



**E**ndrich works hard to offer possibility to its potential customers to call IoT for help to connect their conventional devices into networks and collect different data, which can then be used in various area such as marketing, predictive maintenance or remote surveillance. We would like to make our promise fulfilled: „We make Your device Smart”.

In this writing we are going to introduce how we do it with industrial refrigerators.

## The Smart Fridge

Manufacturers of modern refrigerators often use the term "smart refrigerator" in their advertising materials and marketing communications, with which they advertise the integration of functions such as automatic defrosting (NO-FROST), inverter compressors, or the use of special insulation materials and adjustable shelf systems. However, when we examine the devices with an engineering and not a marketing eye, we should talk about smart functions primarily in the case of devices connected to the network (primarily to the Internet). Of course, a number of well-known manufacturers now offer the possibility to monitor the parameters of our refrigerator through a mobile application, possibly to intervene, or to get an overview of the food stored in the refrigerator. With the help of IOT, it is also possible to "smarten up" our traditional appliances, by integrating simple functions such as monitoring the temperature and humidity of the refrigerator compartment, the status of the door, and the brightness of the interior light. Preventive maintenance can be aided by monitoring the possible presence of extraneous noises, high vibrations, and anomalies in power consumption, while by registering the



frequency and time of door openings, or the length of the open state, data for marketing or commercial purposes can also be easily extracted from devices used in a commercial environment such as gasoline station or other shops.

With the help of state-of-the-art electronics, the goals mentioned above can be achieved quickly and efficiently, not only in the case of devices originally designed with such functions, but also by using IOT devices retrofitted into traditional refrigerators. The requirements for such a telemetry unit are usually small size, easy installation, independence from electrical and wired communication networks, and the possibility of easy commissioning. If the IoT module is battery-powered and uses some kind of wireless communication

technology to transmit sensor data, as well as the necessary sensors are located in the device itself, then the installation can be easily carried out without the involvement of a specialist afterwards. The measurements are ideally recorded by such a module every second, minute or hour - 24 hours a day - and forwarded to the appropriate cloud service for data analysis using the modern, reliable and cheap Narrow Band / LTE-M technology or as a backup using the 2G GSM network.

### **Collection of refrigerator data**

By providing a traditional refrigerator with Internet access, we can make it suitable for submitting its operating parameters to a suitable cloud-based

## Converting conventional fridge into „SMART” device ...

Modularity, flexibility and simplicity in focus ...



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[1] The E-IoT ecosystem is perfect for fulfilling various customer demands via converting conventional device to SMART

database for further processing or display. For this, we need to equip it with suitable sensors and a communication channel, for which we can call on the hardware elements and software services of the E-IoT concept. We can use the data to ensure optimal operating conditions, we can constantly monitor the temperature and humidity of the refrigerator compartment, we can make sure that we did not forget to close the door and we receive an early warning of possible defrosting caused by a power cut. The telemetry unit used also supports preventive maintenance, as it is capable of monitoring anomalies and issuing alarms based on unusually high power consumption, high noise levels, or the appearance of strange vibrations. The question of safety comes up at first by

monitoring the basic conditions for operation, and on the other hand, it arises in connection with material safety. For the former, the monitoring of the increasing temperature in the refrigerator and raising an alarm before defrosting due to the door being accidentally left open or having a power failure. For the latter, the built-in acceleration sensor or the GPS-based device tracking can be used. Controlling the temperature of the refrigerator compartment and monitoring energy consumption contribute to economical operation. Monitoring the opening of the door can be used not only to support predictive functions, but also for data collection for marketing purposes in case of commercial environment such as shops. Logging door openings gives an idea of the

frequency and length of opening, which helps the owner to map shopping habits and calculate the quantities sold.

There are several hardware solutions in the Endrich smart refrigerator concept. All of them are based on easy-to-install sensor modules, which are also able to transmit their data wirelessly to a dedicated cloud. It is done either directly through the mobile phone network or through a local WLAN and its GSM gateway. Sensor modules measuring temperature and humidity, as well as the intensity of interior fridge light, together with mechanical sensors (acceleration sensor and MEMS microphone) were placed inside the compartment. To detect the opening and position of the door, either a magnetic sensor can be used, which is activated by the door magnet, or the six-axis acceleration sensor, which can even detect the degree of the door opening.

All the sensor units are equipped with a battery that can be charged wirelessly, which, depending on the frequency of data transmission, allows this low-power device to operate for a very long time (>Year). For general operation, we use a low-power wireless data communication operating on the sub-GHz (868 MHz ISM) band. This solution allows the individual sensors to be installed separately, so a temperature sensor, humidity sensor or other device can even

be placed in different places inside the refrigerator. All devices operate in a local mesh network, where a WLAN-LPWA gateway is also integrated in. This gateway is built in to the power consumption monitoring device, and simultaneously sends the data transmitted by all sensors to the cloud using a special NB-IoT/LTE-M/2G GSM modem. Since this unit works on mains voltage, there will be no problem with the GSM modem's power consumption of frequent transmission, and in the event of a power failure, the integrated supercapacitor offers a reserve of energy to send one or two last status messages (power failure alarm). An additional advantage of this arrangement is that the telemetry data of several refrigerators located in the commercial real estate can be sent to the cloud at the same time. The LPWA communication technology (NB-IoT) and the low-power ARM-M0+ microcontroller have been designed in to operate with low energy resulting in long lifetime without battery recharge.

All this is possible with very low telecommunication costs, since the prepaid SIM card costs EUR 10 for 10 years with a data volume of 500 MB. About using the data some standard software services ( Smartphone App, Data Access API and a web based administration and data visualization site) , as well as a customer specific software solution exist to take care.