# CLAMS - The Quest for Portability and Audio

## Forth Day 2024

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# Previously on CLAMS

# The original concept - early 2022

- Forth for the Electro-Smith Daisy Seed (Electrosmith 2024)
  - Microcontroller board designed for digital music
  - ARM Cortex-M7 MCU, running at 480MHz
  - Hardware floating point and DSP instructions
  - 64MB of SDRAM for up to 10 minute long audio buffers
  - 8MB external flash
  - Stereo audio output - 96kHz / 24-bit audio hardware
  - No WiFi or Bluetooth
  - $29.95US quantity one
  - Available in various packaged modules
  - Control logic and synthesis both done in Forth

# Revised concept - early 2023

- Forth for the Raspberry Pi Pico (WH)
  - Microcontroller board designed for general applications
  - Dual-core ARM Cortex-M0+, running at 133 Mhz
  - Co-processor for division, interpolation and I/O
  - No floating point or DSP instructions
  - 262KB RAM
  - 2 MB flash
  - No SD card
  - No audio hardware, I2S audio expansion packs available
  - 2.4 GHz WiFi and Bluetooth
  - $7.00 US
  - Control logic and synthesis both done in Forth

# Stepping up a level - what does a digital synthesizer need?

- Reliable generation of accurately-timed pulse-code modula
- Conversion of the stream to analog voltages for recordin
- An interface for the composer / performer

# So what was wrong with the previous two concepts?

1. Portability - Forth needs to be hand-ported to individual MCUs. Other desirable boards:
   - Raspberry Pi Zero 2 W
   - Teensy 4.1
   - ESP32-S3, -C3 and -C6
2. Only I2S audio was realistic. Other desirable interfaces:
   - Class-compliant USB audio and MIDI
   - Bluetooth audio
   - Only MIDI is realistic in Forth

# CLAMS - The New Design

# Arduino or Linux for portability

- Target MCU boards (Daisy, Teensy, ESP32 and Pico / Pico 2) have Arduino support
- Raspberry Pi Zero 2 W has Linux support
- I2S audio is supported on all boards
- Bluetooth audio is supported if the board has the hardware
- USB audio is supported on Teensy and Zero 2 W, others in alpha testing

# ShorePine Systems AMY synthesizer

- Highly portable - written in C
- Has a Python interface for Linux and microcontrollers
- Handles synthesis and I2S audio generation
- Very capable synthesizer - saves me months of Forth coding!

# C3 Forth for Arduino (Christopher Curl Accessed 2024-11-13)

# C3 Forth for Arduino (Christopher Curl Accessed 2024-11-13)

- Token-threaded Forth written in C/C++
- Runs on Linux (native), Raspberry Pi Pico and Teensy 4.1 (Arduino)
- Under active development
- Well-documented

# CLAMS architecture

- a domain-specific language implemented in Forth
- conceptually, ChucK (https://chuck.cs.princeton.edu), (Salazar et al. 2014) semantics with Forth syntax
  - low-level words: digital synthesis and microcontroller audio
  - mid-level words: construct signal flow graph
  - high-level words: algorithmic composition and live performance

# Forth base: C3

# Road map

# Target audio hardware

- Pimoroni Pico Audio Pack
  - ~ $16US plus shipping
  - requires an expander board for UART connection (~ $9US)
- Waveshare Pico Audio Expansion Module
  - ~ $20US plus shipping
  - includes speakers
- Waveshare Overall Evaluation Board
  - ~ $50US plus shipping
  - includes 3.5 inch resistive touch screen
  - includes serial-to-USB adapter
  - includes microSD card adapter

# CLAMS on the web

- GitHub: https://github.com/AlgoCompSynth/CLAMS
- blog: https://www.algocompsynth.com/#category:CLAMS
- this presentation: https://github.com/AlgoCompSynth/CLAMS/blob/main/presentations/CLAMS-intro.pdf

# Me on the web

- Mastodon: https://ravenation.club/@AlgoCompSynth
- LinkedIn: https://www.linkedin.com/in/znmeb
- Bandcamp: https://algocompsynth.bandcamp.com

# References

Christopher Curl. Accessed 2024-11-13. “C3 on GitHub.” https://github.com/CCurl/c3/; Christopher Curl.

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Salazar, S., A. Kapur, G. Wang, and P. Cook. 2014. *Programming for Musicians and Digital Artists: Creating Music with ChucK*. Manning.