

The space occupancy (headcount) sensor



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TECHNICAL REPORT 2017

www.wirelessthings.biz

Executive summary

The space occupancy sensor (OCCUSENSE) is an innovative device that can be used in order to measure the space occupancy/ population, i.e., **the number of people in a space** (room, floor, whole building). In the general case a **space occupancy sensor** consists of a **wireless network of direction detection sensors**.

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Why occupancy?

We typically factor energy use to square meters and not occupants, as if energy is meant to serve square meters and not humans. The reason we prefer to do this is however simple; **it is because of the difficulties in metering occupancy/ headcount.** A different realm will emerge when occupancy metering will enter the mainstream. We will then stop factoring energy to square meters and allocate it to humans (headcount). **Our efficiency indicators are then bound to radically change. They will then make more sense and provide more insight.**

Occupancy allows a **better understanding of how efficiently and/ or intensely spaces are used through time. This applies to far more aspects than energy alone.**

What it is?

A space occupancy sensor consists of a wireless network of direction detection sensors. A direction detection sensor includes

- a WT Baseboard device, equipped with a **microprocessor and a wireless, 802.15.4 compliant radio chip**
- a extension board code that ports two **PIR elements** (passive infrared); these receive infrared radiation from people entering/ exiting the monitored space.
- **Software that is ported on a microprocessor** which receives the signals from PIR element, analyses them, sets thresholds and eventually identifies the direction of the movement

How it works?

One OCCUSENSE needs to be installed in every entrance point. If we have for example 5 points of entrance, 5 direction detection sensors will be needed

All direction detection sensors communicate with a **gateway** by a 802.15.4 (wireless communication protocol for local network of sensors). The gateway calculates, in the real time, the space occupancy and updates a **web application** that reports it to the via a **dashboard** to the target audiences.

The figure below illustrates the principle of operation.

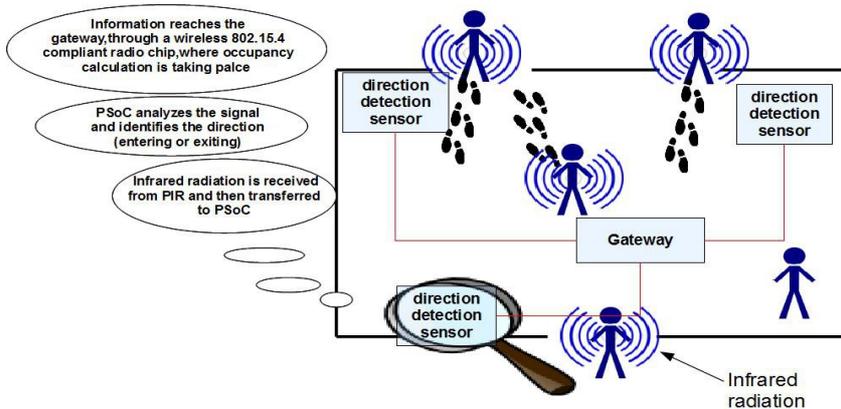


Figure 1: Occupancy sensor for spaces with multiple points of entrance

How is it powered?

The module is battery powered; a mains powered version exists but it is unlikely that it will be preferred as it will require cabling that may compromise the aesthetics or performance of the installation frame.

The battery status is reported to the dashboard/ smart phone. If one so wishes he can also set to receive notifications, should the voltage drop below a specified level (typically 2.55 V)

Board Illustrations

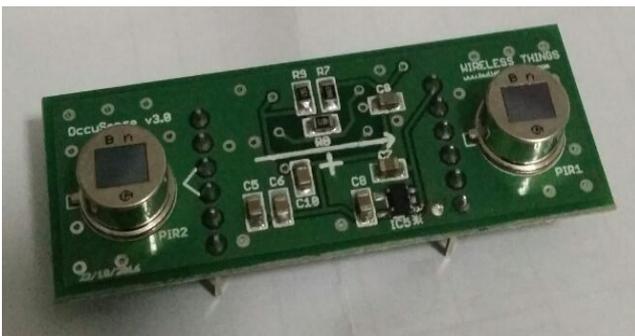


Figure 2: The OCCUSENSE sensor, above; integrated within the baseboard, right



Reporting to the dashboard

The following figure illustrates a two entrance space monitored for occupancy.

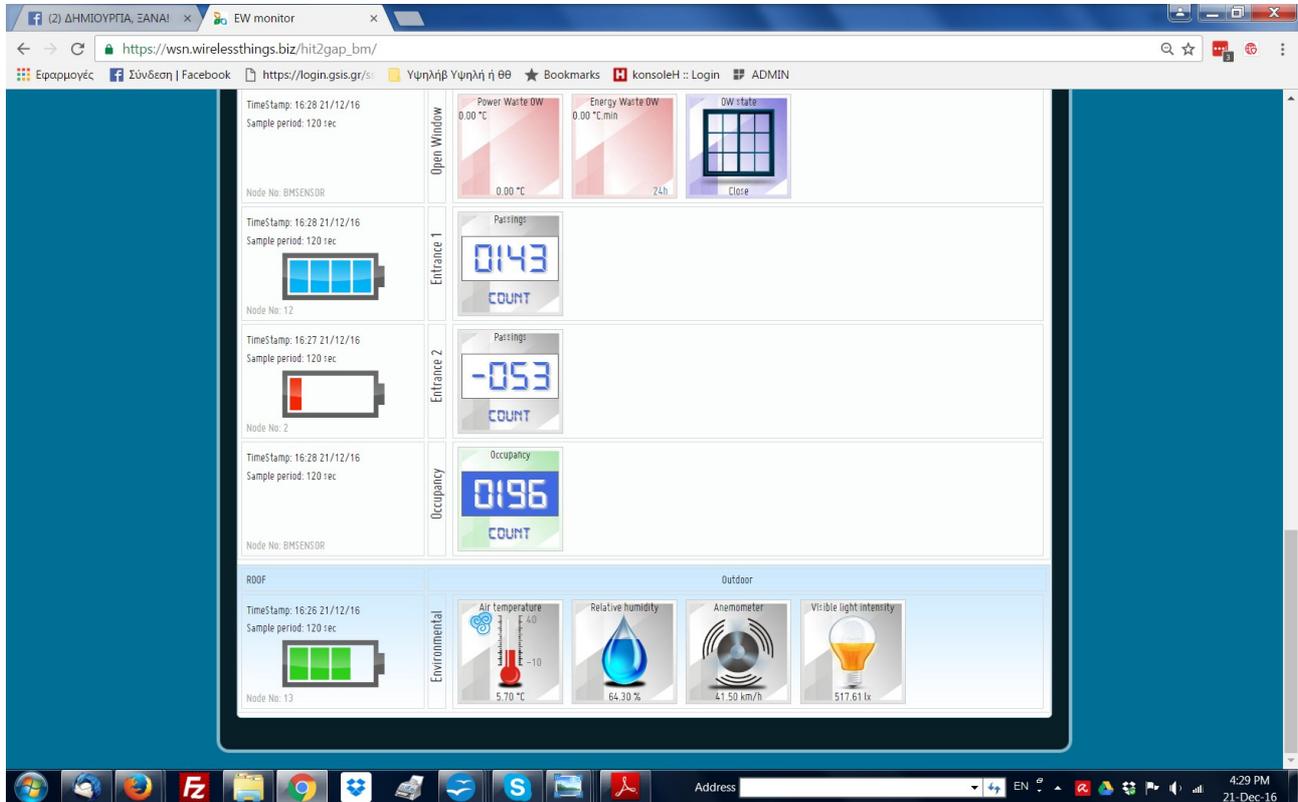


Figure 3 : Dashboard reporting of the network occupancy sensor

In this figure we have a two space entrance;

- passers from entrance 1 are set to increase the space counter if they **enter** the space; 143 therefore means that overall 143 people have moved in the space
- passers from entrance 2 are set to increase the space counter if they **exit** the space; -53 therefore means that overall -53¹ people have moved out, or, equivalently 53 people have moved in the space

Therefore, the headcount is $143 - (-53) = 196$ as reported by the occupancy network sensor .

¹In the WT admin one can flexibly set this relation

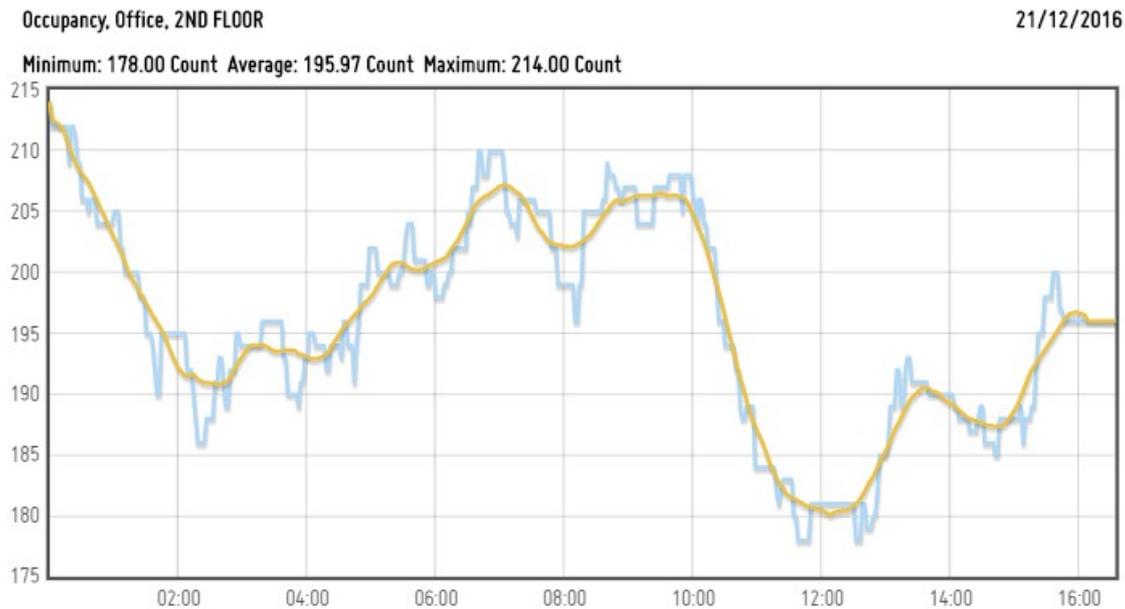


image generated by the hit2gap_bm dashboard at https://wsn.wirelessthings.biz/hit2gap_bm

Figure 4: Typical history chart of the occupancy sensor showing how the space occupancy changed within the selected period

Specifications

There are several limitations that must be observed for a correct use of the OCCUSENSE

a. Battery lifetime

The lifetime of the battery will critically depend on the

- sampling/ dashboard reporting time
- number of passers by

Note! Sampling/ reporting time will not affect the accuracy of occupancy but will affect how up-to-date our dashboard value is. If sampling is set to 10 minutes then we will have the correct value only every ten minutes; it is then that the dashboard will be updated by the fresh value of the network sensor.

The table below illustrates how these two parameters will affect the occupancy metering. Please check with this table to have an accurate estimation of your OCCUSENSE battery lifetime depending on the two above parameters .

Note! Currently a battery optimization is in process that will significantly reduce the sampling consumption per passer pay, that is currently 2 mAs. This is a software

amendment and when available it may be flashed on all installed OCCUSENSEs.

Reporting/ sampling	N	[1] 1 sample/ 2 min	[2] 1 sample/ 5 min	[3] 1 sample/ 10 min	[4] 1 sample/ 30 min	
Throughout	S	[1] 1 passer/min	[2] 5 passers/ min	[3] 10 passers/ min	[4] 20 passers/ min	
N1/ S1		135 N2/ S1		238 N3/ S1	319 N4/ S1	412
N1/ S2		102 N2/ S2		151 N3/ S2	179 N4/ S2	206
N1/ S3		78 N2/ S3		103 N3/ S3	116 N4/ S3	126
N1/ S4		53 N2/ S4		63 N3/ S4	68 N4/ S4	71

Figure 5: Battery lifetime (days) based on sampling rate(N) and flow of passers by (S); the yellow cells are good combinations as they correspond to a lifetime between 3- 12 months

b. Installation

The sensor can be installed (glued) on the side or top frame of a door or even to distances up to 1.5 meters; however it must be certain that the sensor is only aiming at passers by (in or out) of the space through the particular entrance and is not affected by other space residents, people walking outside, etc.

c. Space temperature

The sensor is based on the temperature difference between the human and the ambient environment. For correct operation the passing human (31-33 degrees skin temperature) must have 1-2 degrees difference from the ambient temperature. This means that the sensor may not work accurately for ambient temperatures above 30 degrees Celsius.

d. Operational limitations

Please, before installing an OCCUSENSE consider the following limitations

- People entering/ exiting side by side will also not be identified as separate individuals
- People standing in front of the sensor may confuse him and introduce an error

You will have to evaluate the frequency of such events as they will affect your OCCUSENSE accuracy. **Clear passings will always be accurately registered.**

We are working on filtering out these marginal situations via signal processing and machine learning techniques; in a future release of OCCUSENSE (2018) these issues will most likely have been addressed.

Richard Crossman (UK) pilot validation

Pending. To be completed by April 2017

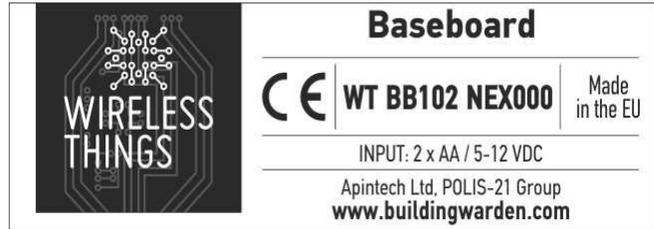
Annex

Attached you may find the **data-sheets** of the

- Baseboard module
- its OCCUSENSE sensor extension

as well as the OccuSense **leaflet**, also with pricing info.

Baseboard



Description

The Baseboard module allows the connection of WT extension boards and/or a range of external sensors that produce an output of the following types:

- Digital (pulse)
- Analog (volt, mA)
- UART

The module samples the sensors and transmits the data to the network gateway connected to a PC, on which the management software is running and then to the internet WT dashboard application. If the distance between the module and the gateway is big, the module will automatically seek other, closer modules to send its data. If they are not available, in between relaying modules will be necessary.

Features

The module includes a 802.15.4 transceiver on 868MHz and a Msp430 microprocessor. The microprocessor runs a firmware for sensor data sampling, data routing as well as control operations. The module configuration options (e.g. sampling frequency) are done from the management software and transferred wirelessly to the module. The firmware of the module can be updated either through a USB connection or Over-The-Air (AirFlash).

The module may be combined with any standard WT extension board and/or external sensors. Both on board and external sensors can be combined and data can be all transmitted via the same wireless transceiver. The module can work on batteries (depending on the external sensors/extension board connected) or with external power supply. The exact pin connectivity for the external sensors is shown below (see Connections).

Specifications

Name of the Product	Baseboard
Brief Description	Wireless device for external sensors measurement
Rated Supply voltage (V, Hz, A)	2xAA/9V Battery OR external power supply 5-12VDC, 500mA
Weight	12gr (without batteries or extension board)
Size (H x L x W)	31mm X 113.82mm X 63.32mm
Connections	VDB, GND, 4xAIN, 3xAUX, 3xDIO
Data transmission distance	500m (open air) – up to 20m (within buildings)
Standards	LVD EN 50491-3 & EMC/ RTTE (ETSI 301 489-3, ETSI 301 481-1, EN 50491-5-2)
Operating Temperature	+/- 40 Celsius
Operating Humidity	10- 90%
Enclosure	plastic available in three colors; transparent blue, gray, black

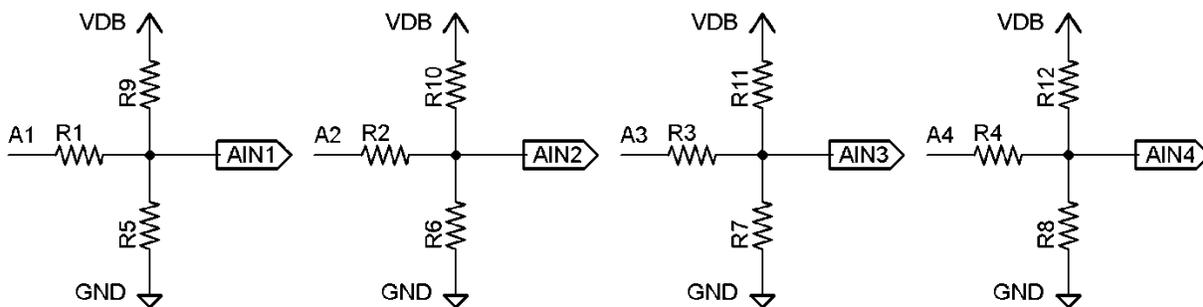
Connections

a. Extension Board: connection of standard WT extension boards

b. External Sensors: pins for the connection of external sensors are as follows

- GND: connection to GROUND
- A1, A2, A3, A4: analog inputs (with custom resistor dividers) [1]
- XS: configurable connection (see Jumpers Configuration)
- X2, X3: direct connection to the extension board
- D1: Digital I/O – UART Rx
- D2: Digital I/O – UART Tx
- D3: Digital I/O
- VDB: Voltage output [2]

[1]: Each analog input pass through a resistor divider network depending on the needs of the sensor connected. The resistors should be defined by the user and are not included on the board.



Baseboard-Product datasheet

[2]: When 2xAA batteries are installed (2xAA variant), voltage output is connected directly to the batteries providing a voltage that depends on the state of charge of the batteries (2.5-3V). When a 9V battery is installed (9V variant) or external power supply is connected, voltage output is provided through the on-board regulator (3.3V, max 150mA).

External power supply must be 5-12VDC, min 500mA with 2.1mm diameter pin.

Variants

Two variants of the module are available according to the type of batteries that can be installed: 2xAA or 9V.

2xAA variant: The module accepts 2xAA batteries. The voltage of the batteries is provided to the VDB pin of the external connector.

9V variant: The module accepts a 9V battery. The voltage of the battery is provided to the XS pin of the external connector (see Jumpers Configuration).

Both variants can be connected to an external power supply. The selection of batteries or power supply depends on the nature of the extension boards and external sensors. The data sheets of the extension boards provide information on this point.

Batteries will last several months; their lifetime is affected by the sampling frequency and the nature of the extension board or external sensor.

Jumpers Configuration

On-board jumpers configure various aspects of connections and voltage provided.

JA6 on: firmware controls external power supply/9V connection to XS pin of external connector (when **JXS12 on**) and/or to extension board (when **JVX on**)

JSI on: external power supply/9V directly connected to XS pin of external connector (when **JXS12 on**) and/or to extension board (when **JVX on**)

JXS12 on: connects external power supply/9V to XS pin of external connector (when **JSI on** OR when **JA6 on** through firmware control)

JXS23 on: XS pin of external connector is connected directly to the extension board

JVX on: connects external power supply/9V to extension board (when **JSI on** OR when **JA6 on** through firmware control)

JA7 on: allows firmware to measure the voltage level of external power supply/9V (when **JSI on** OR when **JA6 on** through firmware control)

Coding

Baseboard modules are coded as **WT BBxxx yyyzzz**

where:

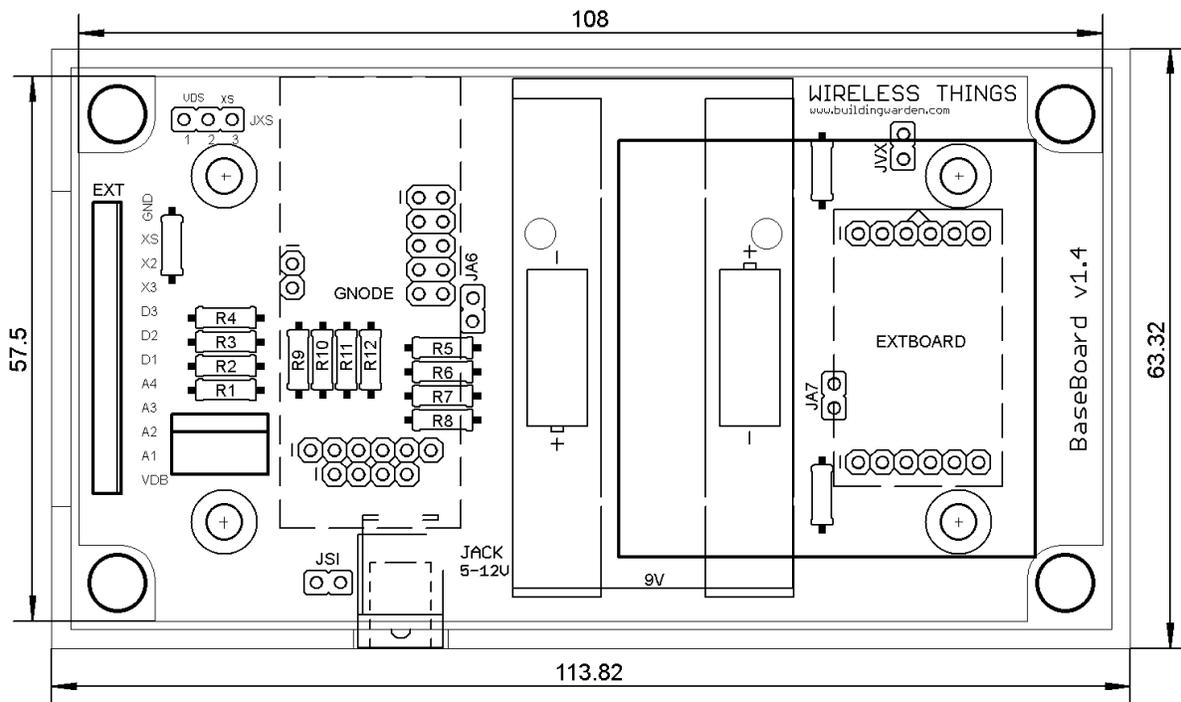
xxx = version of BaseBoard

yyy = type of extension board installed or NEX (no extension board)

zzz = version of extension board or 000 (no extension board)

See relevant extension board datasheet for more information.

Layout



Dimensions in mm.

Occusense



Description

OccuSense is an extension board fitted onto a Baseboard. It is used to count the number of people entering/exiting a space through an entrance of the space. For each entrance of the space a Basebord-OccuSense module is needed. Eventually, the space occupancy is estimated. A Baseboard with an OccuSense extension board can operate on 2xAA batteries for several months.

Installation

A Baseboard-Occusense module is preferably installed on the side frame of the entrance, facing at the opposite side, at a height of around 1.2m. It can also be installed at the middle of the top frame, if the width of the entrance is no more than 1m and at a height no more than 3m, facing downwards. In each case, the orientation of the module must match the direction of movement through the entrance. Alternative installations are also possible provides the line of sight of the sensor is not affected by other people mobility, in or out the space

Accuracy

In general, the module can be 100% accurate, but there are several factors that have to be considered for the best accuracy:

- the temperature of the space is less than 30° C
- people are not standing in front of the sensor
- people are not passing through the entrance side-by-side
- people passing through the entrance are separated by at least 20cm

Real time delay

The real space occupancy each moment will be delayed according to the reporting frequency of the modules installed. The shorter the reporting frequency, the faster the estimated space occupancy will match the real one, but the battery lifetime will be reduced. For example, if all installed modules are configured to report at a frequency of 2 minutes, this is the maximum time the real occupancy will be delayed. If the modules are configured in different reporting frequencies, the bigger one determines the delay.

Specifications

Name of the Product	Baseboard- Occusense
Brief Description	Wireless device for sensing direction
Rated Supply voltage (V, Hz, A)	2xAA Battery OR external power supply 5-12VDC, 500mA
Weight	gr
Size (H x L x W)	31mm X 113.82mm X 63.32mm
Connections	12: VOUT (3.3V OR SUPPLY)
Max. clock frequency	16MHz
Data transmission distance	500m (open air) to 10- 20m (within buildings)
Standards	LVD EN 50491-3 EMC/ RTTE (ETSI 301 489-3, ETSI 301 481-1, EN 50491-5-2)
Operating Temperature	- 10 Celsius to 40 Celcius
Enclosure	Grey/ Black/ Blue plastic box

Battery lifetime

The lifetime of the battery will depend on the number of people passing through and on the frequency the module is reporting the counts. The table below gives an estimate of the battery

lifetime.

Battery lifetime (months)		Passings/hour (count)			
		30	60	300	600
Reporting frequency (minutes)	2	4.7	4.6	3.6	2.9
	5	8.7	8.2	5.5	3.9
	10	12	11.1	6.7	4.5
	30	16.2	14.5	7.8	5

Coding

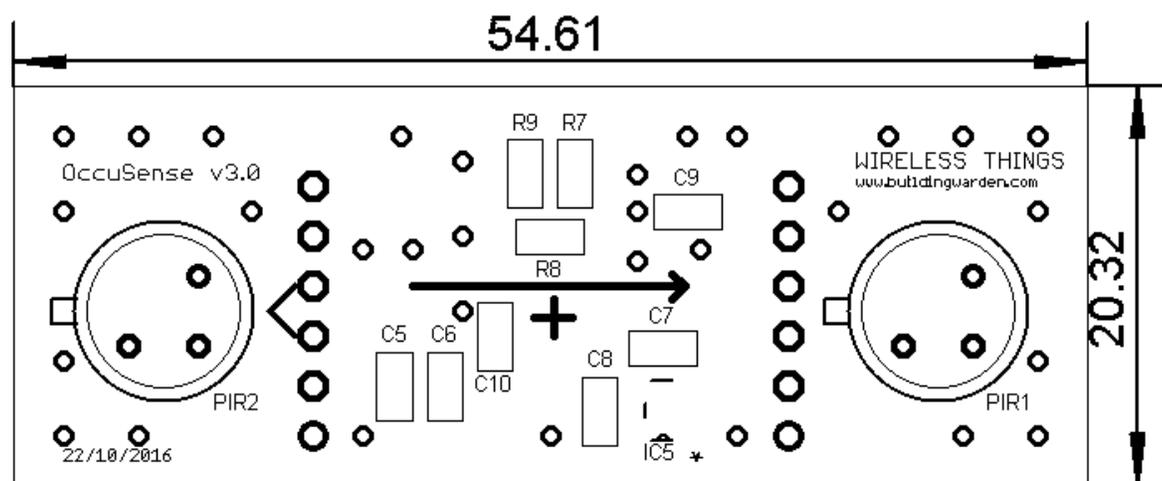
Baseboard modules with OccuSense extension board are coded as **WT BBxxx OCCzzz**

where:

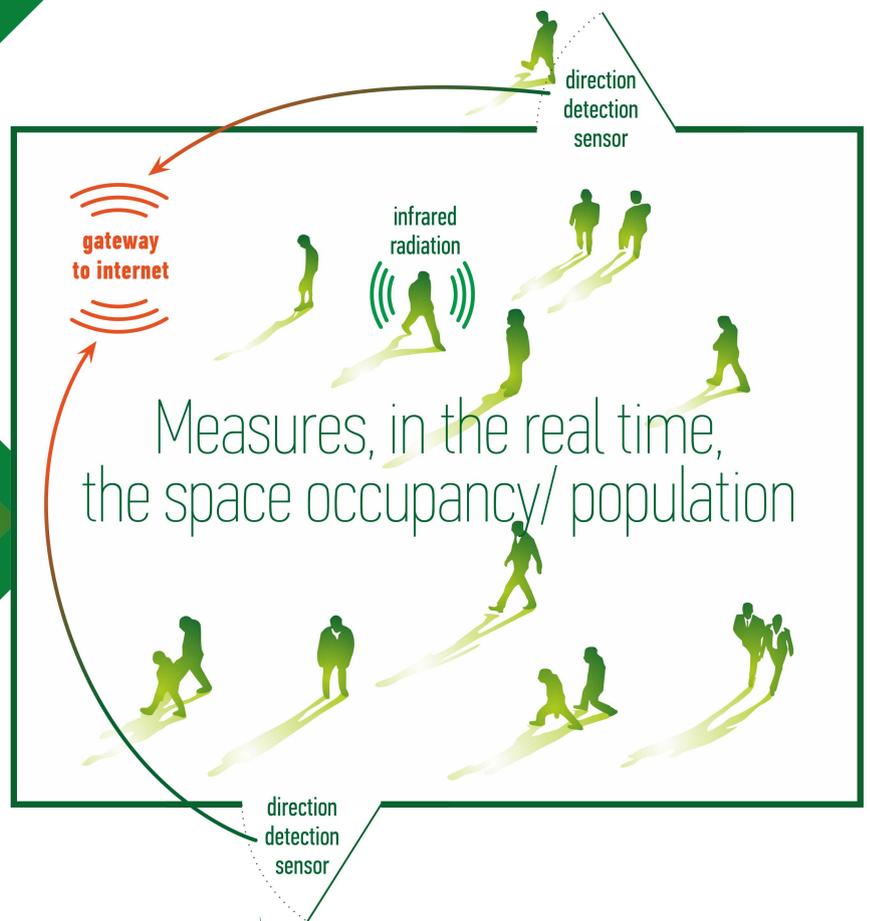
xxx = version of BaseBoard

zzz = version of Occusense extension board

Layout



WT-OccuSense



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WT-OccuSense

Headcount your spaces!

Measures, in the real time, the **space occupancy/ population**, i.e., the number of people in a space (room, floor, whole building). In the general case, where the space may have many entrances the space occupancy sensor is consisted of a wireless network of direction detection sensors

WT- Occusense typical use cases include:

- ◆ real time information on space headcount
- ◆ assessment of space use efficiency
- ◆ assessment of space energy efficiency

Use case example: WT- Occusense is used as part of the WT hello! suite (www.horeca21.com) for the HoReCa industry, where it calculates in the real time, premise and toilet hall waiting population.

Features

- ◆ Single or multi entrance spaces
- ◆ Battery powered (6-12 months lifetime depending on set-up resolution)
- ◆ Clear and cost effective pricing
 - Buy; 300E+ 200/ entrance (e.g a space with 1 entrance will cost 500E; with 3 entrances it will cost 900E). Optional hosting at 50E / year.
 - Lease; 200E + 100/ entrance/ 3 months (e.g a space with 1 entrance will cost 300E for 3 months; with 3 entrances the cost will be 500E for three months). Free hosting.
 - no other cost (software, etc.) applies, besides courier transport and possibly VAT costs.
 - 1 year full replacement guarantee
 - Plug and play deployment; remote management
 - Enters automatically a 802.15.4 wireless sensor network
 - High quality web/ phone interfaces
 - Email/ SMS alerting if values go high or low, beyond specified thresholds
 - 1- 2 months lead time for delivery

Info/ requests for quotations: info@buildingwarden.com