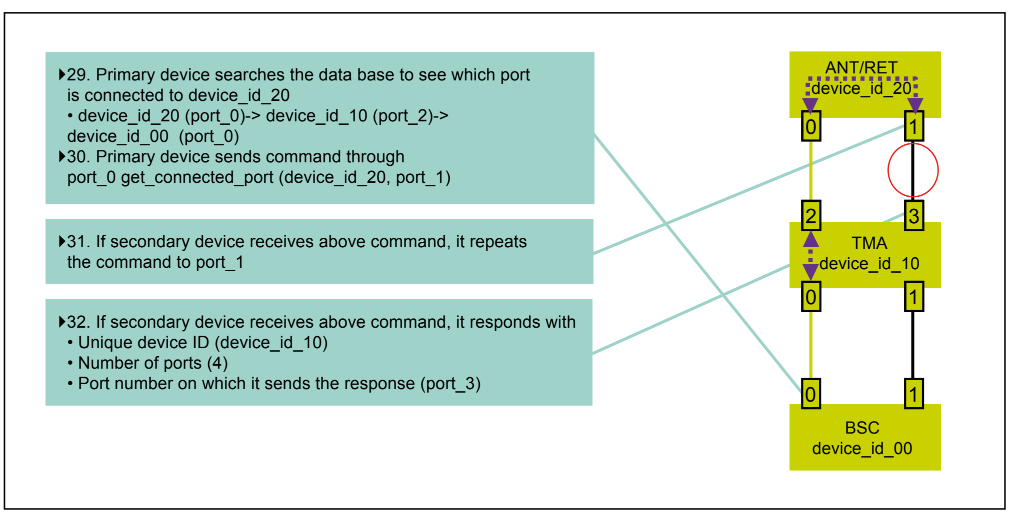

Figure 11

Figure 11 Site Scan command sequence (8)

Figure 12 Site Scan command sequence (9)

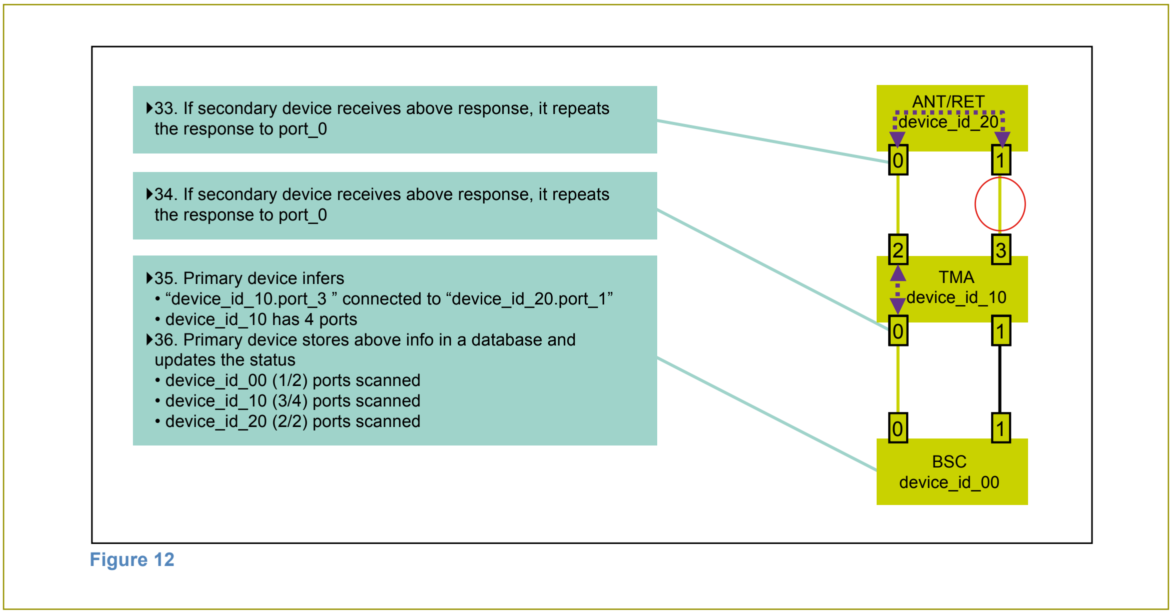

Figure 12 Site Scan command sequence (9)

Figure 13 Site Scan command sequence (10)

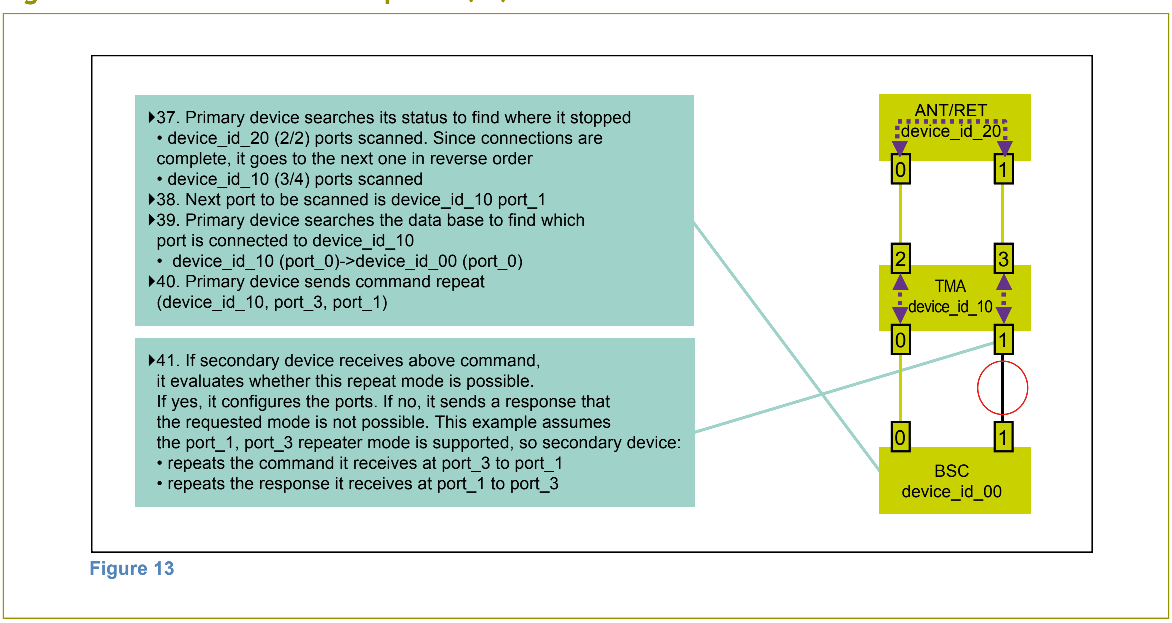

Figure 13 Site Scan command sequence (10)

Figure 14 Site Scan command sequence (11)

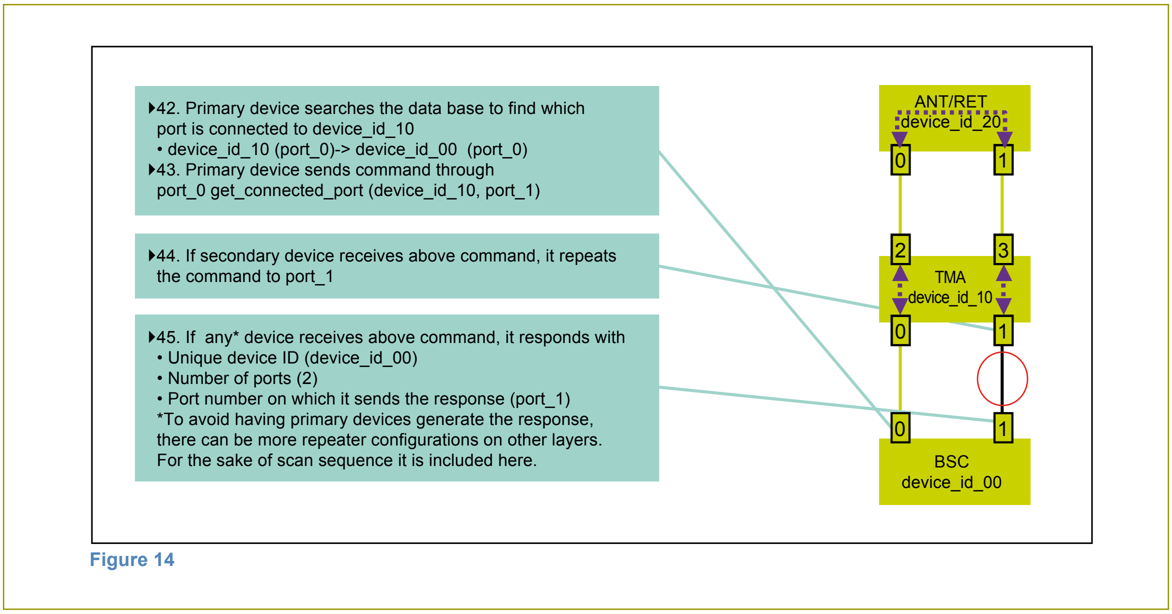

Figure 14 Site Scan command sequence (11)

Figure 15 Site Scan command sequence (12)

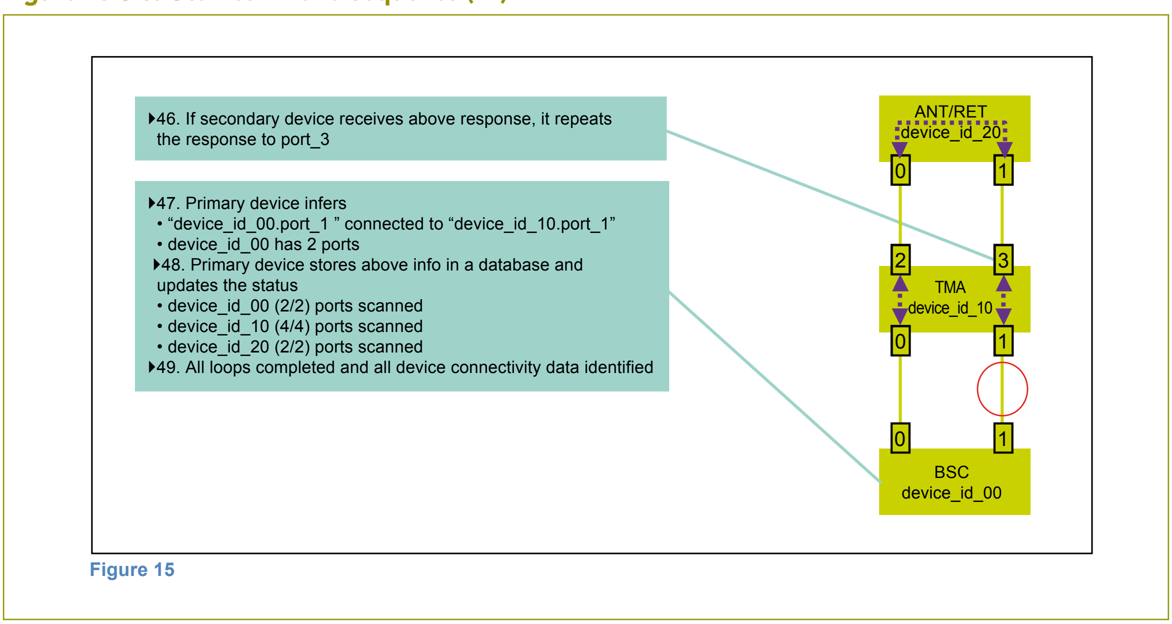

Figure 15 Site Scan command sequence (12)

Figure 16 Site Scan command sequence (13)

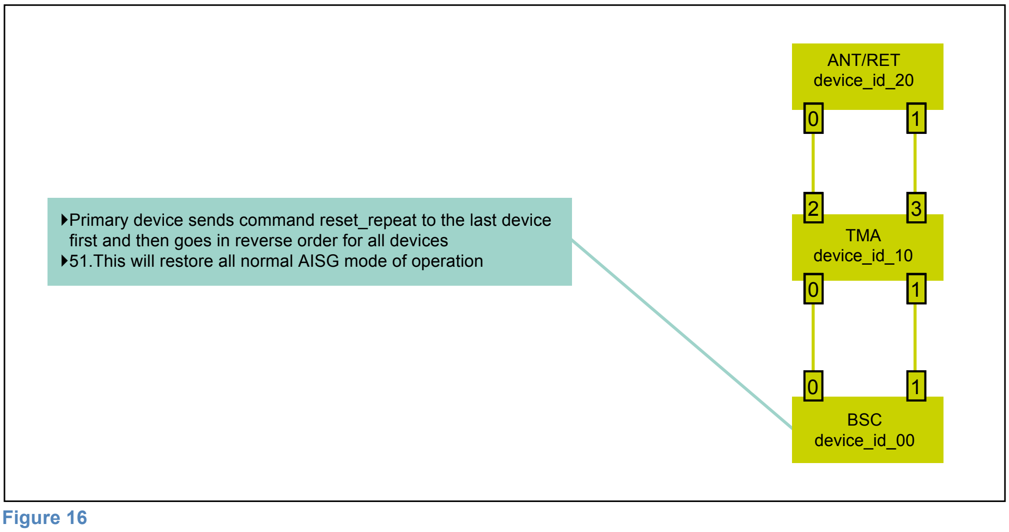

Figure 16 Site Scan command sequence (13)

Extending for more layers and devices

The above solution can be extended to any layer. It can also be extended to any number of devices in a single layer. If there are multiple vertical connections, then the BSC must scan one each after the other. To cover all the possibilities, the scan must proceed systematically. By setting rules and having information about the intended connectivity, bad or inconsistent connections can be identified.

Star/passive (Smart Bias Tee) connectivity

Star connectivity is a passive connection, so the system must have on-board intelligence to perform the scan procedure. Star connectivity must be absorbed within the ALD. This creates one more port for the device. If the device is capable of connecting the AISG modem to these ports, it will be used during Site Scan when connectivity information is gathered. Similar to a star connector, a passive devices such as a smart bias tee, which sits outside the active ALD, cannot be scanned. Some efforts have already been made to integrate the smart bias tee into the TMA or the antenna, and this is consistent with the Site Scan approach.

There are several considerations for star/passive connectivity:

- Star connectivity, or splitters need to be absorbed into the devices
- When devices absorb these connections, each port must be AISG-enabled
- Keeping the splitter outside the device defeats the scan connectivity
- If the device is not addressable and ALL ports are not AISG-enabled, the scan will not be possible
- Repeater mode connectivity from the primary device connection port is needed for all ports
- Ideally, the Smart Bias Tee is absorbed inside devices like the TMA and the antenna

Command timing with repeater mode connection

Several kinds of repeater connections are possible, including transmitter-to-receiver cross connections and receive, store, and forward for commands and responses. There are, of course advantages and disadvantages to each approach.

With the cross-connection approach, where many modems are chained together, there may be degradations in duty cycle. This becomes increasingly important as the number of layers goes up. With the receive, store, and forward method, there may be an increase in delay due to the storage of commands and responses. If the delay exceeds the limits of the protocol, a secondary device can be used to send the response or resend the command at a later point. The secondary can also forward the command to the repeater port and collect the response. When the repeater receives the command, the secondary forwards the collected response.

Database for connectivity

Connectivity information can be stored in many formats, including a netlist. This information can be sent to the operations and maintenance center for connectivity evaluation and debug purposes. The connectivity format can be binary, with defined fields, or human-readable ASCII.

```
device_id_00,
port_0 (device_id_10.port_0),
port_1 (device_id_10.port_1),
end;
device_id_10,
port_0 (device_id_00.port_0),
port_1 (device_id_00.port_1),
port_2 (device_id_20.port_0),
port_3 (device_id_20.port_1),
end;
device_id_20,
.......
.......
```

Some useful commands

It can be very useful to get the properties of ports and devices in the base station for debug and connectivity evaluation. Some of these commands are already available in the AISG protocol. Many of the attributes are related to the device itself but all of them can be related to ports. The following are examples:

- Direction of port
- RF frequency of port
- 3G standard of port
- Position of port
- Color code of port

Diagnostics of connectivity

Knowing the various properties of components and ports in a remote base station (such as environmental factors and connectivity data), opens up the possibility for extensive analysis, including the following:

- Open connections or cable and connecter faults
- Wrong connections (e.g. input to input or output to output)
- Frequency and 3G protocol mismatch
- Non-compatible device connection

Using the available data, the operations and maintenance center can generate a fault location report, complete with device/connector/cable location color coded on a port map, before sending staff to the site. This can save time and reduce maintenance costs. The system can detect faults when they occur, in real time, so the down time associated with connector damage is reduced, and operational costs remain low.

Debug of failing connector/cable

Figure 17 Debug of failing connector/cable

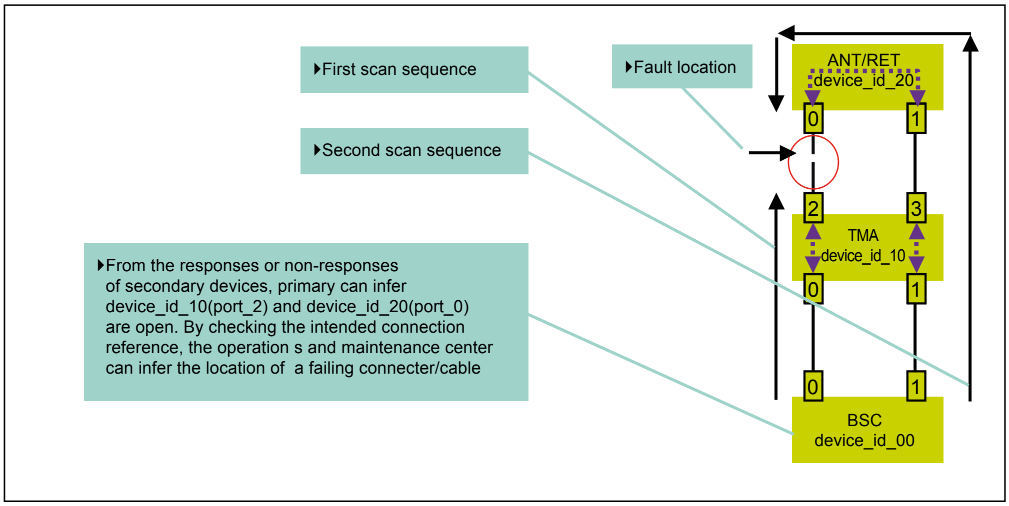

Figure 17

Figure 17 Debug of failing connector/cable

Port and device sequence

In this example, when a new sequence starts, the scanner looks for the last non-completed device and the next port in the incremental order. The sequence of this scan is not important. If the device is capable of repeater mode connection, following a particular port and device sequence will trace all connections. At minimum, There should be vertical repeater mode connections at every port and horizontal repeater mode connections at various levels. This makes it possible to access all nodes from either side, so fault location can be predicted more accurately. The scan procedure adds very little software overhead to the ALD. Most of the procedure and analysis happens on the BSC side. Site Scan can be supported in the ALD with the additional of a few resources. In most cases, existing BSC processors and their associated resources are adequate for implementing Site Scan.

Simplified flow diagram for Site Scan procedure

Figure 18 Simplified flow diagram for Site Scan procedure

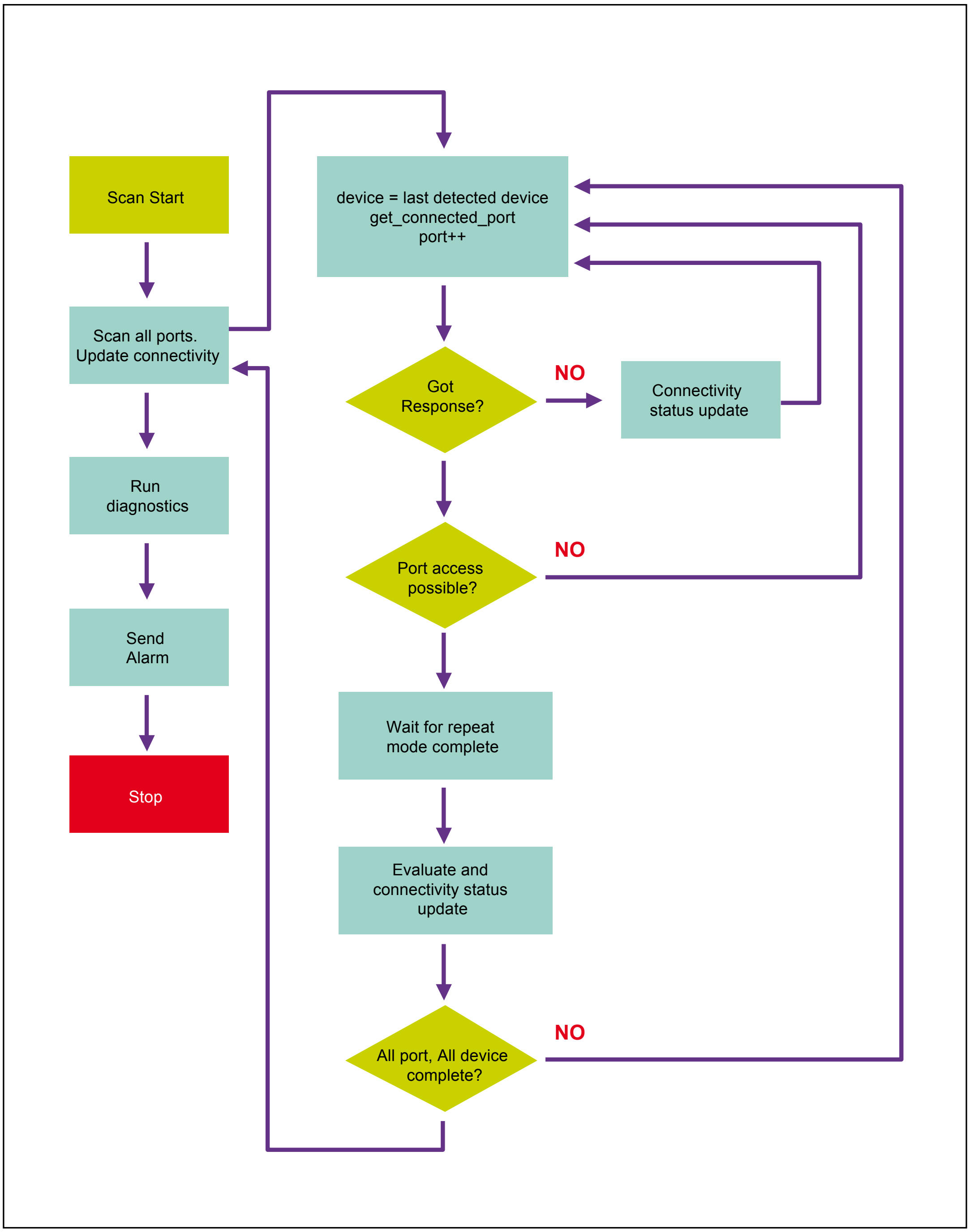

Figure 18

Figure 18 Simplified flow diagram for Site Scan procedure

Disadvantages

Implementing Site Scan requires additional commands, responses, and procedures at the BSC and additional command support at each ALD. Insertion of AISG modems at each port also increases the RF insertion loss.

Conclusion

Site Scan is a simple but reliable procedure for retrieving information about base station connectivity from a remote location. With this procedure extended to full-scale cellular base stations, the operations and maintenance center can gather details that are useful for debug and analysis, including interconnections, components, device parameters, and environment. Implementing such a system is non-trivial and involves a number of intermediate steps. The procedure is suitable for use as an AISG standard.

About the author

Jaijith Radhakrishnan is a senior architect at NXP Semiconductors and acts as one of NXP's representatives in the AISG standardization group. As lead architect Jaijith is involved in the development of NXP's AISG products and system architecture.

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