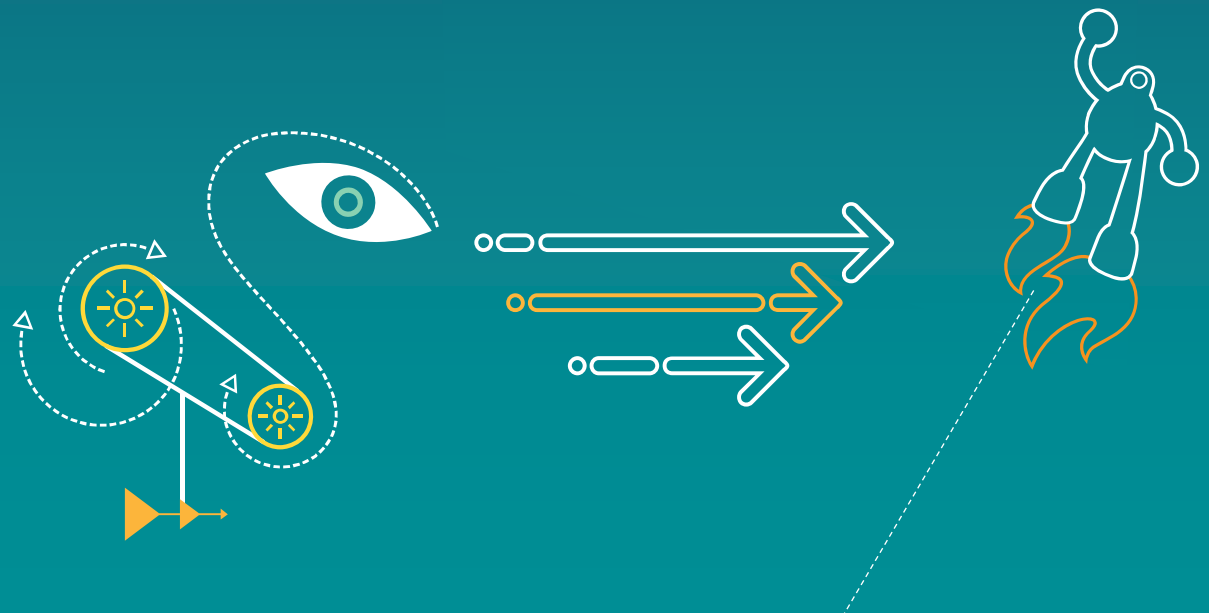
Danny Petkevich, Director Business Development, Qualcomm
Prakash Iyer, Senior Manager of Software Development, Toshiba

Snapdragon Application Processors: *Best Practices for Device Driver Development*

QUALCOMM®



Mobile: A Vibrant, Unprecedented Opportunity

~6.6B+

Mobile Connections

$1.5T

Global Mobile Revenues

#1

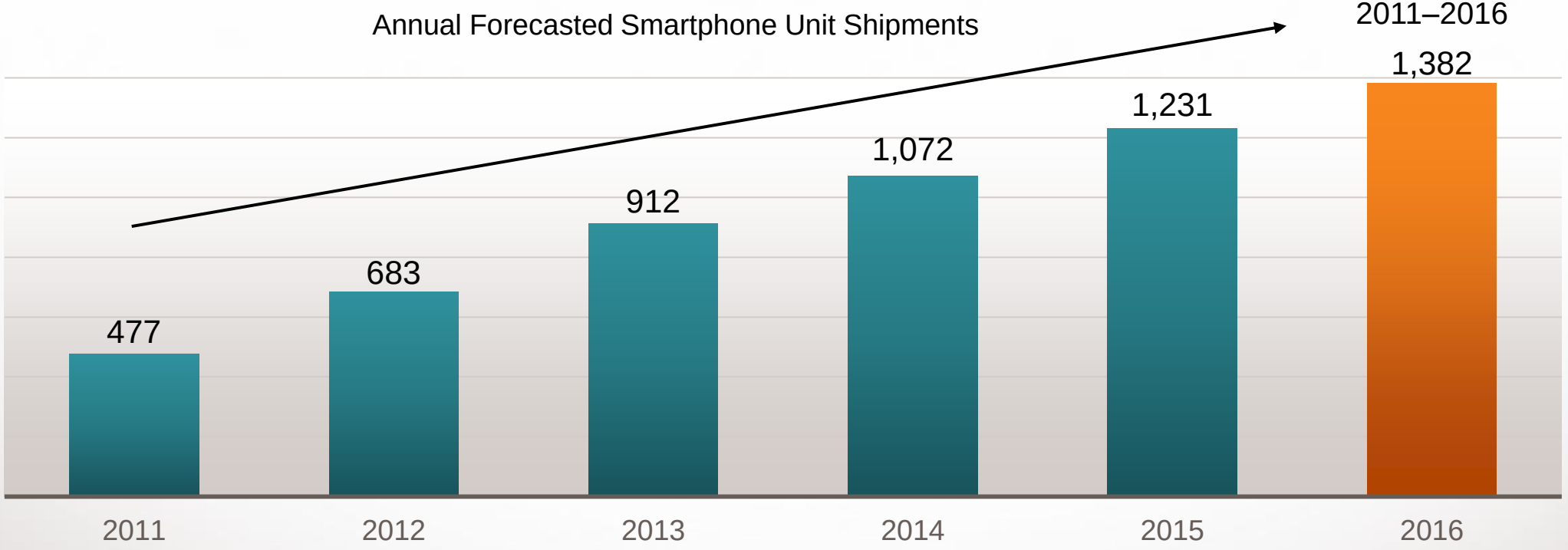
Most Used Device

Source: Wireless Intelligence, Jan. 2013, CIA World Factbook, Dec. ’11, Chetan Sharma Consulting, May, 2012

Continued Smartphone Momentum

Displacing Feature Phones

24% CAGR
2011–2016



Cumulative Smartphone Unit Sales Forecast Between 2012–2016

~5B

Source: Average of Gartner, Oct. ’12; Strategy Analytics, Aug. ’12

Expanding Areas for Smartphone Innovation

CPU
2MB L2 (8064 only) · aSMP · Custom Krait · High Performance Floating Point · Custom System Interconnect · Web Tech Innovations

GPU
FlexRender™ Technology · GPGPU Compute for Imaging/Video (Renderscript, OpenCL, LLVM) · Unified Shader Architecture · Stereoscopic Rendering · Profiling Tools · Low Power Innovations · Accelerated WebGL

DSP/Multimedia
20x Digital zoom · 21 MPix · Zero Shutter Lag · 7.1 Surround Playback · Stereo 3D video · Ultrasound · 5.1 Surround Camcorder · 1080P HD video · Computational Camera · Browser with HTML5 and 1080p Flash · Noise cancellation

Modems
LTE World Mode · LTE Broadcast · Coexistence with connectivity · LTE TDD · VoLTE / SRVCC · RF Multi-band · TD-SCDMA · Advanced Receivers · Power Optimization

Connectivity
GPS/GNSS · Indoor Location · BT · .11ac · Miracast · Coexistence with WWAN · FM · Multiband

Sensors
Proximity · Pressure · Ambient light · Gestures · Accelerometer · Humidity · Temperature · Gyroscope · IR Sensing · Magnetometer

Displays
Content Adaptive Backlight · MEMS · 3D · Color correction · Wireless Display · Frame Buffer Compression

Qualcomm snapdragon · Qualcomm gobi · Qualcomm ATHEROS · mirasol · pixtronix

Mobile is Redefining Computing

High Performance Computing

- High resolution screens
- Responsive devices
- Fast, always-on connectivity
- Rich multimedia experience

Without Compromising Mobility

- Sleek, ultra-light
- Longer battery life
- Thermal efficiency

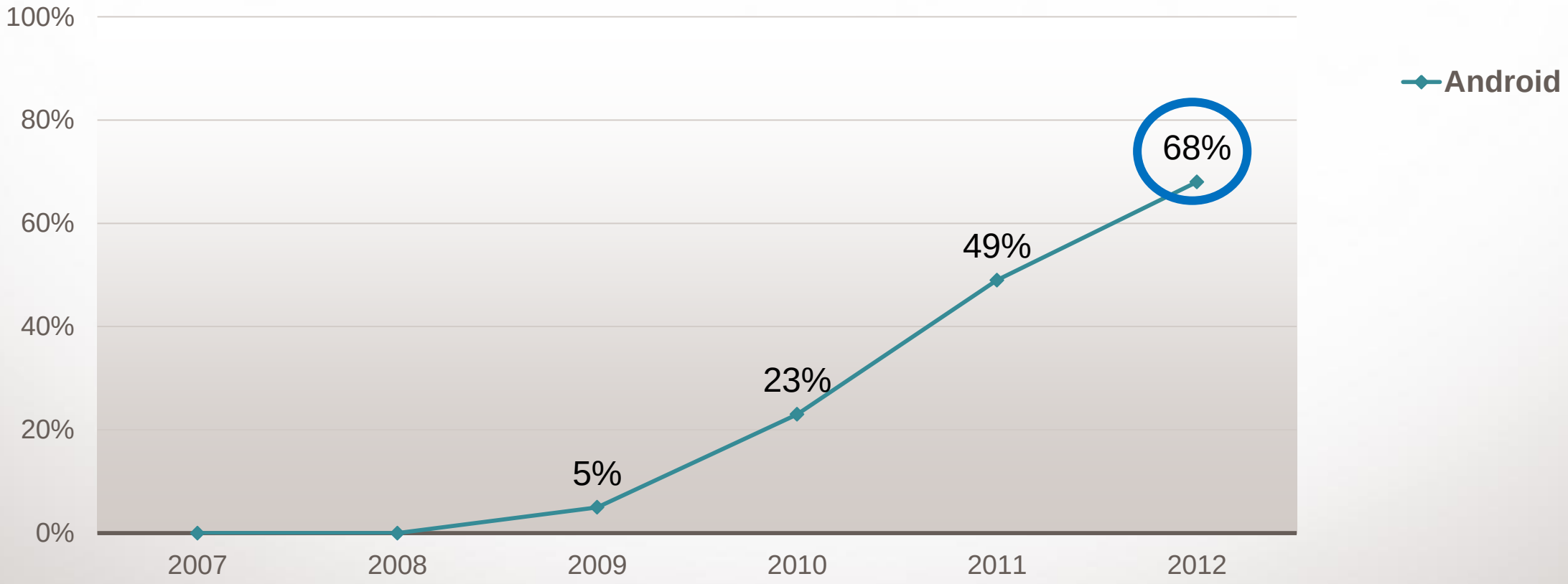
Snapdragon for Embedded

Delivers a Best in Class System Solution

Benefits of Mobile Application Processors for Embedded

- Power, Power, Power
  - No Fans, no noise
  - Reduced thermal constraints rendering smaller industrial design
  - Same platform for battery powered or wall powered products
  - Lower cost power supplies
- Feature rich, new capabilities
  - Multiple HD Cameras and microphone arrays
  - Video/Audio/2D & 3D Graphics processors
  - Multiple HD Displays, Miracast
  - Sensors: 3D accelerometers, 3-axis gyro, compass, ambient light, proximity, temperature & pressure, humidity, medical, chemical, ultrasound pen and gestures, finger print reader, etc
  - Location services
  - Computer vision

Android Leading Global Smartphone OS Market Share



Global Smartphone OS Market Share: 2007-2012

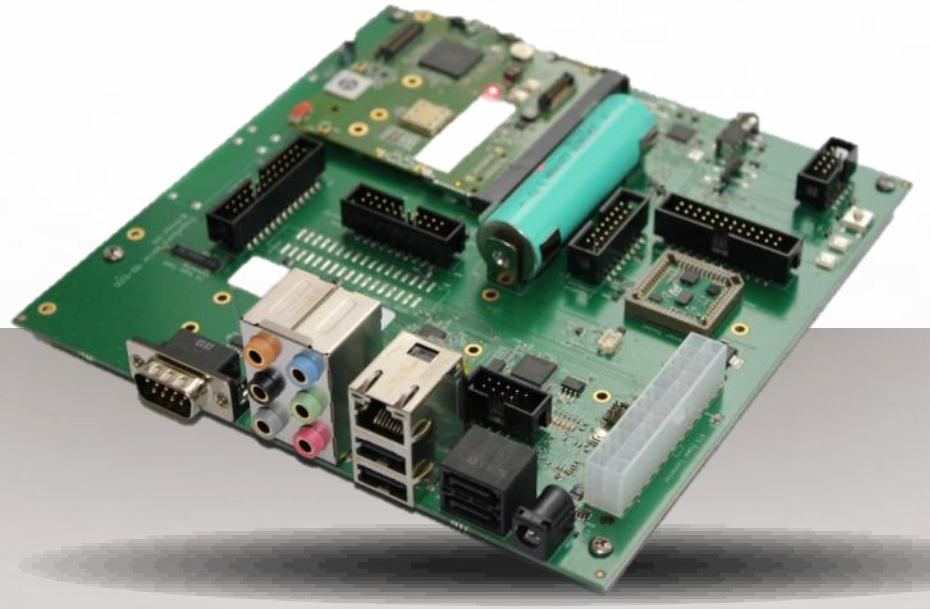
Source: Strategy Analytics Insight – Wireless Smartphone Strategies – Jan 28, 2013

Why Android for Embedded?

- Known user experience
- Standardized development environment
- Skilled developer community
- Royalty free… (Google provides Android at no charge)
- Linux as the foundation
- Source code access, destiny in your hands
- Massive investment as a platform

DragonBoard™

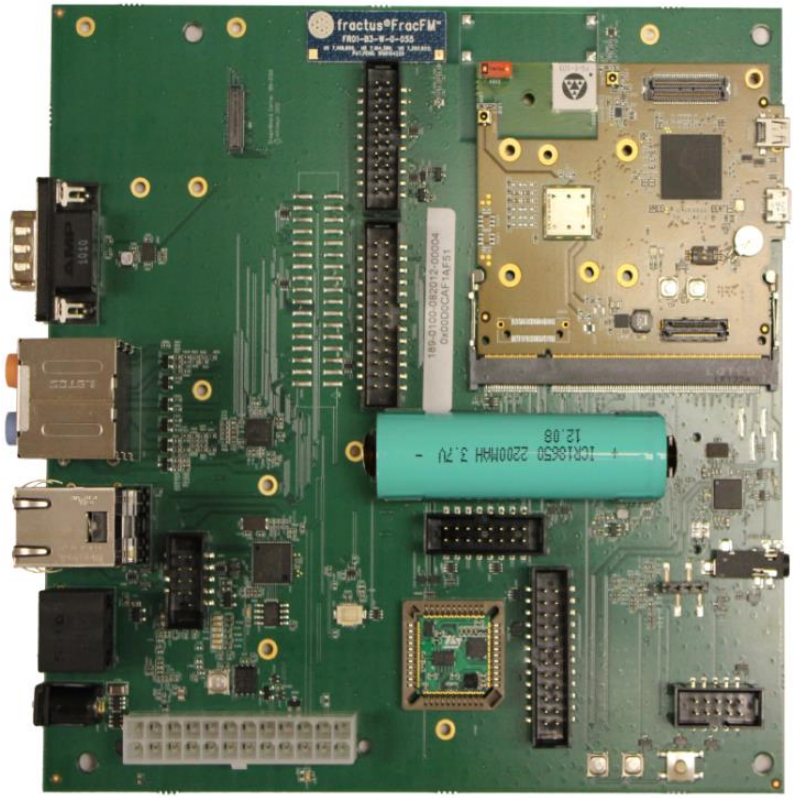
A powerful, feature-rich, versatile and easy-to-use exposed board platform for component vendors, software and embedded developers. It consists of a complete System on Module (SoM) with a Snapdragon processor, a mini-ITX carrier board and a peripheral kit.



8060a DragonBoard ™ Development Kit Specifications

* **Hardware**
  * Snapdragon S4 APQ8060A processor at up to 1.7GHz
  * 1GB of LPDDR2 RAM
  * 16GB of eMMC
  * MicroSD & Dual SATA I/F
  * HDMI out
  * GPS, Wi-Fi, Bluetooth 4.0 and FM radios
  * USB OTG & Host, UART, JTAG, & Ethernet
  * Front and back camera I/Fs – one 8MG Pix supplied with the kit
  * Dual Display I/F – one WVGA LCD with capacitive touch supplied with the kit
  * 5.1 Audio Line In/Out
  * Headset speaker and dual microphone I/Fs
  * Sensors – compass, accelerometer, gyro, and pressure.
  * PMIC with battery support
  * Interface options for NFC, TV Tuner, IR remote control, etc

* **Software**
  * Preloaded with Android 4.0
  * Additional OS support, including Debian Linux and other operating systems are on the road map



SYS 6400 – 8064 Development Platform

Processor and Memory
- Qualcomm Snapdragon S4 – APQ8064
- ARM15 class, 4-core, 1.7GHz, 2MB L2 cache
- Up to 2 GB on-board DDR3 (PCDDR 533MHz)

Network Interfaces
- 10/100/1000bT Ethernet

Storage
- MicroSD card connector
- eMMC 4GB (exp. To 64GB)
- 2 x SATA2 Connectors

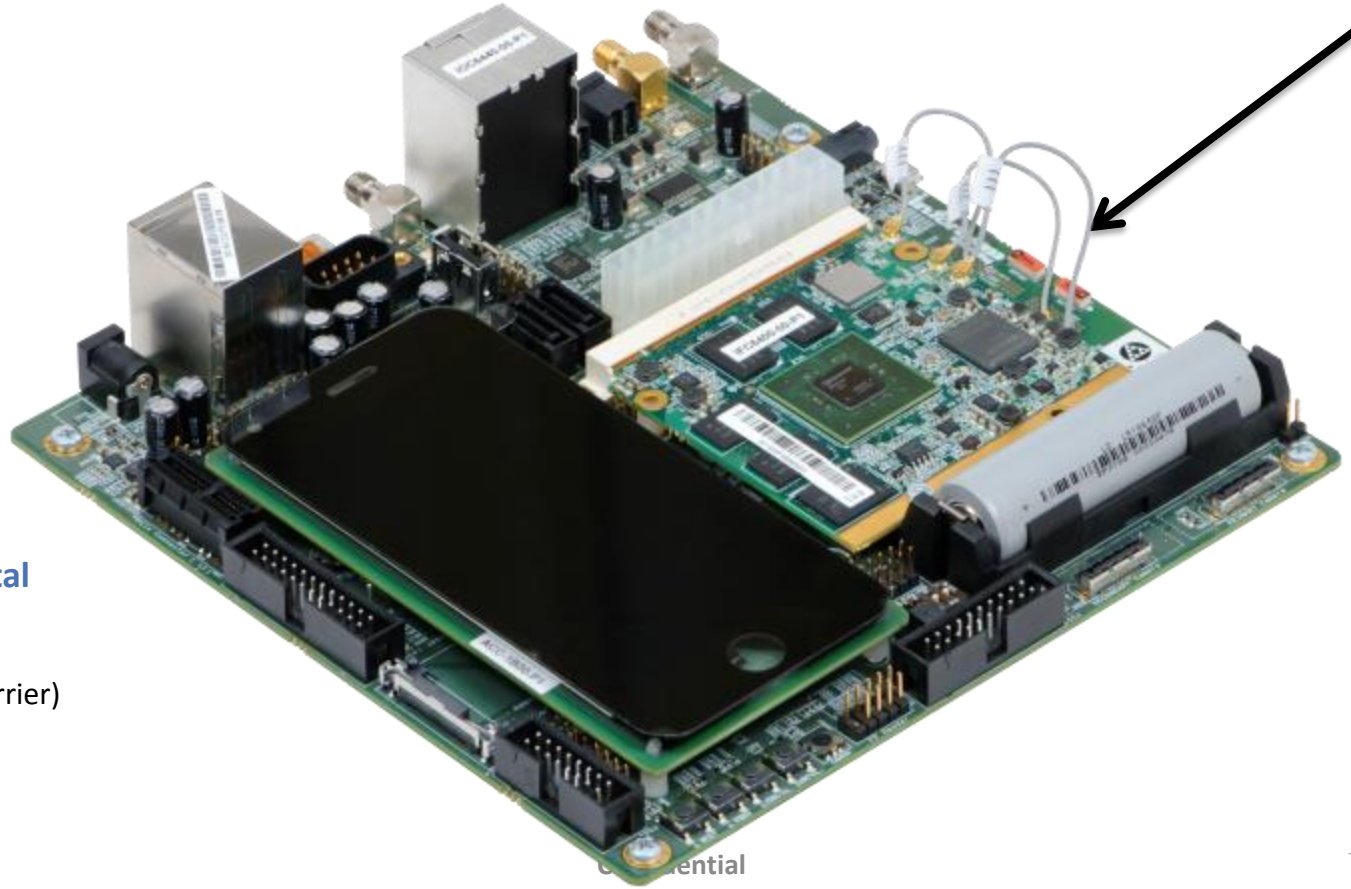
Multimedia
- HDMI for HD1080p
- LVDS
- MIPI-CSI (20MP camera)
- 5.1 Audio In/Out

Q7 Connector
- 2x USB2.0, 1x USB OTG
- Serial console

on-board connectors
- I2C, SPI, USB, SATA, LVDS

Power, Mechanical & Environmental
- **Power:** +5V Input Socket (5A typ.)
- **Dimensions:** 70mm x 70mm (Qseven)
  17cm x 17cm (Mini-ITx Carrier)
- **Operating Temp:** 0 to 70 C

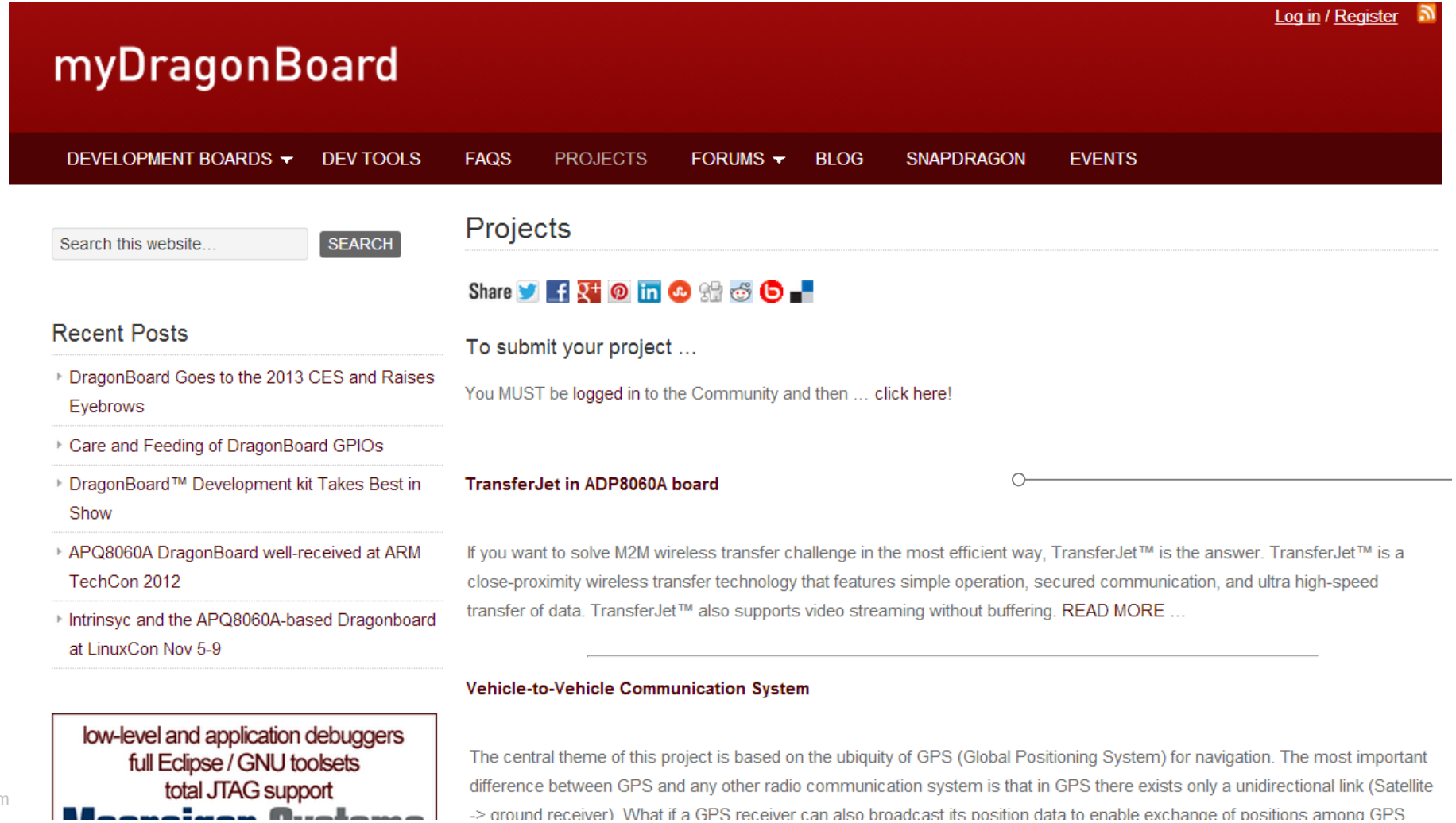
Software
- Android 4.1 Jellybean
- Ubuntu Linux



8064 SOM

myDragonBoard.org, Snapdragon Community

Dev Tools, Projects, Forums, Blogs, …



Post your project and or questions here

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ELECTRONIC COMPONENTS

Device Driver Development on Snapdragon™ Processor Based DragonBoard™ Development Platforms – Best Practices

Using Toshiba Peripheral Devices to Enable Embedded Devices with SnapDragon™

Pico Projectors

Virtual Reality Glasses

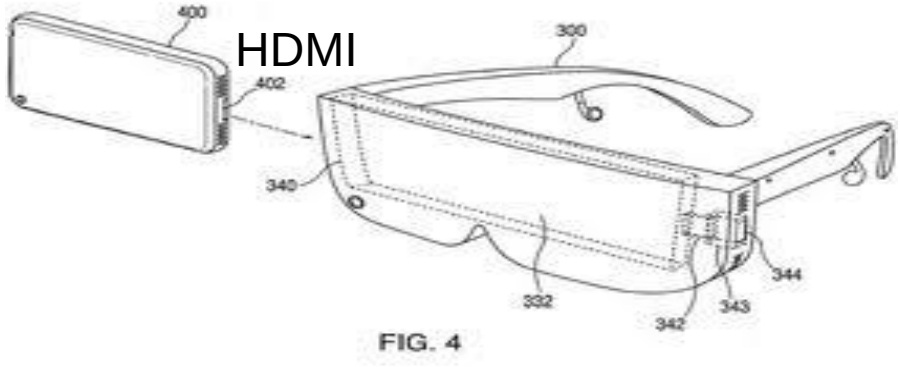
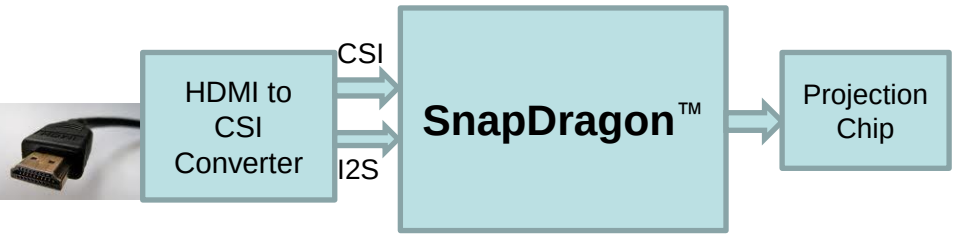


FIG. 4

Portable Video Recorder



Toshiba Device driver development on Snapdragon™ Processor Based DragonBoard™ Development Platforms

1. Mobile Peripheral Devices(MPD) Bridge Chips on DragonBoard™ 8060A Development Kit

   a) MIPI® -DSI to LVDS Converter Low Power (D2LLP) - (TC358775XBG)

   b) HDMI to MIPI® -CSI Converter (H2C) - (TC358743XBG)

2. TransferJet® Technology Compliant IC (TC35420XLG) on DragonBoard™ 8060A Development Platform

3. Audio Codec IC (TC94B24WBG) on DragonBoard™ 8060 Development Platform

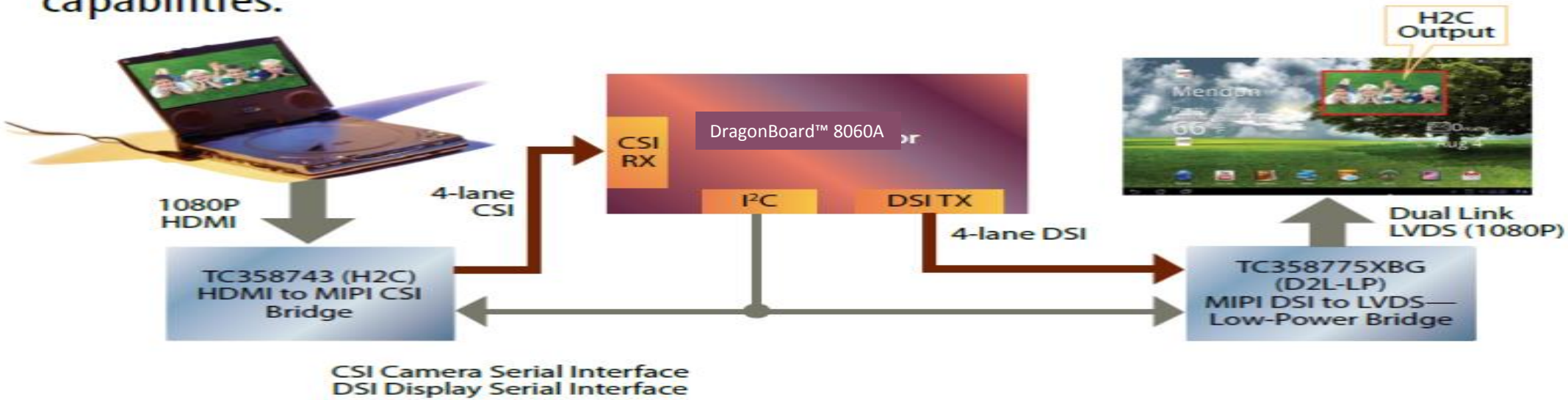
Device Driver Development – Best Practices

1. Hardware Feasibility
2. Determine DragonBoard™ Platform/Linux Release to use
   a) Support for required hardware interfaces
3. Use Existing Linux Device driver frameworks, models and API's
4. Determine device driver type - Built-in kernel driver or Module driver
5. Follow Linux Coding guidelines
6. Robust device driver with good error handling
7. Device driver interface with user space programs
   a) Special functions
   b) Debugging
8. Portability considerations
9. Debugging considerations

   Dynamic Debugging, file system interfaces, user programs

MPD Demo System 1: H2C + D2L-LP

- This demo shows HDMI data converted into MIPI CSI by the TC358743 bridge IC enabling Host Processors to have HDMI RX capability. The video data is then displayed to an LVDS panel. The TC358775 bridge IC enables the Host to have LVDS TX capability.
- Mobile Host Processors have MIPI® interfaces for displays and cameras, the Toshiba bridge ICs add interfaces that enable new features, functions and capabilities.



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D2LLP Features

- Receives video on the DSI receiver interface and transmits the video on the LVDS output interface.

- DSI Receiver
  - Supports upto 4 data lanes with max bit rate of 1Gbps/lane
  - Video input data formats: RGB565, RGB666 and RGB888
  - Up to WUXGA resolutions (1920x1200 24-bit pixels) to dual-link LVDS display panel

- LVDS FPD Link Transmitter
  - Supports single-link or dual-link
  - Maximum pixel clock speed of 135 MHz for single-link or 270 MHz for dual-link
  - Supports display up to 1600x1200 24-bit/pixel resolution for single-link, or up to WUXGA (24 bit/pixel) resolutions for dual-link

D2LLP Driver - Overview

1. D2LLP chips could be programmed using either I2C or DSI
   a) Programming of D2LLP chip done using DSI in this driver
2. Char driver interface provided to user layer to read and write D2LLP registers
3. Reused existing DSI subsystem interface code on Snapdragon™ processor based platform
4. Initialization of D2LLP chip
5. Panel Timing configuration using the registers in D2LLP
   a) HBP,HFP,HPW, HACT, VBP,VFP, VACT, VPW
6. Debugging using following D2LLP registers
   a) Interrupt Status
   b) Debug Registers
   c) System Status

H2C Features

- Converts HDMI Video Data to MIPI-CSI-2 Video Data
- HDMI-RX Interface
  - HDMI 1.4 - Video Formats Support (Up to 1080P@60fps)
  - RGB, YCbCr444: 24-bpp @60fps ,YCbCr422 24-bpp @60fps
- Supports 3D, HDCP, DDC, EDID,
- Maximum HDMI clock speed: 165MHz
- Supports up to 4 CSI2 data lanes at 1 Gbps per data lane
- Video, Audio and InfoFrame data can be transmitted over MIPI CSI-2
- I2C Slave interface used for configuring registers
- Support I2C speeds of 100Khx, 400Khz and 2 MHz

H2C Driver - Overview

1. H2C driver is basically a MIPI-CSI input capture driver where MIPI-CSI input is received from H2C chip in YUV format
2. Start with a working sensor source code as a template
3. Use existing framework functions where possible
4. Override other functions which need specific implementation for H2C
5. H2C registers can be read/written using the I2C interface.
6. H2C registers can be accessed as 8 bit, 16 bit or 32 bit registers.

   User programs as well as /sys/* file system interface
7. Program H2C registers to
   a) Output the appropriate format and frame rate on CSI
   b) Do RGB to YUV conversion if required
   c) Program EDID
8. Program settle time appropriately as per MIPI® specification
9. Dynamic Debugging

H2C Driver Implementation

- **Major interface with sensor - V4L2**

```
struct msm_sensor_ctrl_t h2c_s_ctrl = {
        .msm_sensor_reg = &h2c_regs,
        .sensor_i2c_client = &h2c_i2c_client,
        .sensor_i2c_addr = 0x0f << 1,
        .sensor_output_reg_addr = &h2c_reg_addr,
        .sensor_id_info = &h2c_id_info,
        .cam_mode = MSM_SENSOR_MODE_INVALID,
         .csic_params = &h2c_csic_params_array[0],
        .csi_params = &h2c_csi_params_array[0],
        .msm_sensor_mutex = &h2c_mut,
        .sensor_i2c_driver = &h2c_i2c_driver,
        .sensor_v4l2_subdev_info = h2c_subdev_info,
        .sensor_v4l2_subdev_info_size = ARRAY_SIZE(h2c_subdev_info),
        .sensor_v4l2_subdev_ops = &h2c_subdev_ops,
        .func_tbl = &h2c_func_tbl,
};
```

H2C Driver Implementation

- sensor_output_reg_addr

```
struct msm_sensor_output_reg_addr_t h2c_reg_addr = {
        .x_output = 0x0060,
        .y_output = 0x0064,
        .line_length_pclk = 0x0068,
        .frame_length_lines = 0x006c }
struct msm_sensor_id_info_t h2c_id_info = {
    .sensor_id_reg_addr = 0x0000, /*Chip and Rivsion ID*/
     .sensor_id = 0x0000, /* As per data sheet it is read only register*/
};
```

- csic_params

```
struct msm_camera_csi_params h2c_csic_params = {
    .data_format = CSI_8BIT,
    .lane_cnt    = 2,
    .lane_assign = 0xe4,
    .dpcm_scheme = 0,
    .settle_cnt  = H2C_SETTLE_CNT,
};
```

H2C Driver Implementation

```
struct msm_camera_csid_vc_cfg h2c_cid_cfg[] = {
        {0, CSI_YUV422_8, CSI_DECODE_8BIT},
};
struct msm_camera_csi2_params h2c_csi_params = {
        .csid_params = {
                .lane_assign = 0xe4,
                .lane_cnt = 2,
                .lut_params = {
                        .num_cid = ARRAY_SIZE(h2c_cid_cfg),
                        .vc_cfg = h2c_cid_cfg,
                },
        },
        .csiphy_params = {
                .lane_cnt = 2,
                .settle_cnt = H2C_SETTLE_CNT,
        },
};
```

H2C Driver Implementation

- Sensor_i2c_driver

```
struct i2c_driver h2c_i2c_driver = {
        .id_table = h2c_i2c_id,
        .probe  = msm_sensor_i2c_probe,
        .driver = {
                .name = SENSOR_NAME,
        },
};
```

- sensor_v4l2_subdev_info

```
struct v4l2_subdev_info h2c_subdev_info[] = {
        {
        .code   = V4L2_MBUS_FMT_YUYV8_2X8,
        .colorspace = V4L2_COLORSPACE_JPEG,
        .fmt    = 1,
        .order    = 0,
        },
};
```

H2C Driver Implementation

- sensor_v4l2_subdev_ops

```
static struct v4l2_subdev_core_ops h2c_subdev_core_ops = {
        .ioctl = msm_sensor_subdev_ioctl,
        .s_power = msm_sensor_power  };
static struct v4l2_subdev_video_ops h2c_subdev_video_ops = {
        .enum_mbus_fmt = msm_sensor_v4l2_enum_fmt  };
static struct v4l2_subdev_ops h2c_subdev_ops = {
        .core = &h2c_subdev_core_ops,
        .video  = &h2c_subdev_video_ops };
```

- func_tbl

```
static struct msm_sensor_fn_t h2c_func_tbl = {
.sensor_start_stream = h2c_start_stream,
.sensor_stop_stream = h2c_stop_stream,
.sensor_csi_setting = h2c_csi2_setting,
.sensor_set_sensor_mode = msm_sensor_set_sensor_mode,
.sensor_mode_init = msm_sensor_mode_init,
.sensor_get_output_info = msm_sensor_get_output_info,
.sensor_config = msm_sensor_config,
.sensor_power_up = h2c_power_up,
.sensor_power_down = h2c_power_down,
.sensor_adjust_frame_lines = msm_sensor_adjust_frame_lines1,
.sensor_get_csi_params = msm_sensor_get_csi_params  };
```

TransferJet

A Simple, High Speed, M2M Wireless Transfer Technology

- **Simple** - Just Touch
- **High Speed** - 560*/375** Mbps
- **Low Power** - Comparable to BT
- **Toshiba Offers Total Solution**
  - IC, Module, Accessories (MicroSD Card an
    USB Adaptor

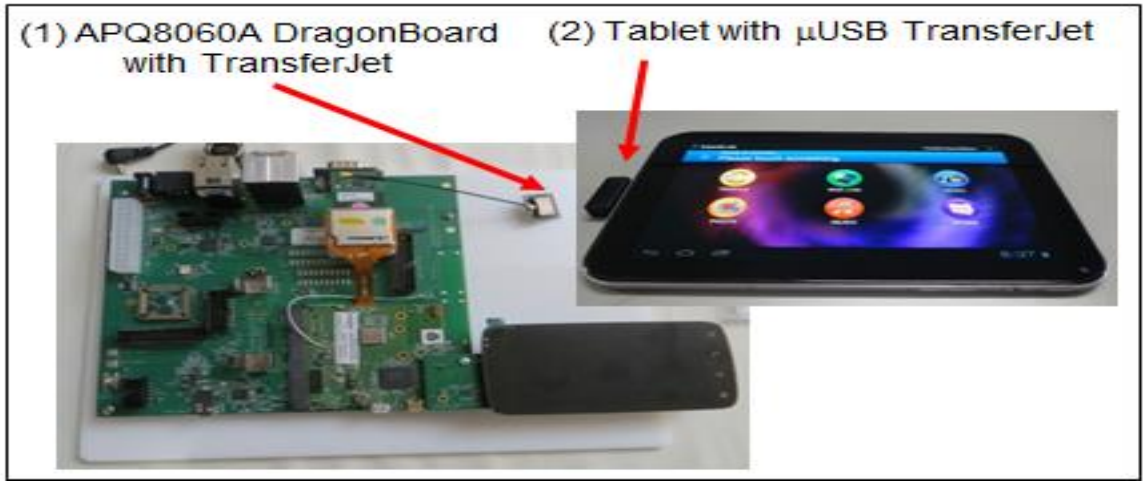
* Raw Speed
** Effective Speed

DragonBoard™ Platform TransferJet® Technology Demo

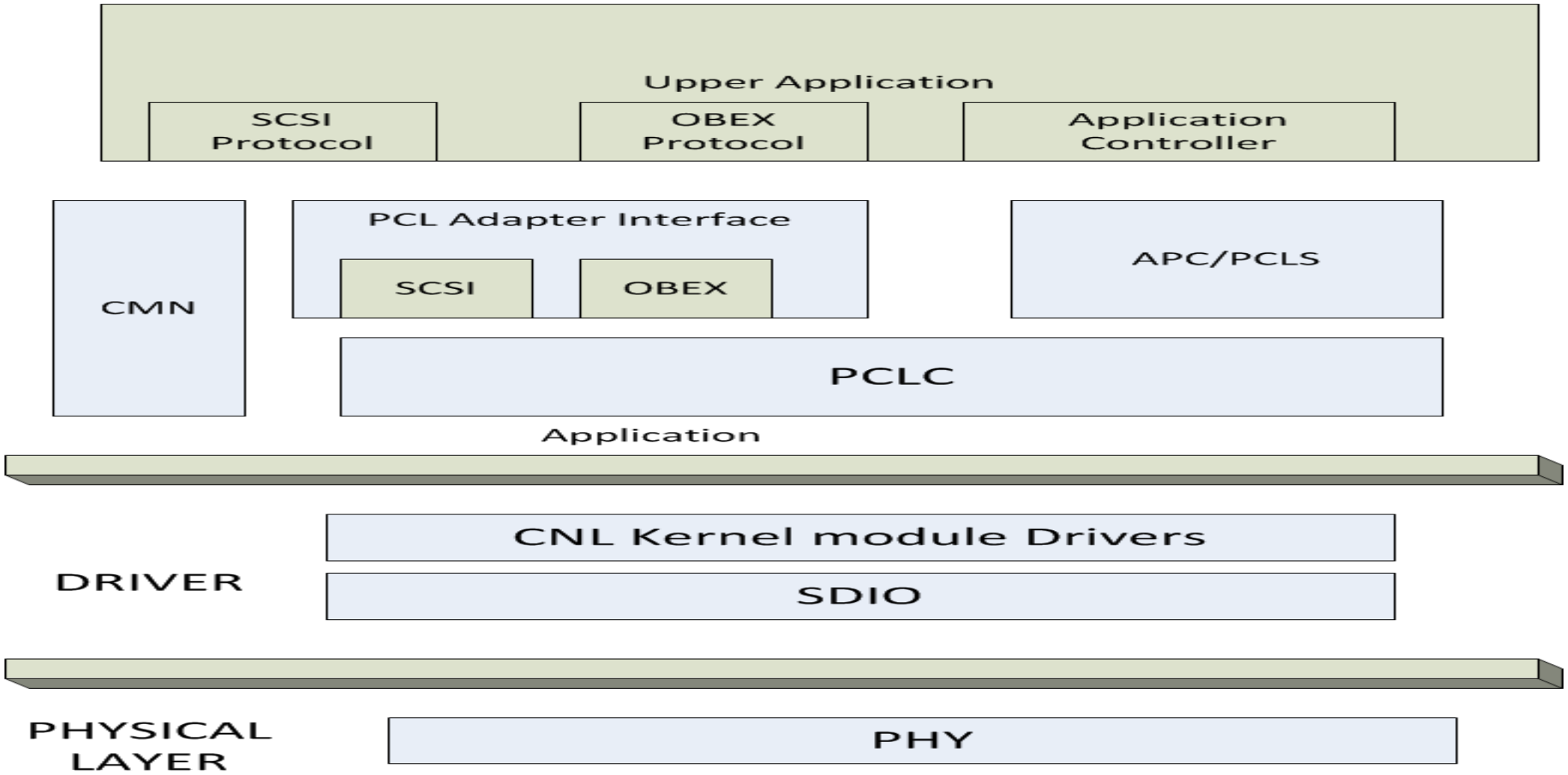
TransferJet® is a Machine-to-Machine, Simple, High Speed Wireless Technology

- **Simple – Just a Touch**
- **High Speed – 560Mbps Raw Speed / 375Mbps Effective Speed**
- **Low Power – Comparable to Bluetooth**
- **Secured Communication**

The demo shows that the APQ8060A DragonBoard™ with TransferJet Transceiver IC integrated can transfer file to or receive file from a TransferJet ready Tablet in a simple, high speed, and secured fashion



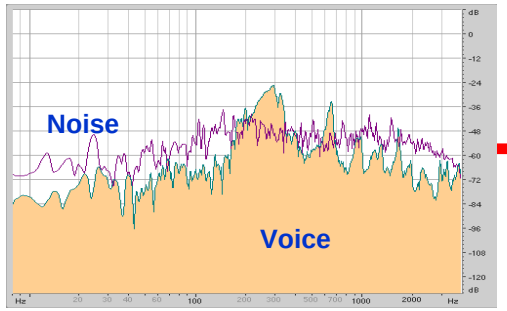
TransferJet® – Software Stack



Audio CODEC

Mobile Audio Solution with Superb Noise and Echo Cancellations

Handfree Call with Noise



TC94B24WBG

- I2C Control
- G-class stereo headphone
- 4-ch Digital microphone interface
- Ear speaker amplifier
- 2-ch ADC for analog microphone
- I2S I/F (4input、4output)
- DSP CEVA-TeakLite-III™
  - Noise Cancellation Algorithm
  - Echo Cancellation Algorithm

After Noise Cancellation

- **Excellent Noise Cancellation**
  Unique algorithm with statistical noise estimation and min mean square error approach
- **Excellent Echo Cancellation**
  Unique algorithm with time-domain echo cancelling adaptive filter and frequency-domain echo suppression
- **NC/EC Can be Achieved by 1 Mic**

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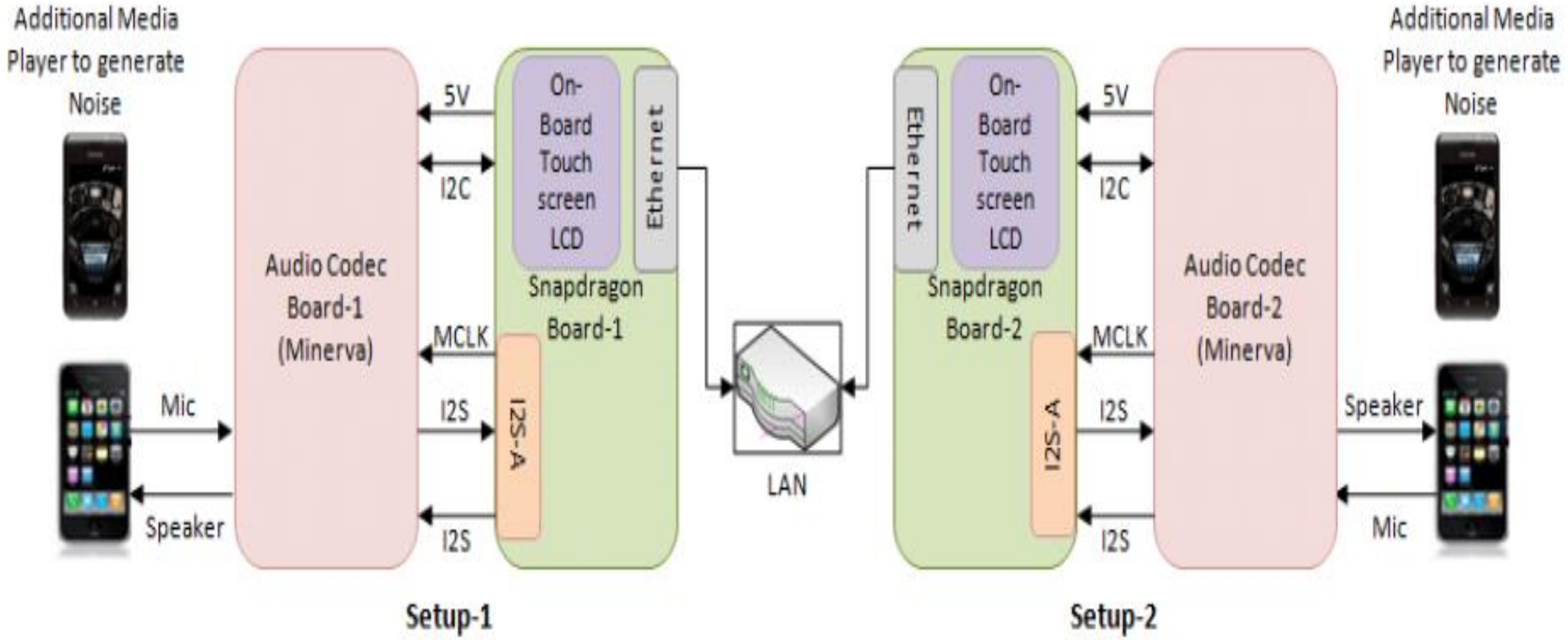
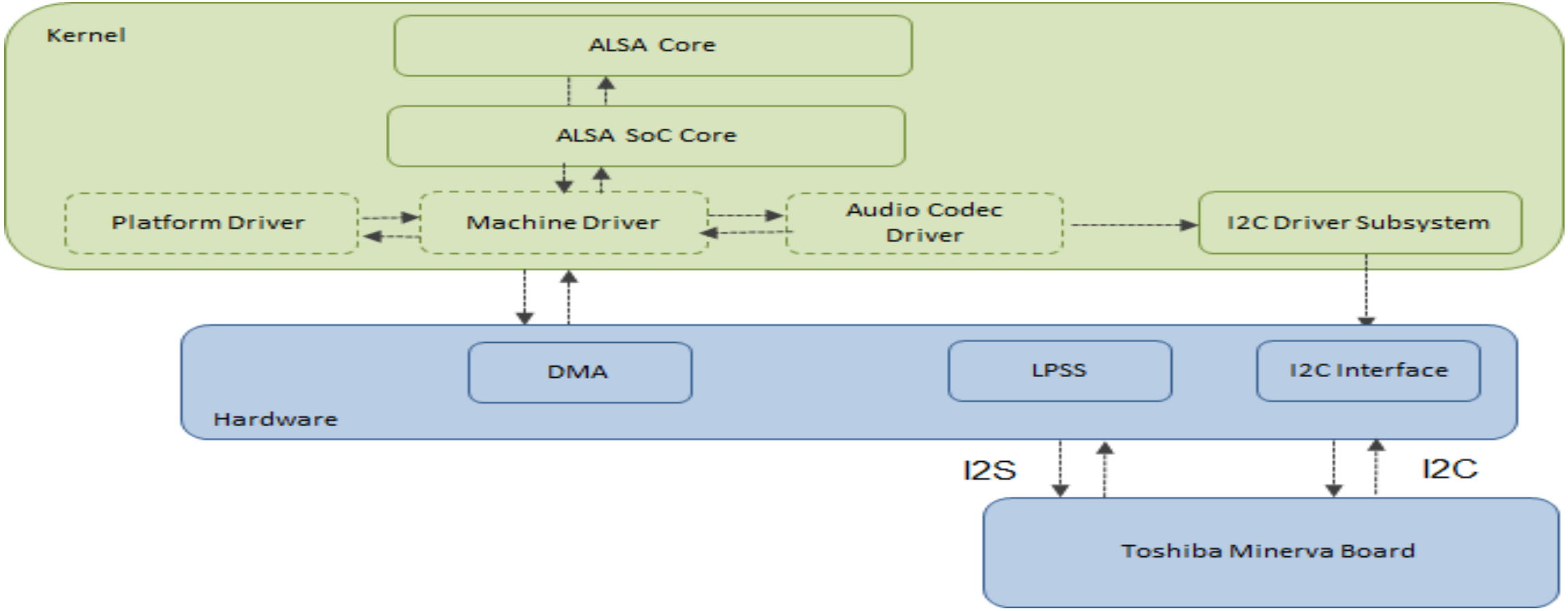
Audio Codec(TC94B24WBG) – Block Diagram



Audio Codec Driver



Q & A

Thank you

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