Imagination

Leading provider of semiconductor IP

- Established technology powerhouse
  - Founded 1985; LSE FTSE 250 (IMG.L)
  - UK HQ; global operations; ~1,600 employees
  - Fastest growing design IP provider in 2012
- Leading silicon, software & cloud IP supplier
  - 3M units a day shipping with Imagination IP
  - Cumulative > 5B units shipped
  - #1 IP supplier of graphics, video IP
- Pure: our strategic product division
  - Shipping ~ 1M devices annually
  - Digital radio, internet connected audio, home automation

Imagination

IP business pathfinder
Market maker/driver

Comprehensive IP portfolio for SoCs & cloud connectivity
Global presence

- Support closer to our growing customer base
- Sales and business development operations
- R&D across all product families

In more products than ever before

More than 5 billion products
3 million per day

Note: now includes MIPS
The Internet of Things

*Fully Connected - An IP address for every “thing”*

- M2m Nodes
- Smart Sensors, Control & Energy Monitoring
- ZigBee/Z-wave/WiFi/BT/3G/4G Wireless Network
- Home Control
- Home Monitoring
- Healthcare
- Smart Grid
- M2m Hub
- Internet
- Smartphone
- Tablet
- Wearable Computing
- Smart meters

Bringing together people, devices & services
Connected SoC – easy, right?
What’s the priority?

- Single Function
- Multi Function
- Input or Output
- Interactive
- Battery Life
- Fast response

Wearable requirements, enablers and challenges

Lack of standards creates opportunities and challenges

- Low power
  - Battery operated: days/weeks (fitness) – months (home health) – years (embedded vital signs)
- Low cost
- Low memory footprint
- Information security and accuracy
  - Protecting data gathered and transmitted
- Storage
  - Processing and managing enormous amounts of new data in a useful way
- Connectivity
  - Low bandwidth and efficient power optimized network usage
  - Support for low-power mesh networks, Wi-Fi, and cellular networks
- Short design cycle
**Wearable device classes**

Wearable devices will vary in capabilities

Input Nodes – Fitness and Health bands

Mainstream Output Wearables - Watches

High End Output Wearable - Glasses

- RPU
- M-class
- Sensor
- Complements Smartphone
- 30 day battery life

- Cloud
- Hubs
- Data Analysis at the Node
- High end Output
- Nodes / Displays
- Information at a Glance
- Simple interaction
- Complements Smartphone
- Weeks of battery life

- Sensor only collects data
- Complements Smartphone
- 30 day battery life

- ABI Research, BI Intelligence, IHS

**Wearable devices will vary in capabilities and feature requirements**

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**Wearable output – possible use cases**

Investigating the most convenient use cases

<table>
<thead>
<tr>
<th>Communication</th>
<th>Organization &amp; Info</th>
<th>Health &amp; Wellness</th>
<th>Entertainment &amp; Leisure</th>
<th>Home &amp; Auto</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Voice</td>
<td>• Calendar alert</td>
<td>• Fitness and Tracking</td>
<td>• Music control</td>
<td>• Home Security</td>
</tr>
<tr>
<td>• Call Alert</td>
<td>• News</td>
<td>• Sleep Tracking</td>
<td>• Camera control</td>
<td>• Home Control</td>
</tr>
<tr>
<td>• Video</td>
<td>• Weather</td>
<td>• Alarm</td>
<td>• Audio hub, BT enabled</td>
<td>• Google Now – turn by turn information</td>
</tr>
<tr>
<td>• “Quick” chat</td>
<td>• Stock update</td>
<td>• Emergency</td>
<td>• Cast</td>
<td>• Vehicle Alerts</td>
</tr>
<tr>
<td>• Social Media alert</td>
<td>• Convenience – taxi, bus</td>
<td>• Proximity alert – shopping, social</td>
<td>• Proximity alert – shopping, social</td>
<td></td>
</tr>
</tbody>
</table>
Generic IoT/M2M module block diagram

M2M -> Internet of Things

**Sensors:**
- Accelerometers
- Gyroscopes
- digital compasses
- inertial modules
- pressure sensors
- microphones
- temperature sensors
- touch sensors
- ECG/ECG
- Pulse
- Temperature
- Blood Pressure
- Glucose
- etc.

**Control:**
- Motor
- Actuators
- Switches
- Valves
- Controllers
- etc.

**Connectivity:**
- 2G/3G/4G
- WiFi
- Bluetooth LE
- Zigbee
- etc…

- M2M was traditionally SIM card / cellular-based applications
- Internet of Things/Everything expands this definition to any connectivity standard

(MEMS) Sensor Controller

- Motion tracking sensors – I²C/SPI
  - 6 axis
    - 3 axis accelerometer
    - 3 axis gyroscopes
  - 9 axis +digital compass
- Controller used for
  - Sampling data
    - 1 – 2000 samples (degrees/g/μT / sec)
  - Sensor data algorithms
  - Calibration
  - Fusion of sensor data

MEMS Sensor controller processing requirements

- Power consumption levels that drive <100uA @ 100MHz
- 100DMIPS @ 75MHz today
- Up to 500DMIPS in future
- Impact on die costs (65nm) of <$0.005
- Need processing power headroom to enable more intelligent sensor data analysis.
  - Current
  - IMG Creating a solution platform
    - MIPS + Ensigma + Flow + Security

MEMS sensor controller ecosystem

- Working with Sensor and Sensor Algorithm companies to port to microMIPS
  - Movea Sensor Fusion
  - PNI Corporation
  - ST
  - Bosch
  - Invensense
- Ensuring RTOS and microkernel support for IoT
  - ContikiOS, Nucleus, MeOS, threadX
- Deliver secure IoT platform
- Enable AllSeen compatibility in FlowCloud
  - discovery of adjacent devices, pairing, message routing and security
Fragmentation in wearable watches

Smart Accessory Watches vs. Smart OS Watches

- Proprietary OS
- Alerts
- Caller ID
- Read txt msgs
- Reminders

No Standard APIs…. YET
Android Wear Watch / iWatch

Wearable Device Requirements

<table>
<thead>
<tr>
<th>SoC requirement</th>
<th>Wearable Fitness</th>
<th>Smartphone accessory Watches</th>
<th>SmartWatches</th>
<th>Glasses/Goggles/AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>&lt;100MHz microcontroller µAptiv UC or M51xx</td>
<td>200MHz – 500MHz single core – Inter, m51xx</td>
<td>300MHz dual core – 10GHz quad core Inter, m51xx</td>
<td>500MHz – 1GHz dual/quad core Inter, m51xx</td>
</tr>
<tr>
<td>Graphics</td>
<td>N/A</td>
<td>SGX</td>
<td>PowerVR 6XE</td>
<td>PowerVR 6/6XE</td>
</tr>
<tr>
<td>Vision</td>
<td></td>
<td></td>
<td>V2500</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td>N/A</td>
<td>N/A</td>
<td>Optional E4500 / Jasper / D4500</td>
<td>h.264 BP/VP8/JPEG E4500 / Jasper Optional D4500</td>
</tr>
<tr>
<td>Display</td>
<td>N/A</td>
<td>eInk</td>
<td>~QVGA / 320x320</td>
<td>VGA - WXGA</td>
</tr>
<tr>
<td>Memory requirements</td>
<td>16KB – 64KB SRAM</td>
<td>OS dependent</td>
<td>128MB – 512MB DDR</td>
<td>256MB – 1GB DDR</td>
</tr>
<tr>
<td>Connectivty</td>
<td>BT 4.0 Smart(LE)</td>
<td>BT 4.0 Smart(LE)</td>
<td>BT 4.0 Smart(LE) + WiFi b/g/n</td>
<td>BT 4.0 Smart(LE) + WiFi b/g/n</td>
</tr>
<tr>
<td>Sensors</td>
<td>Accelerometers, inertia</td>
<td>Accelerometers, pulse, inertia, gyro</td>
<td>Accelerometers, pulse, inertia, gyro, mic</td>
<td>Accelerometers, pulse, inertia, gyro, mic</td>
</tr>
<tr>
<td>Battery Life</td>
<td>1 month</td>
<td>1 week</td>
<td>3 days</td>
<td>1 day</td>
</tr>
<tr>
<td>Battery Size</td>
<td>200-300mAh</td>
<td>300-500mAh</td>
<td>300-500mAh</td>
<td>500 – 700mAh</td>
</tr>
</tbody>
</table>
Wearable compute devices

- Low power consumption dominant
- Hierarchy of CPUs
- Little or no GPUs
- Small 1.5” screens (optional)
- Small batteries (~250 – 350 maH)
- Low power Bluetooth 4.0
- Watch, Notifications, voice interaction

SoCs need to be designed specifically for wearables

- Up to 10x better battery life
  - Battery life that are months, not days
- Designed for wearable use cases
  - Sensors, BLE, and speech always on
  - Screen information available at a glance
- Use IP cores that are highly configurable for reuse
Wearables processing requirements

**microAptiv UC Core Features**
- Microcontroller level performance and functionality
- Optional FPU and DSP
- Designed for embedded, real-time systems
- RTOS/kernel
- Ideal for wearable input

**MS1xx Core Family Features**
- Microprocessor level performance and functionality
- MMU & cache controller
- Optional FPU and DSP
- Supports virtualization
- anti-tamper and debug security
- RTOS/Linux/Android

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**Wearables processing requirements**

**interAptiv Core Features**

- Multi core options
- MIPS32 multi-threading enabled
- Dual virtual processing elements (VPEs)
- Up to 9 thread contexts mapped to VPEs
- Hardware thread resources for:
  - Policy manager provides scheduling and QoS
  - Inter-thread communication (ITC) w/ core & cluster
  - Yield qualifier
- Optional FPU and DSP
- Ideal for Android enabled devices
Android Wear

New Google OS targeted for wearables

- Android Wear extends the Android platform to a new generation of wearable devices.
  - The user experience is designed specifically for wearables
  - Based on current notification APIs and Google Now cards

- Glance-able information
  - Short snippets of information

- Zero to low user interaction
  - Touch swipes or voice

- Imagination has MIPS-based silicon partners that are currently working on delivering Android Wear compatible products

Imagination IP fit and value propositions

Wearable computing

### PowerVR Graphics
- Necessary in high end wearable displays and smartwatches
- Small die size and battery life drives requirement
- Helpful when video/vision hardware not present
- Required in Augmented reality use case

### MIPS Processors
- M2M modules
- μControllers – microAptiv or SMALLER
- Sensor data analysis – filter our unnecessary data and send only valuable data
- Extremely low power – battery life should approach μW

### Ensigma - Communication
- BT 4.0LE (Smart) will dominate low end of market
- Communicates with Hub. Either Smartphone or Home Hub or other BT devices.
- Wi-Fi

### PowerVR Video
- Necessary in high end wearable displays
- Encoding for video capture devices
- e.g. Google Glass
- Possible video decoder requirement for video conferencing

### PowerVR Vision - Camera ISP
- Photo/Video capture devices in high end wearable displays
- Augmented reality

### FlowCloud – Cloud connected platform
- Allows cloud based infrastructure for wearables
- Ready to use solution
- Enables data analysis modules for specific sensor data (e.g. – Accelerometers, Gyroscope, temperature sensors, etc.)
Summary – wearable computing

Providing ecosystem, solutions, and platforms for wearable computing

- Imagination understands the business, dynamics, and relationships of wearable computing
- One stop IP shop for wearable computing devices!
  - Low-power and efficient processor technology - MIPS
  - Low-power connectivity technology - Ensigma
  - Low-power graphics/imaging/vision technology - PowerVR
  - Ready to use cloud connected platform - FlowCloud
- Developing reference solutions and ecosystem to ease customer time-to-market

Thank You!