DroneCode and ArduPilot

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Lego Autopilot

- The beginnings of DiyDrones
  - built in 2007 by Chris Anderson
  - Lego Mindstorms
  - fixed wing aircraft
  - simple compass navigation
The Arduino Era

- Moved to AVR boards in 2009
  - Based on an Arduino 'sketch'
  - Stretched the limits of the AVR architecture
  - Community flourished, growing to over 50,000 members
  - Still works, but now at end of life
The PX4

- In 2012 started collaboration with PX4 project
  - 32 bit STM32 processors
  - NuttX RTOS operating system (posix-like)
  - PX4Firmware middleware
  - huge improvement in performance and capability
Native Linux Ports

- Native Linux port started in 2013
  - built on top of generic I2C/SPI interfaces
  - using Preempt/RT kernels
  - On BeagleBoneBlack, RaspberryPi and Odroid
AP_HAL for Hardware Abstraction

• AP_HAL in ArduPilot
  - creates hardware abstraction layer
  - allows porting to many OSes and CPU architectures
  - each HAL provides minimal system level glue

• Current ports
  - AP_HAL_AVR (8 bit AVR2560)
  - AP_HAL_SITL (SITL simulator)
  - AP_HAL_PX4 (PX4 based autopilots)
  - AP_HAL_Flymaple (low cost ARM autopilot)
  - AP_HAL_VRBrain (ARM32 autopilot)
  - AP_HAL_Linux (embedded Linux port)
  - AP_HAL_Empty (very useful!)
DiyDrones Community

- ArduPilot/PX4 have spawned a lot of interesting projects
  - experimental aircraft
  - drone image systems
  - disaster management
  - search and rescue
  - agricultural applications
Experimental Aircraft
(TeamTiltrotor)
Precision Landing
Daniel Nugent
Optical Flow (no GPS)
(Paul Riseborough)
Extreme Flight
(NTNS - North Texas Near Space)
Lohan Rocket Plane
(Registered Special Projects)
TradHeli and Rover
(Rob Lefebvre and Grant Morphett)
Outback Challenge 2014
(CanberraUAV)
Live Demo
(at Drone BOF 6:30pm tonight)

Live demo from Canberra, Australia
- BeagleBoneBlack with PXF cape
- 3.8 Preempt RT kernel
- Compiling Linux kernel while flying on same CPU
Demo Setup

- BeagleBoneBlack running Debian
  - 3.8.13-RT kernel
  - ArduPilot 3.3-devel
- Sensors
  - MPU9250 accel/gyro on SPI
  - MS5611 barometer on SPI
  - Ublox Lea6H GPS on 38400 UART
  - HMC5883 compass on I2C
  - MS4525DO airspeed sensor on I2C
- IO
  - SBUS input via PRU2
  - PWM output via PRU1
  - telemetry radio plus 3G link
  - EMMC and microSD for storage
I2C and SPI

- Fast sensors on SPI
  - using /dev/spidev interface, user-space drivers
  - works very well!
  - able to handle 4k SPI transactions per second with 25% CPU load on BBB
  - no DMA used due to DMA overhead for small transfers (typically a transfer is around 20 bytes)

- Slower sensors on I2C
  - using /dev/i2c smbus API, drivers in user space

- Why user space?
  - common drivers across multiple operating systems, using AP_HAL abstraction

- Moving to uavcan in future to replace most I2C
Scheduling

• 6 realtime (FIFO scheduled) threads
  – timer thread (1kHz timer, for regular tasks)
  – UART thread for all UART serial operations
  – RCIN thread for processing RC input pulses
  – main thread for core autopilot code
  – tonealarm thread for buzzer sounds
  – IO thread for all filesystem IO (logging, parameters and terrain data)
BeagleBoneBlack PRUs

- PRU1 used for RC Input
  - watches for state change on 1 pin
  - writes timing of state changes to a ring buffer
  - ARM code consumes entries from ring buffer, calling `process_rc_pulse()`
  - just 70 lines of C code on PRU

- PRU2 used for PWM output
  - shared buffer of PWM channel pulse width frequency
  - continuously reads shared buffer and updates 12 channels
  - just 235 lines of C on PRU
DroneCode.org

- New umbrella organisation for free software UAV development
  - Part of Linux Foundation Collaborative Projects
  - Forum for collaboration between projects, users and companies using the technology
- Collaborative development of core UAV projects
  - MAVLink
  - ArduPilot
  - PX4
  - MAVProxy
  - DroneAPI
More information

• Key sites
  – DroneCode: http://dronecode.org/
  – ArduPilot: http://ardupilot.com/
  – PX4: http://px4.io/
  – MAVLink: http://mavlink.org/
  – DiyDrones: http://diydrones.com/

Questions?