Open Portable Platform for Hearing Aid Research

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This work in the context of a large NIDCD initiative to facilitate the translation of the advances in basic research to hearing aid algorithms

The Problem

A researcher is working on a solution to reduce environmental noise based on the new discovery in binaural signal processing

How does she go about testing the new concept?

1. A portable and well documented hearing aid is needed

2. The hearing aid software environment should be at a high level (C++, Linux) - not Assembly

3. The Hearing aid needs an environment of base algorithms to be a hearing aid

4. The new algorithm needs to be well integrated in that environment

5. End to end latency (System + Algorithms) less than 10 ms

Why Open Design requirement?

Open Design approach is the key to achieving **the critical mass of available tools** developed both within and outside the funded projects

but also “**a link across awardees**” to achieve the required synergy for a successful product development.

We report on two closely related projects:

RO1 Award R01DC015429
Volker Hohmann and Chas Pavlovic
July 2016

SBIR Award R44DC016257
Chas Pavlovic
July 2017

Software

Hardware

Hardware platforms

1. Desktop setup - off the shelf; available now

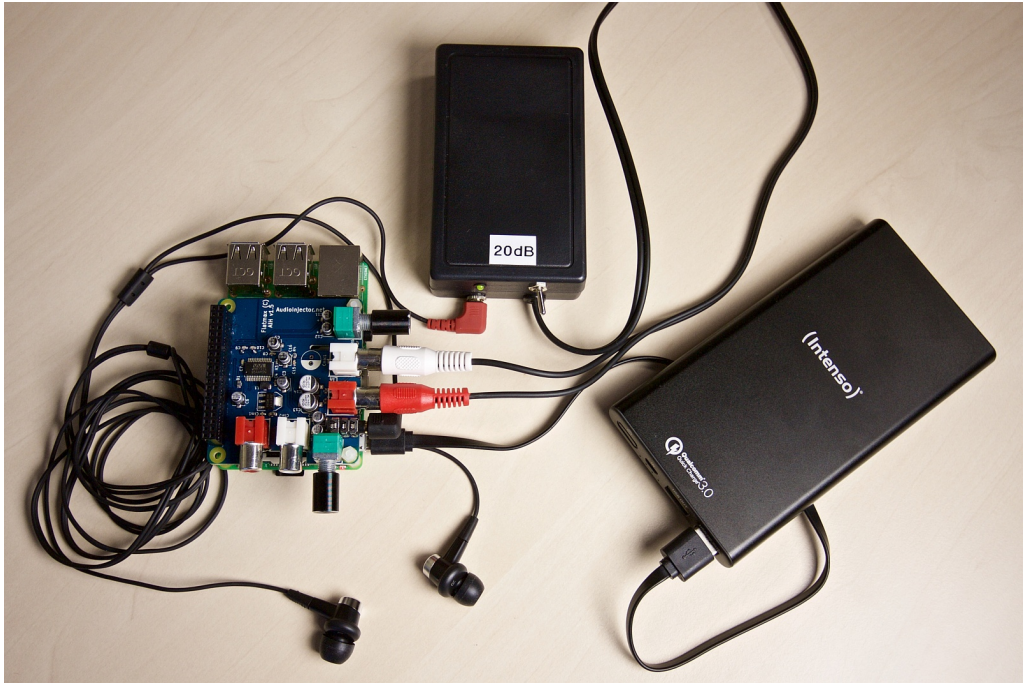
- PC or Mac (in this case a small-form-factor PC)
- PC multi-channel audio interface
- preamplifier
- 2 hearing aids that provide binaural microphones and speakers

Hardware platforms

2. Single board computer: A user project (Marc René Schädler, Ph.D.)

off the shelf; available now

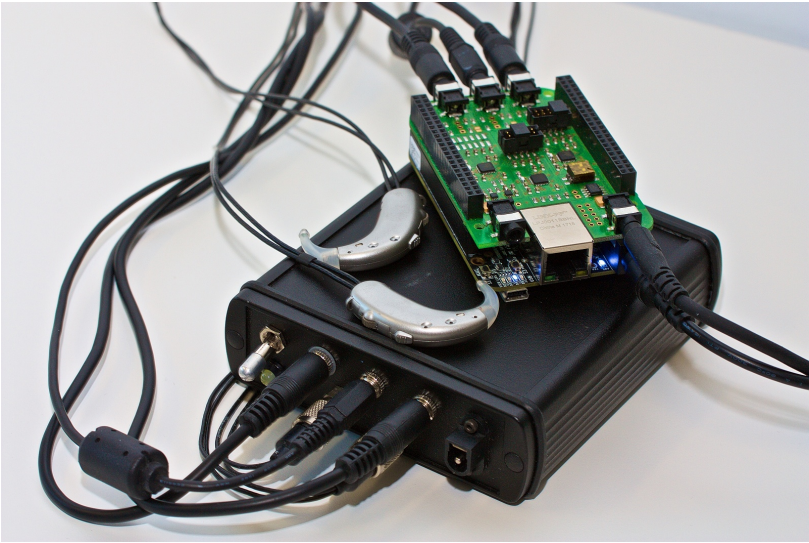
- binaural microphones / earphones
- single-board computer **(Raspberry Pi)**
- Sound card
- power bank



Hardware platforms

3. Single board computer and own codec board
limited quantities

- single-board computer (Beaglebone Black)
- self developed "Cape4All" open source board featuring three codecs with 6 input and 6 output channels
- preamplifier
- 2 hearing aids

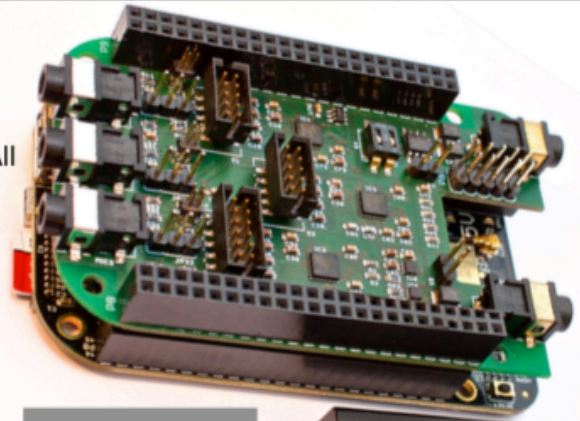


Hardware platforms

4. Semi portable version - Fall 2018

B&C
Binaural RIC
BTE
(Dual Mics)

BBB &
Cape4All
Codecs



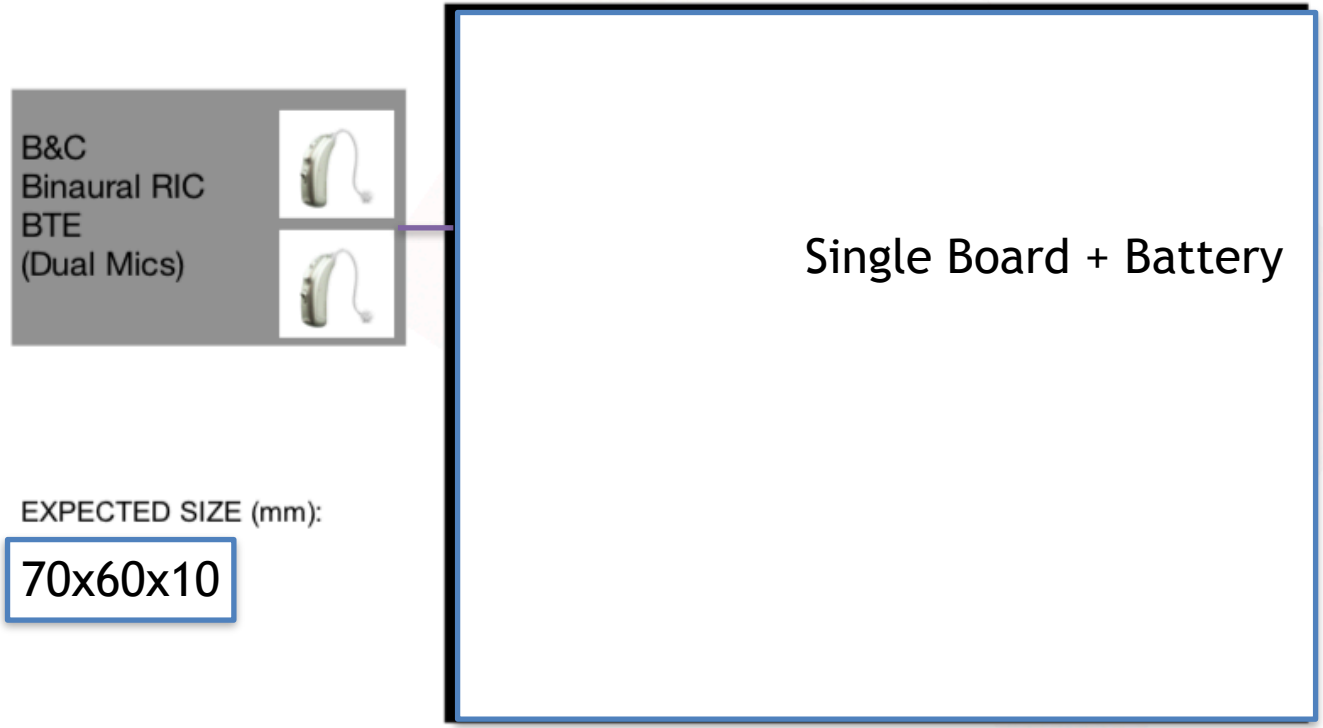
B&C Adapter
and
InterfaceBoard

EXPECTED SIZE (mm):

90x55x36

Hardware platforms

4. Portable platform single board design - **summer 2019**



Software: Open Master Hearing Aid (open MHA)

REQUIREMENTS

- end to end latency < 10 ms
- programmable in C++
- Linux, MacOS, Windows environment
- hardware-independence

Designed for different user groups

I Audiological researchers who can

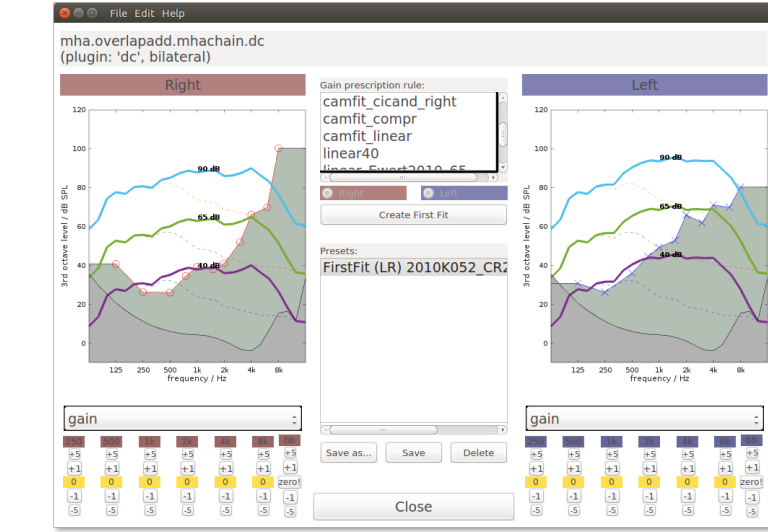
- use Plug-and play software modules
- change Processing parameters at high level

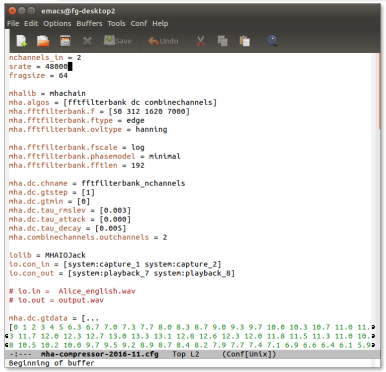
II Application engineers who can

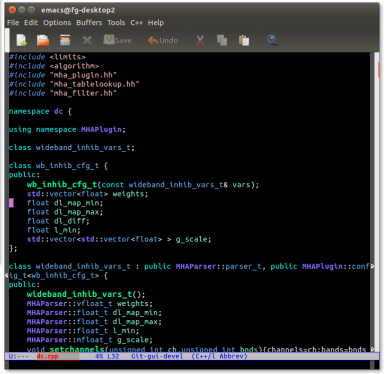
- set up measurement tools and customize algorithms
- access configuration interface at an advanced level

III Plugin developers who can

- Develop and implement new plugins in the openMHA framework







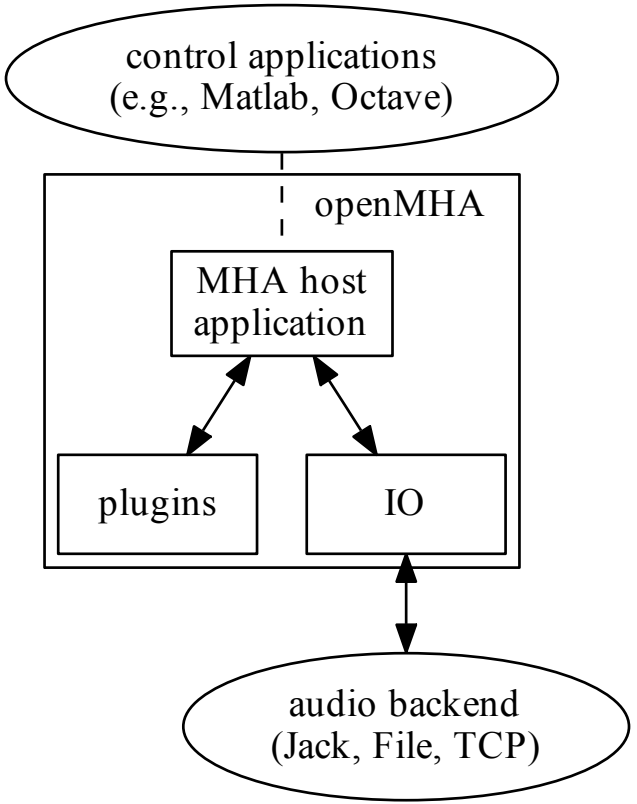
openMHA – structure

Basic framework

- MHA host application
- toolbox with plugins
- communication interfaces (I/O)
- Matlab/Octave GUI for audiological usage

Documentation

- manuals for different usage scenarios
- example configuration files for algorithms

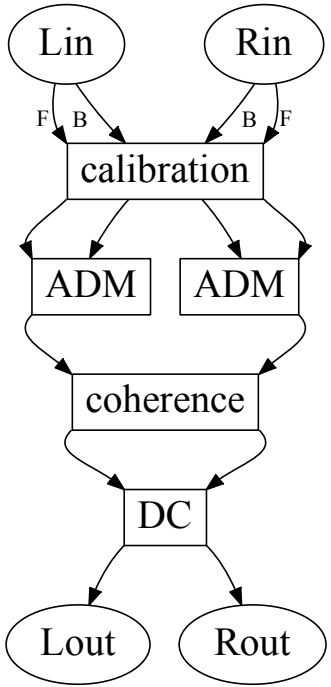


openMHA - current status

openMHA software is already available under Linux and MacOS and Windows from July

Hearing aid processing modules, release 4.5.5:

- calibration
- multi-band dynamic compressor
- adaptive feedback cancellation
- single-channel noise reduction
- adaptive differential microphone
- binaural coherence filter
- binaural beamforming algorithms
- sound source localization



Hardware: Open Portable Auditory Laboratory (OPAL)

further details: www.BatAndCat.com

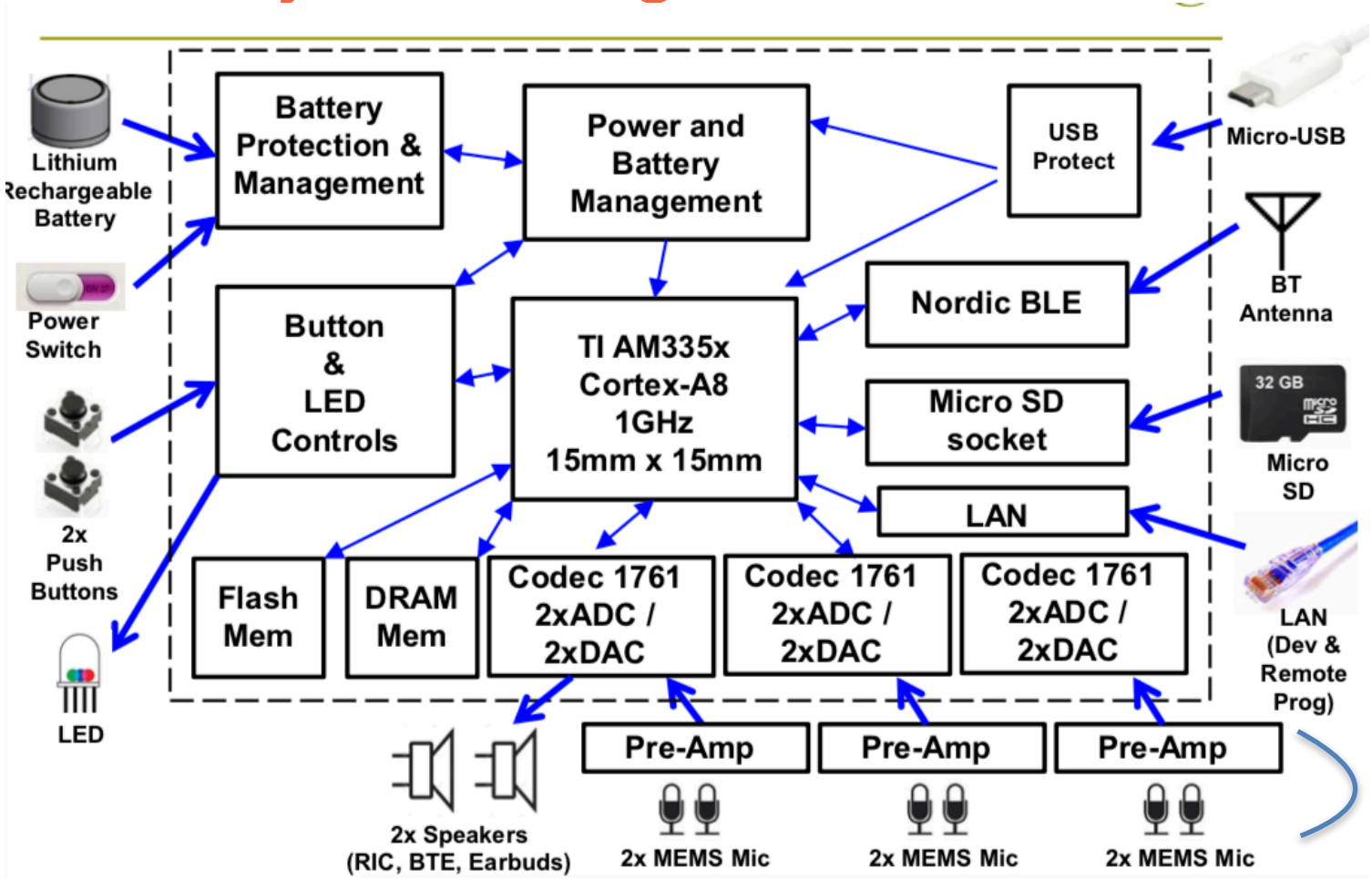
The system was designed so that the basic openMHA algorithm suit, needed to support development of new algorithms, runs in twice the real time.

This leaves 50% of the processing capacity for the algorithms in development.

Basic openMHA algorithms:

- Calibration
- STFT filter bank
- Directional microphone
- FFT based multiband compression
- Wind noise reduction, and
- Binaural coherence filter for feedback reduction

OPAL System Design



- RIC and Dual Mics
- Preamps

OPAL Development Schedule - Year 1

- General system specifications: complete
- Detailed **Single Board** Electrical design: complete

OPAL Development Schedule - Year 1

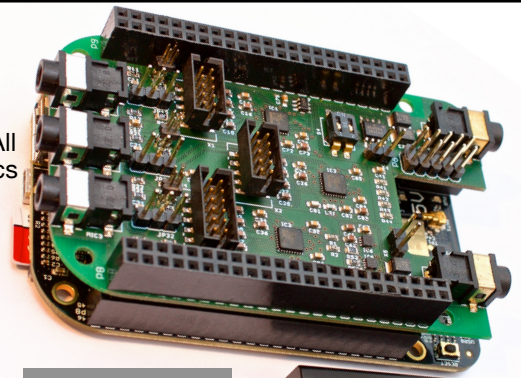
- To test the singe board design, a multi board prototype will be completed in June and ready for detailed testing - upon which the single PCB production will be allowed to start
- Includes all all elements of the single board design
- Mechanical earpiece design in August 2018

B&C: Binaural

RIC; 2 mics

Preamps

BBB &
Cape4All
Codecs



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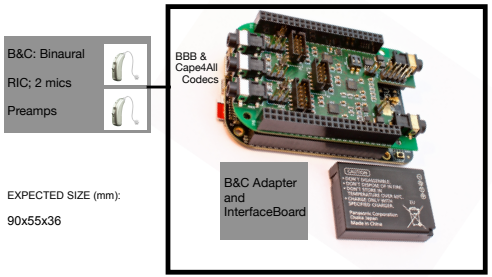
EXPECTED SIZE (mm):

90x55x36

Note re. the semi-portable prototype

- This device was designed for our internal testing purposes to qualify the single board PCB design
- However, if interest exists, we can arrange for the production of the required number of PCBs (Earpiece, B&C Adapter Board, Cape4All) and the mechanical parts of the earpieces, as well as for the assembly
- Such devices could be expected to be available in November 2018

- Note that our single board portable devices should be available in the summer 2019



Opal Prototype tests already done

Equivalent Electrical Inout Noise:

MEMS mike: 26 dB SPL

Power supply and circuit: 20 dB SPL (does not include the earpiece cable noise)

Expected total (microphone, cable, circuit and power supply) under 28 dB SPL

openMHA software runs successfully with the following latencies:

very impressive!:

direct routing through JACK server (MHA):3.2 ms

with MHA in time domain: 3.9ms

with STFT and overlap-add: 5.2 ms

OPAL Development Schedule - Year 2

Y2: A single board device design and Alpha samples

- Testing Multi-board prototypes and final electrical design modification
- Mechanical design of earpieces completed
- *Single board PCB manufacturing*
- Single board prototype assembled and tested
- Final device design and Alpha samples (+ 2m if another PCB turn needed)
- The device volume estimate (not the actual form factor): 7x6x1 cm)

thank you!

See websites...

http://batandcat.com/nih-supported-projects.html
http://www.openmha.org/
https://github.com/HoerTech-gGmbH/openMHA
https://github.com/HoerTech-gGmbH/Cape4all

OPAL Development Schedule - Year 3 and Year 4

Y3: Alpha test by the Community; modifications, and Beta samples

Y4: Beta tests by the Community; and transfer to manufacturing