Sensor Node Functional Trade-off Study

ÄRTEN™

An ARRL Foundation Club Grant Fueled Project

19 March 2023

KB1ZZU

ÄRTEN™

(Amateur Radio Training Experiment Network)

- A pilot community learning opportunity in the 1-10GHz Super High Frequency (SHF) ham bands at the intersection of amateur radio + mesh network technology.
- The ÄRTEN™ project was started in 2020 at the Newport County Radio Club (NCRC) to provide a low cost of entry ($20 to $100) opportunity for club members to learn about and use HAM SHF bands and learn about RF networking techniques.

ÄRTEN™ Node Requirements

- Mesh nodes are based on commercial 2.4 GHz WiFi routers running OpenWRT (from *open wireless router*).
- Further, routers are selected from the AREDN (Amateur Radio Emergency Data Network) compatibility list and then re-flashed with AREDN firmware to enable amateur radio frequency use.
- ÄRTEN™ uses the 2.4 GHz (13 cm) band to avoid the more popular (emergency) use of the 5 GHz (5 cm) band.

ARRL Target Grant Categories and ÄRTEN™ Goals

- NCRC received a 2023 ARRL Foundation Club Grant to continue ÄRTEN™
  - Goal #1: Introduce Hams to low cost equipment to get on the air in the SHF bands
  - Goal #2: Provide Hams the opportunity to be active by participating in the team project
  - Goal #3: Expose Hams to RF networking techniques
  - Goal #4: Expose youth and adults to concepts of wireless communications in the 1-10 GHz range
  - Goal #5: Expose youth and adults to environmental monitoring (other than weather) using CO_2 sensors and an Amateur Radio supported Internet of Things (IoT)
  - Goal #6: Provide Hams another opportunity to utilize granted SHF privileges

ÄRTEN™ Sensor Node Requirements

(1) Low cost

(2) AREDN compatibility

(3) Low power *(for battery-powered remote locations)*

(4) Environmental enclosures *(for outside deployment)*

(5) Long range *(for broad accessibility)*

(6) Reproducible *(for broad participation)*

Concept Commonalities

- The following functions will not be discussed as all the concepts have similar needs:
  - Battery power
  - Solar panel and charge controller
  - Environmental (weather-proof) enclosure

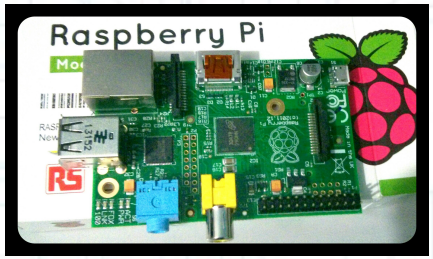
Original 2022 Concept

Sensor

Vaisala GMP343

CO_2 Sensor

- 11 to 36 vDC
- 1 to 3.5 Watts
- RS-232/RS-485



Interface

Raspberry Pi

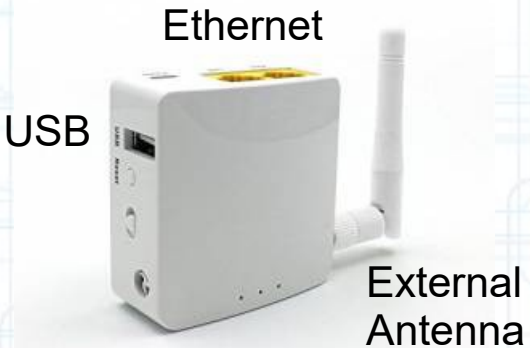
- 5VDC 0.5 to 4Watts

Arduino

- 9 vDC 4 to 100 mAmps

RS-232-USB adapter

FPGA



Router

GL·iNet

GL-AR150-Ext

- 5 vDC / 1 Amp
- < 1.5 Watt
- USB/Ethernet

Cost Analysis

- Indicate the financial advantages for the customer
- Compare quality and price with those of the competition

Cost Analysis

EQUIPMENT	COST
Router: GL·iNet GL-AR150-Ext	$60
Interface:	
Raspberry Pi	$15 to $200
Arduino Shield(s)	$18 to $105 $3 to $25
RS-232 to USB adapter	$12
Field Programmable Gate Array	TBD
Sensor: Vaisala GMP343	$6,000
TOTAL	> $6,000

NOTES:

- Obviously, the $6,000 sensor, while highly accurate, is a non-starter for a low cost project.
- However, since NCRC has two units on-hand, they may be worth experimenting with.
- Further, the GL·iNet GL-AR150-Ex is end-of-life.

Strengths and Advantages

- Router external antenna allows range upgrades
  - Router range tested in 2021 to 3+ miles with external 4 Watt WiFi Booster and Yagi antenna
- Highly accurate sensor
- Lowest power option if USB sensor interface can be implemented in OpenWrt directly on the router.
  - USB port may only be for phone tethering

2023 Ethernet Sensor Concept

Sensor

Temco CO2-W-TH

CO_2 /Temp/Humid

- Ethernet/RS-485
- 15-24 vDC or AC
- 2 Watts typical
- PoE

Interface

Ethernet Cable

Router

GL·iNet

GL-AR300M16-Ext

- Ethernet/USB
- 5vDC / 2 Amps
- < 2Watts

Cost Analysis

EQUIPMENTco	COST
Router: GL·iNet GL-AR300MT16-Ext	$27
Interface:	
Ethernet Jumper	$2
Sensor: Temco CO2-W-TH	$144
TOTAL	$173

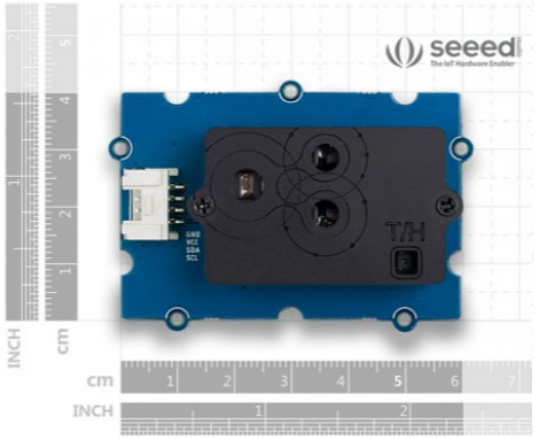
NOTES:

- GL·iNet GL-AR300M16-Ext router is a MIMO device. Two RF inputs will likely double the cost of external WiFi range boosters and antennas over standard devices.
- 15 vDC sensor presents supply voltage challenge.

Strengths and Advantages

- Router external antenna allows range upgrades.
  - MIMO offers opportunity for greater range
- 4 Watts total power consumption.
- Built-in sensor Ethernet offers simplest integration with router.

2023 Arduino Ethernet Concept



Sensor

Grove - CO2 & Temp. & Humid. Sensor for Arduino (SCD30) - 3-in-1

- 3.3 to 5.5 vDC
- 19 mAmps Avg.
- 0.1 Watt

Interface

Arduino Mega 256

- 9 vDC
- 73 mAmps
- 0.7 Watts

Ethernet Shield 2

- 5 vDC
- 200 mAmps
- 1 Watt

Router

GL·iNet GL-AR300M16-Ext

- Ethernet/USB
- 5vDC / 2 Amps
- < 2Watts

Cost Analysis

EQUIPMENT	COST
Router: GL·iNet GL-AR300MT16-Ext	$27
Interface:	
Arduino Mega 256	$49
Ethernet Shield 2	$32
Sensor: Grove - CO2 & Temp. & Humid. Sensor for Arduino (SCD30) - 3-in-1	$59
TOTAL	$167

NOTES:

- GL·iNet GL-AR300M16-Ext router is a MIMO device. Two RF inputs will likely double the cost of external WiFi range boosters and antennas over standard devices.
- More effort to integrate: requires Arduino programming

Strengths and Advantages

- Router external antenna allows range up-grades.
  - MIMO offers opportunity for greater range
- 3 Watts total power consumption.
- Offers most flexibility to lower cost per unit
  - Arduino model & sensor options
- Offers most flexibility to lower power consumption
  - Arduino model & low power modes
- Large Arduino support community

Next Steps

- Begin Integration of Ethernet Sensor Concept
  - Purchase Temco CO2-W-TH CO_2 /Temperature/Humidity Ethernet Sensor w/POE (Power Over Ethernet)
- Begin Power Studies
  - Battery sizing
  - Solar panel choice
  - Solar charger choice