



## **SmartDiagnostics® Application Note** **Maximum Number of Sensors per Network**

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### **Overview**

The SmartDiagnostics® wireless network uses a proprietary protocol to communicate between the sensor nodes and wireless receivers. This application note describes the key considerations that should be taken into account when defining the maximum number of nodes allowable within a SmartDiagnostics® wireless network.



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### Network Load

Most industrial facilities can be logically broken into regions in which Collection Servers are located to provide wireless coverage. The wireless coverage area of the receivers connected to a Collection Server is roughly ~200 feet in a typical industrial facility. Within each of these regions hundreds of nodes can be collecting data and sending it to a Collection Server. The limit on the maximum number of nodes in a given region depends on the reporting interval of the sensors and the desired reliability of each data transaction. As the wireless traffic increases, some of the packets collide and may be lost. SmartDiagnostics® uses multiple methods to ensure the communication reliability avoid lost data, however, as the frequency of the transmissions increase, there are fundamental limits on the capacity of a given wireless channel, which ultimately limits the data throughput.

This application note describes these tradeoffs and provides a basis for determining the maximum data acquisition/transmission interval and number of nodes that can be support in a given wireless coverage area.

Each Collection Server can host between 1 and 5 receivers (typically collocated with the Collection Server) in a given wireless coverage area. Each of these receivers supports communication on a single wireless frequency or channel given in the following table.

SmartDiagnostics® Channel	A	B	C	D	E
Center Frequency (MHz)	2429	2436	2443	2450	2457

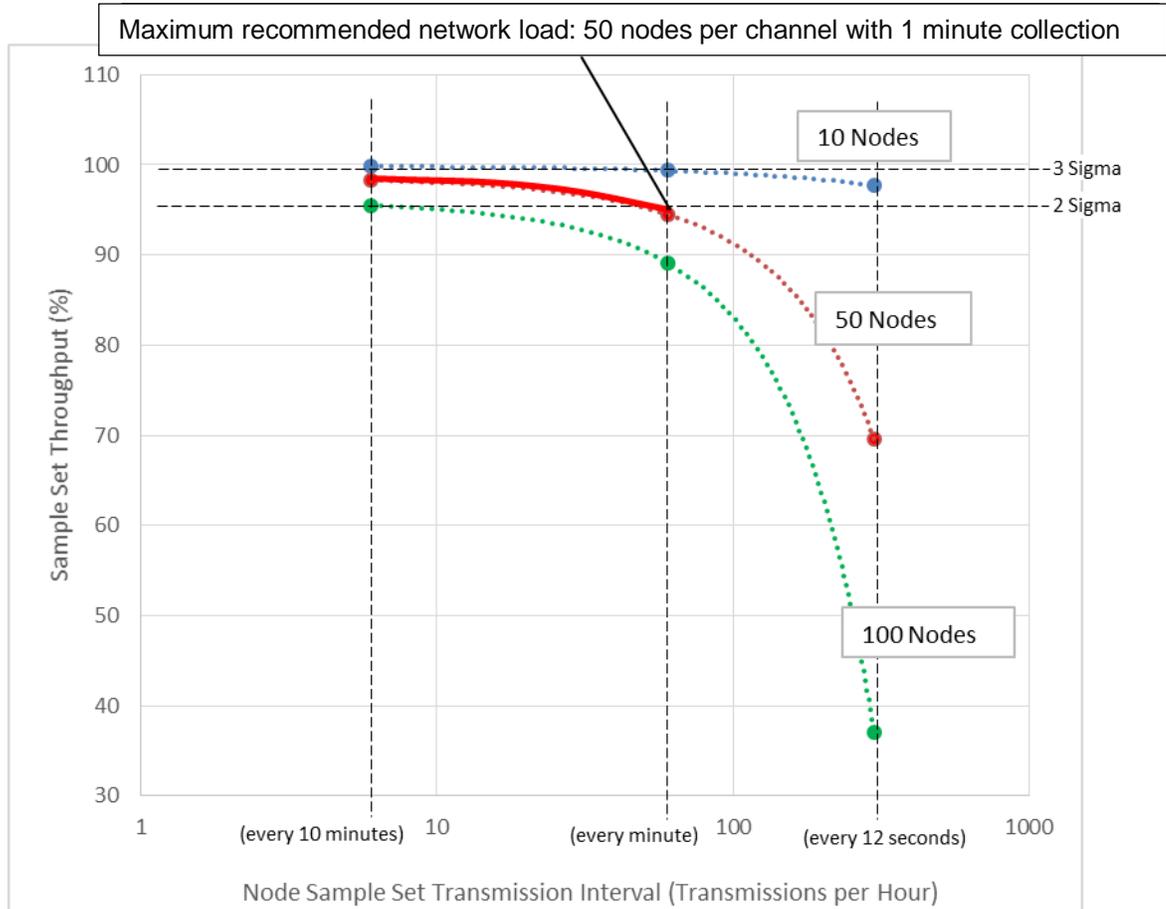
The receivers or channels operate independently and can therefore can be incrementally added (but limited to a maximum of 5) to a Collection Server to increase the number of nodes supported in a given wireless coverage area. For example, in the case where the maximum allowable number of nodes per channel is 50, the total maximum number of nodes supported at each Collection Server is 250.

### Wireless Channel Load

SmartDiagnostics® networks do not have a fixed limit on the number of nodes per channel. However, a nominal starting point for most applications is 50 nodes per channel or 250 nodes per Collection Server. This network size limit ensures that a high 98% throughput is maintained for a typical data acquisition/transmission interval of 10 minutes. Decreasing the sampling interval to every one minute increases the traffic and reduces the data throughput to 95%. At the extreme of sending one vibration data set every 12 seconds, the throughput is further reduced to 70%.

This trade-off in sampling interval, number of nodes, and throughput is shown in the following figure. The channel loading shown in the figure is for a single wireless channel or receiver. These result are based on experimental testing in a controlled environment where external interference (from WiFi and other sources) is minimized.





Notice that a throughput of 95% (2 sigma) is expected for a single channel supporting 100 nodes and transmitting data sets every 10 minutes. This configuration would allow for 500 nodes to be supported in a single wireless coverage area. At the other extreme, a 98% throughput can be expected for 10 nodes transmitting data every 12 seconds.

### Throughput vs. Traffic Density Tradeoff

The SmartDiagnostics® primary sensor node, the SD-VSN-2 (Vibration Sensor Node), acquires data sets that contains 1650 data points. These data sets are transmitted to receivers immediately after the data is acquired. This occurs on a user configurable interval that depends on the particular application. Data sets are typically acquired and transmitted as frequently as once per minute or as infrequently as once per day.

In addition to the data transmissions, the SmartDiagnostics® network also sends a heartbeat packet on a fixed 4 second interval. This heartbeat sustains the network and allows commands to be sent to the nodes on a timely basis.

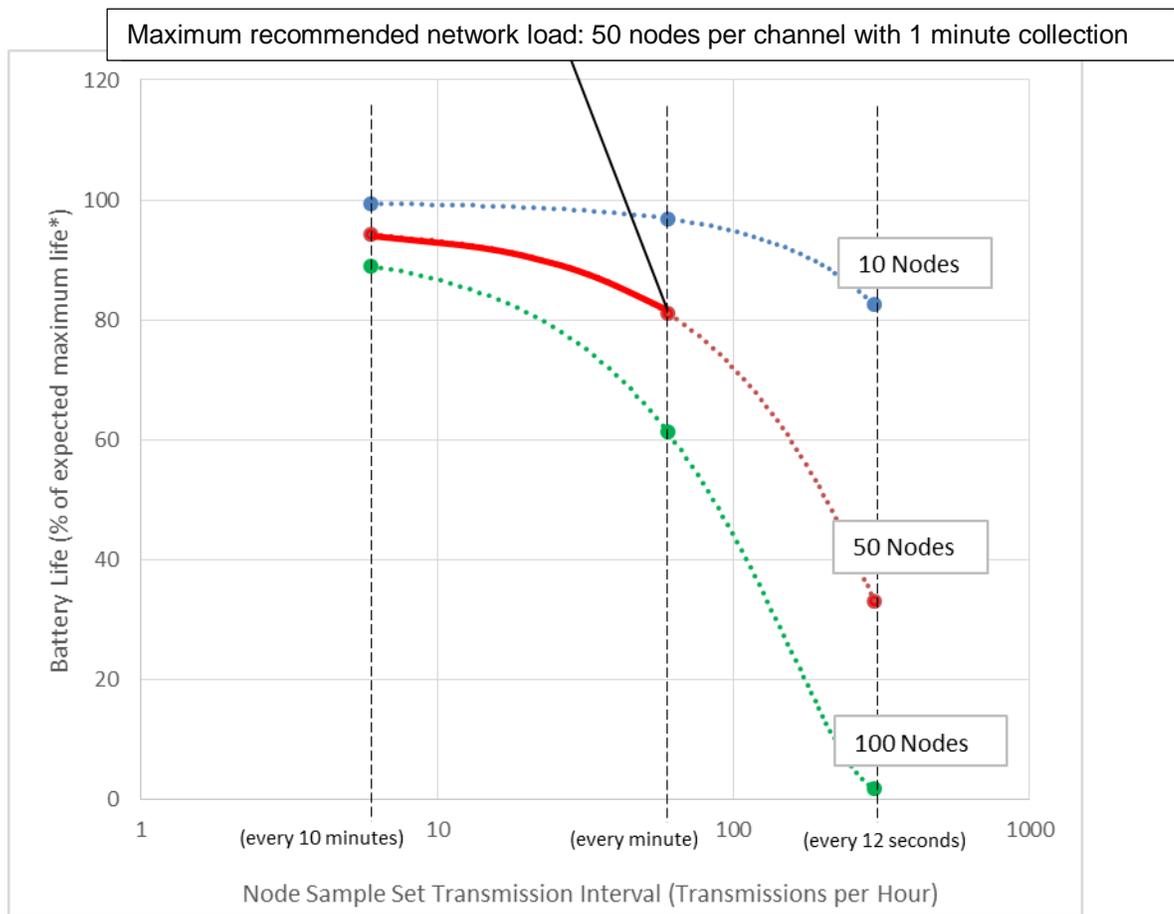
All communication between the sensor nodes and the receiver is acknowledged with a confirmation packet sent by the receiving transceiver. This enables the node to recognize if it should retransmit the data packet.



If data sets are corrupted in anyway due to wireless (over-the-air) packet collisions or other interference, the packets are discarded and the data is resent. To keep problematic transmissions from being repeatedly reissued and ultimately overloading the network, data that is unsuccessfully transmitted after multiple attempts, is discarded and the node stops attempting to send the data. For this reason, achieving high data success and throughput rates in a large network can be traded for network traffic density, as shown in the figures.

### Battery Life Expectations

Heavily loaded networks require additional data retransmissions due to packet collisions and or other interference. These retransmissions influenced the net energy consumed by the node for a given transaction. This in turn influences the battery life. The following plot shows how the battery life is affected by network loading.



\* The maximum expected battery life is shown on the sensor data sheet