BeanDevice®

Version 1.1

BEANAIR®

AGGREGATION CAPACITY
WILOW® WIFI IOT SENSORS

BeanAir

Rethinking Sensing Technology

Wilow

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Contents

1. TECHNICAL SUPPORT 7

2. VISUAL SYMBOLS DEFINITION 8

3. ACRONYMS AND ABBREVIATIONS 9

4. AIM OF THE DOCUMENT 10

5. WSN MODELING 11

6. COEXISTENCE AND INTERFERENCE WITH IEEE 802.15.4 NETWORK 12

7. RELATIONSHIP BETWEEN RF PARAMETERS 13

8. TEST BED SETUP & METHODOLOGY 14
   8.1 Test equipment description 14
   8.2 Methodology 14

9. TEST RESULTS WITH STREAMING MODE 16
   9.1 WSN with three BeanDevice® WiLow AX-3D 16
   9.2 WSN with five BeanDevice® WiLow AX-3D 16
   9.3 WSN with five BeanDevice® WiLow HI-INC 16
   9.4 WSN with two BeanDevice® WILOW AX-3D and three BeanDevice® WILOW HI-INC with the same sampling rate 17
   9.5 Tests summary 17

10. TEST RESULTS WITH STREAMING MODE-BAD WIFI SIGNAL 18
   10.1 WSN with three BeanDevice® WiLow AX-3D 18
   10.2 WSN with five BeanDevice® WiLow AX-3D 18
   10.3 WSN with five BeanDevice® WiLow HI-INC 19
   10.4 WSN with two BeanDevice® WILOW AX-3D and three BeanDevice® WILOW HI-INC with the same sampling rate 19
   10.5 Tests summary 19

11. HOW TO DECREASE DATA LOSS? 20
   11.1 Avoid WIFI connetion issues 20
   11.2 USE Store & Forward 20
   11.3 Use “Tx & Log” or “Log only” 20

List of figures

Figure 1: Wifi and IEEE802.15.4 spectrum 12
Figure 2: Wifi and IEEE802.15.4 frequency offsets 12
Figure 3: Network deployment presentation 15
Figure 4: Network deployment presentation (bad signal) 18
Figure 5: Decrease your sampling rate 20
Figure 6: Store & Forward+ 20

List of Tables

Table 1: Test Equipment List 14
Table 2: Three BeanDevices® WiLow AX-3D 16
Table 3: Five BeanDevices® WiLow AX-3D 16
Table 4: Five BeanDevices® WiLow® HI-INC 16
Table 5: Two BeanDevices® WiLow® AX-3D & Three BeanDevices® WiLow® HI-INC 17
Table 6: Three BeanDevices® WiLow AX-3D 18
Table 7: Five BeanDevices® WiLow AX-3D 19
Table 8: Five BeanDevices® WiLow® HI-INC 19
Table 9: Two BeanDevices® WiLow® AX-3D & Three BeanDevices® WiLow® HI-INC 19

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1. TECHNICAL SUPPORT

For general contact, technical support, to report documentation errors and to order manuals, contact ***BeanAir Technical Support Center*** (BTSC) at:

tech-support@beanair.com

For detailed information about where you can buy the BeanAir equipment/software or for recommendations on accessories and components visit:

www.beanair.com

To register for product news and announcements or for product questions contact BeanAir's Technical Support Center (BTSC).

Our aim is to make this user manual as helpful as possible. Keep us informed of your comments and suggestions for improvements.
BeanAir appreciates feedback from the users of our information.

2. VISUAL SYMBOLS DEFINITION

Symbols	Definition
	***Caution or Warning** – Alerts the user with important information about BeanAir wireless sensor networks (WSN), if this information is not followed, the equipment /software may fail or malfunction.*
	***Danger** – This information MUST be followed if not you may damage the equipment permanently or bodily injury may occur.*
	***Tip or Information** – Provides advice and suggestions that may be useful when installing BeanAir Wireless Sensor Networks.*

3. ACRONYMS AND ABBREVIATIONS

LQI	Link quality indicator
PER	Packet error rate
WLAN	A wireless local area network links two or more devices over a short distance using a wireless distribution method.
WSN	Wireless Sensor Network
LOS	Line-of-sight
Mb	Mega-Bytes
Mbps	Mega-Bytes per second
RF	Radio Frequency
P_{rf}	Radio Power. (Unit : dBm)
dBm	It's an abbreviation for the power ratio in decibels (dB) of the measured power referenced to 1 milliwatt (mW): 18 dBm = 63 mW.
FTP	File Transfer Protocol is a standard network protocol used to transfer files from one host to another host over a TCP-based network.
TCP	The Transmission Control Protocol is one of the core protocols of the Internet Protocol Suite.
m	Meter(s)
RSSI	Received Signal Strength Indication
SSD	System Shock Detect

4. AIM OF THE DOCUMENT

Like a highway that is tightly tucked between a mountain cliff and a lake or an ocean, Wireless IOT sensors are subject to limitations due to a similar lack of a physical resource –namely wireless bandwidth. Like congested road systems in highly populated metropolitan areas, Wireless IOT sensors are unequally solicited by a various type of wireless sensors (temperature, tilt, vibration…). One way or another, we need to share the wireless bandwidth, just as we share the public road and highway systems.
The aim of this document is to characterize the aggregation capacity of Beanair Wireless IOT sensors.
This document is not intended to study radio interferences on the WIFI 2.4 GHz Band, but it helps the end user to determine the network bandwidth on a Wireless IOT sensors by stochastic calculus.
"**Streaming**" data acquisition mode was used during these tests.

Please note that these computed values will change, depending heavily on the environment.

5. WSN MODELING

Aggregation capacity of WSN includes the amount of data packets transmitted, received or lost during a short period.

The capacity of WSN can be modeled by the following parameters:

- **LQI** Link Quality Indicator

LQI is equivalent to Received Signal Strength Indication (RSSI).
The LQI value is between 0 and 255.
As close to 255 is the LQI, higher is the received signal power.

- **PER** $\text{Abslute Packet Error Rate} = \sum_{k=0}^{n} \frac{\text{Packets Lost(n)}}{\text{Packets Sent}}$

  (e.g.: 3 of 1000 Packets lost on the network/on a device)

- **Bandwidth** $\text{Bandwitdh} = \sum_{k=0}^{n} \text{BeanDevice}_n * \text{Sampling Rate}_n$

6. COEXISTENCE AND INTERFERENCE WITH IEEE 802.15.4 NETWORK

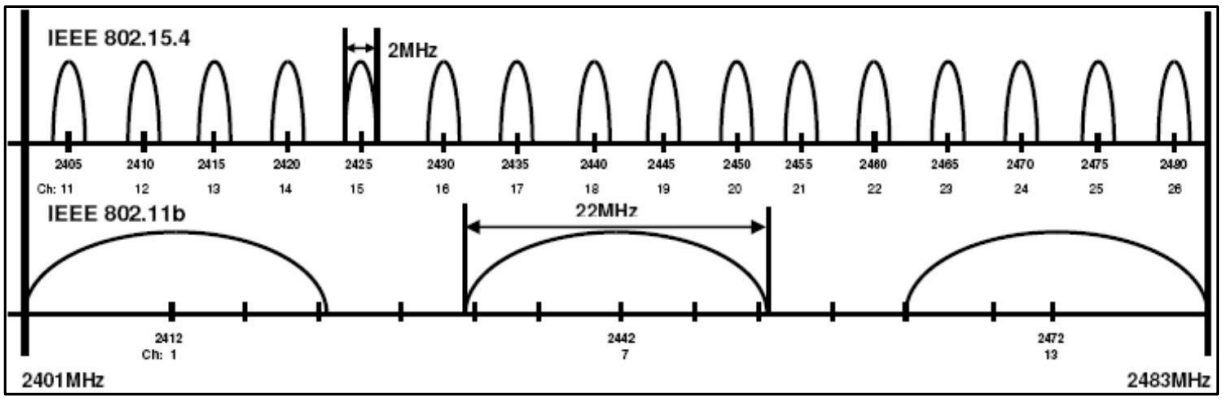


Figure 1: Wifi and IEEE802.15.4 spectrum

Frequency Offsets		IEEE 802.11b/g		
		Channel 1 2412 MHz	**Channel 7** 2442 MHz	**Channel 13** 2472 MHz
IEEE 802.15.4	**Channel 15** 2425 MHz	13 MHz	17 MHz	47 MHz
	Channel 16 2430 MHz	18 MHz	12 MHz	42 MHz
	Channel 21 2455 MHz	43 MHz	13 MHz	17 MHz
	Channel 22 2460 MHz	48 MHz	18 MHz	12 MHz

Figure 2: Wifi and IEEE802.15.4 frequency offsets

For further information, please read the following technical note:

TN_RF_011 – "Co-existence of Beanair WSN at 2.4 GHz"

7. RELATIONSHIP BETWEEN RF PARAMETERS

- There is no standard formula to compute the LQI, which depends on chipmakers.
- In a quiet environment, PER will decrease as LQI decreases, however, if there is any interference, the PER can decrease with no significant changes observed on the LQI.
- RSSI is an indication of the power level being received by the antenna. Generally, the higher the RSSI level is the stronger the signal.

During the test procedures, we admit:

- One RF channel is selected
- Network and PAN addresses are static.
- RSSI value is high

Aggregation capacity of a WSN depends on the following influence factors:

- Wireless Range
- RF Transmission Power
- Obstacles (Water, Metal, …)
- WSN density (number of BeanDevice® on the same network)
- Sampling Rate per BeanDevice® (0 to 3kHz)
- Number of sensor channel on the same BeanDevice® (1 to 4)
- Antenna (type, length, …)
- Interference Source (Wi-Fi, Bluetooth….)

8. TEST BED SETUP & METHODOLOGY

8.1 TEST EQUIPMENT DESCRIPTION

The test bed consisted of the following devices under test (DUT):

- **WIFI Access Point**

- **BeanDevice® WiLow AX-3D (+/- 2g)**
  - Powered by internal battery 780mAh

- **BeanDevice® WiLow AX-3DS (+/- 2g)**
  - Powered by internal battery 780mAh

- **BeanDevice® WiLow HI-INC (15° et 30° Monoaxis and Biaxis)**
  - Powered by internal battery 780mAh

- **Laptop with the BeanScape® software installed**

Type	Product Type	Quantity	Number of sensor channels	Soft Version
Protocol Stack	IEEE 802.11 b/g/n			
Topology	Star Network			
WIFI Access Point	Any WIFI Access Point	1		
BeanDevice®	BeanDevice® WiLow AX-3D	3	3	V3.0
	BeanDevice® WiLow AX-3DS	1	3	V3.0
	BeanDevice® WiLow HI-INC	5	2	V3.0
BeanScape®	BeanScape® Wilow RA	1		3.2.0.2

Table 1: Test Equipment List

8.2 METHODOLOGY

- "Streaming" mode function is evaluated during these tests plan.
- Network behavior will be studied with different sampling frequency.
- Each test iteration was run with a 10 minutes duration, and each test repeated three times to ensure repeatability of results;

- The distance observed between the BeanDevice® and the WIFI Access Point is 10 meters.

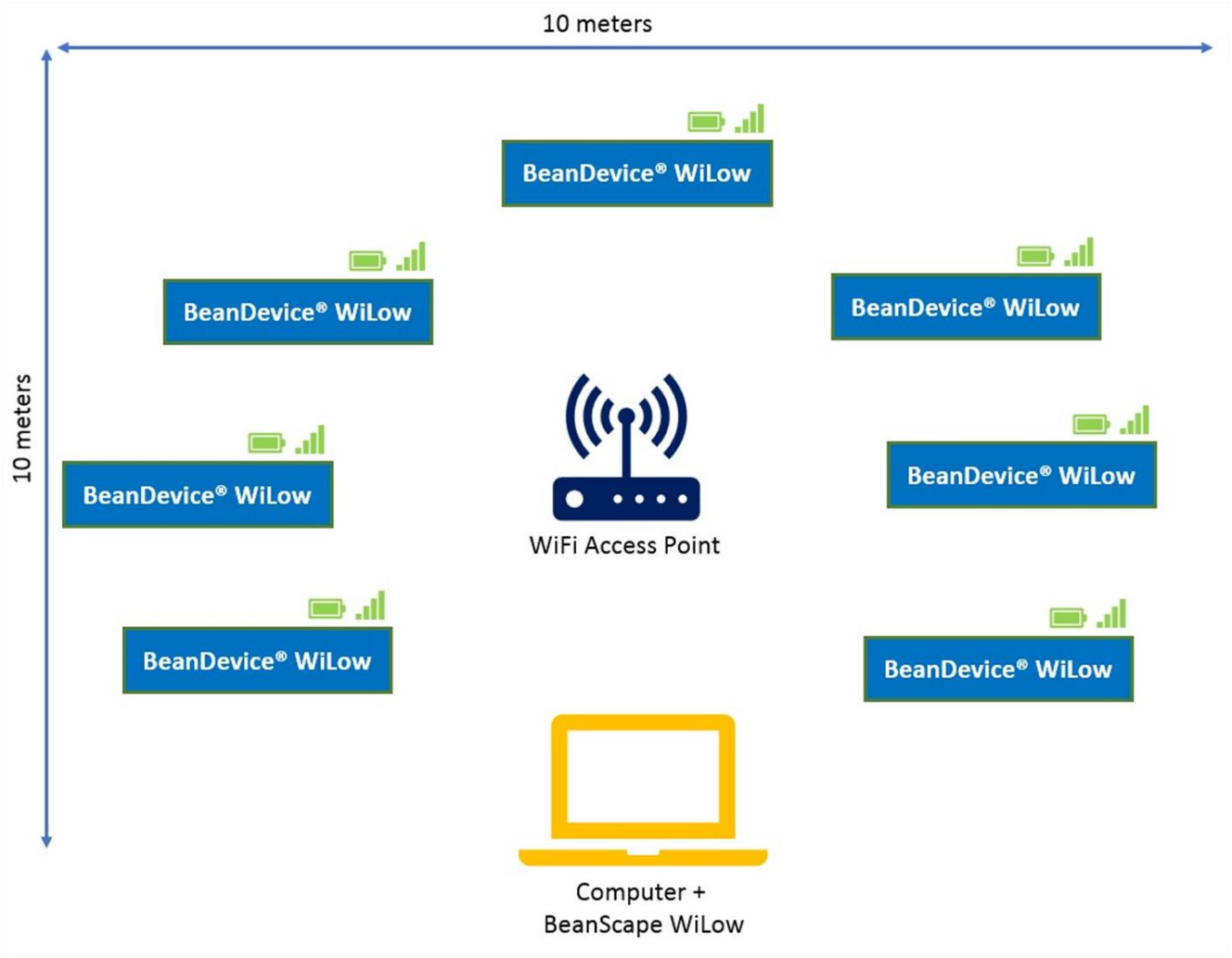


Figure 3: Network deployment presentation

For further information about the streaming packet mode, please read the technical note:

TN_RF_008 – "Data acquisition modes available on the BeanDevice®"

9. TEST RESULTS WITH STREAMING MODE

All the BeanDevices® were configured with the same sampling rate.

9.1 WSN WITH THREE BEANDEVICE® WILOW AX-3D

BeanDevice® Sample Rate (Hz)	PER 1 (%)	PER 2 (%)	PER 3 (%)
100	0,00	0,00	0,00
400	0,00	0,00	0,00
800	0,00	0,00	0,00
1000	0,00	0,00	0,00

Table 2: Three BeanDevices® WiLow AX-3D

9.2 WSN WITH FIVE BEANDEVICE® WILOW AX-3D

BeanDevice® Sampling Rate (Hz)	PER 1 (%)	PER 2 (%)	PER 3 (%)	PER 4 (%)	PER 5 (%)
100	0,00	0,00	0,00	0,00	0,00
400	0,00	0,00	0,00	0,00	0,00
800	0,00	0,00	0,00	0,00	0,00
1000	0,00	0,00	0,00	0,00	0,00

Table 3: Five BeanDevices® WiLow AX-3D

9.3 WSN WITH FIVE BEANDEVICE® WILOW HI-INC

BeanDevice® Sampling Rate (Hz)	PER 1 (%)	PER 2 (%)	PER 3 (%)	PER 4 (%)	PER 5 (%)
100	0,00	0,00	0,00	0,00	0,00
400	0,00	0,00	0,00	0,00	0,00
800	0,00	0,00	0,00	0,00	0,00
1000	0,00	0,00	0,00	0,00	0,00

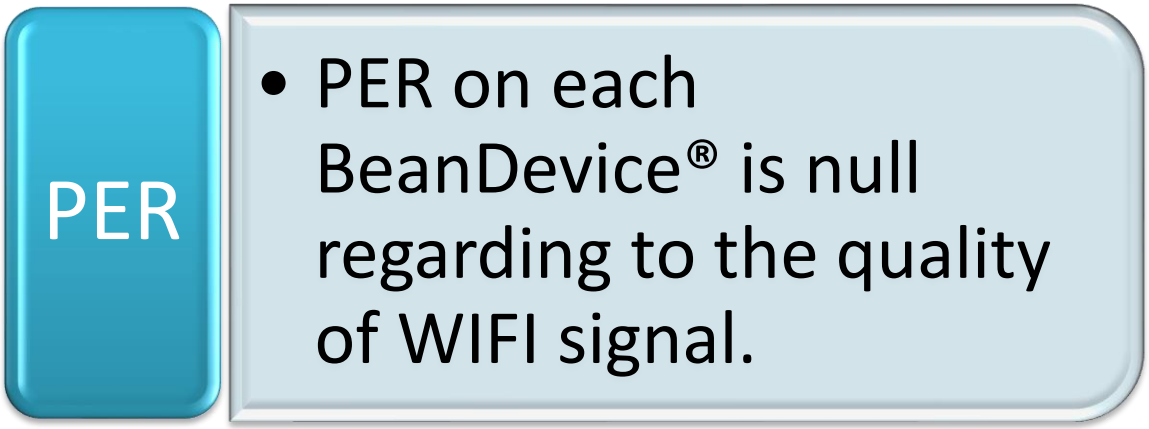
Table 4: Five BeanDevices® WiLow® HI-INC

9.4 WSN WITH TWO BEANDEVICE® WILOW AX-3D AND THREE BEANDEVICE® WILOW HI-INC WITH THE SAME SAMPLING RATE

BeanDevice® Sampling Rate (Hz)	AX3D PER 1 (%)	AX3D PER 2 (%)	HI-INC PER 3 (%)	HI-INC PER 4 (%)	HI-INC PER 5 (%)
100	0,00	0,00	0,00	0,00	0,00
400	0,00	0,00	0,00	0,00	0,00
800	0,00	0,00	0,00	0,00	0,00
1000	0,00	0,00	0,00	0,00	0,00

Table 5: Two BeanDevices® WiLow® AX-3D & Three BeanDevices® WiLow® HI-INC

9.5 TESTS SUMMARY



10. TEST RESULTS WITH STREAMING MODE-BAD WIFI SIGNAL

In this scenario, we will use the same methodology but with a bad WIFI signal

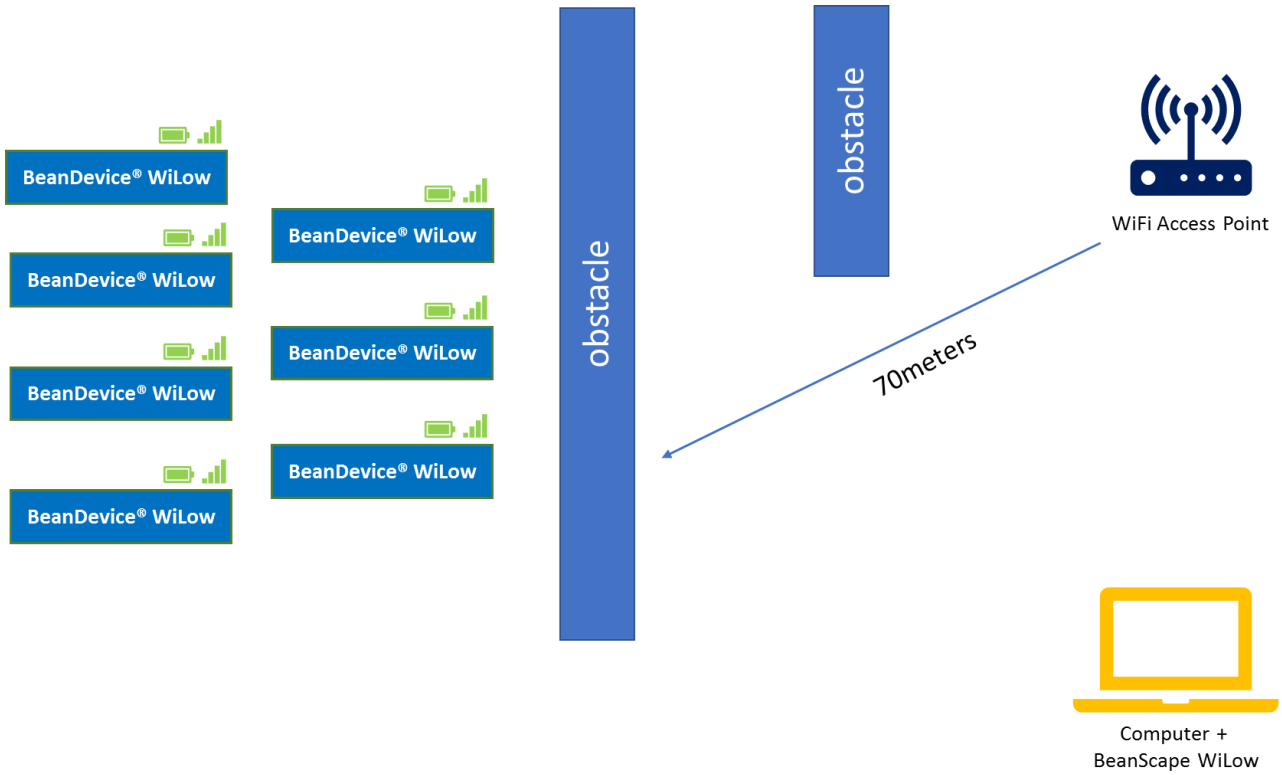


Figure 4: Network deployment presentation (bad signal)

10.1 WSN WITH THREE BEANDEVICE® WILOW AX-3D

BeanDevice® Sample Rate (Hz)	PER 1 (%)	PER 2 (%)	PER 3 (%)
100	0,16	0,17	0,20
400	0,19	0,21	0,21
800	0,22	0,22	0,26
1000	0,31	0,34	0,40

Table 6: Three BeanDevices® WiLow AX-3D

10.2 WSN WITH FIVE BEANDEVICE® WILOW AX-3D

BeanDevice®	PER 1 (%)	PER 2 (%)	PER 3 (%)	PER 4 (%)	PER 5 (%)

Sampling Rate (Hz)					
100	0,16	0,18	0,18	0,18	0,15
400	0,22	0,23	0,22	0,27	0,23
800	0,52	0,61	0,64	0,57	0,59
1000	0,62	0,73	0,78	0,77	0,91

Table 7: Five BeanDevices® WiLow AX-3D

10.3 WSN WITH FIVE BEANDEVICE® WILOW HI-INC

BeanDevice® Sampling Rate (Hz)	PER 1 (%)	PER 2 (%)	PER 3 (%)	PER 4 (%)	PER 5 (%)
100	0,14	0,16	0,15	0,19	0,15
400	0,19	0,17	0,21	0,19	0,22
800	0,47	0,59	0,55	0,61	0,49
1000	0,74	0,88	0,78	0,96	0,89

Table 8: Five BeanDevices® WiLow® HI-INC

10.4 WSN WITH TWO BEANDEVICE® WILOW AX-3D AND THREE BEANDEVICE® WILOW HI-INC WITH THE SAME SAMPLING RATE

BeanDevice® Sampling Rate (Hz)	AX3D PER 1 (%)	AX3D PER 2 (%)	HI-INC PER 3 (%)	HI-INC PER 4 (%)	HI-INC PER 5 (%)
100	0,18	0,19	0,16	0,17	0,17
400	0,21	0,27	0,19	0,19	0,19
800	0,47	0,52	0,46	0,42	0,53
1000	0,91	0,94	0,83	0,77	0,91

Table 9: Two BeanDevices® WiLow® AX-3D & Three BeanDevices® WiLow® HI-INC

10.5 TESTS SUMMARY

- PER on each BeanDevice® is increasing regarding to the quality of WIFI.
- PER value increase regarding to the sampling rate of the BeanDevice®.

11. HOW TO DECREASE DATA LOSS?

11.1 AVOID WIFI CONNETION ISSUES

As shown in section 11, your WSN could be exposed to network saturation as much as your WIFI signal is bad or interrupted and this can be clearly noticed when the sampling rate is higher. This problem could be multiplied if you are running too much BeanDevices.

Figure 5: Decrease your sampling rate

11.2 USE STORE & FORWARD

BeanDevice® WiLow® can operate in Store and Forward to avoid data loss. This technology let the BeanDevice® store in its own memory a sequence of measurements in Streaming mode and interact with BeanScape® to detect an interruption of connection and replace the lost data to keep your streaming data safe.

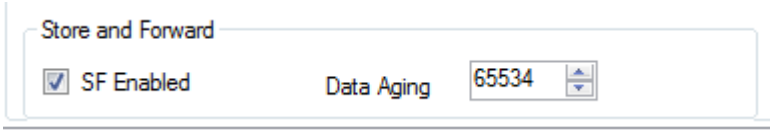


Figure 6: Store & Forward+

11.3 USE "TX & LOG" OR "LOG ONLY"

The BeanDevices integrate an internal Datalogger on which samples could be stores and then downloaded through the BeanGateway.

When operating with the Datalogger, there is no Data transmitted from BeanDevice to BeanGateway. So, the user should not be afraid about any data loss through radio transmission.

In the Tx&Log mode, the Datalogger is enabled at the same with the radio transmission as a backup to store Data when there is an issue with the network such as Network cut or saturation.

For further information about the Datalogger, please read the technical note:

"TN-RF-007-BeanDevice-wireless-sensor-DataLogger-User-Guide"