Embedded intelligence for the next wave of smart systems
Opportunities and challenges on the edge

Jean-Marc Chery
President & CEO
STMicroelectronics
Among the world’s largest semiconductor companies

- Serving over 100,000 customers across the globe
- 2018 revenues of $9.66B, with year-on-year growth of 15.8%
- Listed: NYSE, Euronext Paris and Borsa Italiana, Milan
- Signatory of the United Nations Global Compact (UNGC), Member of the Responsible Business Alliance (RBA)

- ~46,000 employees worldwide
- ~7,400 people working in R&D
- 11 manufacturing sites
- Over 80 sales & marketing offices
Assisted Living
Assisted Driving
Digital everything

Smart City tech
Smart Driving tech
Smart Industry tech

Personal healthcare
Energy saving tech
Electric vehicle tech

Cloud Infrastructure
Automation of services and manufacturing

Autonomous Systems
Robotics

Securely Connected Machines & Personal Devices

Electrification of Automobiles and Infrastructure

IoT

More Power efficient Systems
**Smart Connected Objects**

- **300 million** in 2017
- **800 million** in 2021
  - \( \downarrow \)
  - Wearable computing devices

- **0.4 billion** in 2017
- **1.8 billion** in 2021
  - \( \downarrow \)
  - Excluding PCs & digital home

- **4 billion** in 2017
- **10 billion** in 2021
  - \( \downarrow \)
  - Retail, advertising, supply chain & Industrial IoT

- **1.1 billion** in 2017
- **2.2 billion** in 2021
  - \( \downarrow \)

Source: ABI
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Key Trends in Embedded Processing

More Computing Power & Memory
- More eNVM, more Flash
- More MIPS, FLOPS
- Graphics & AI accelerators

Lower Power Consumption
- Ultra-low power operating modes
- Efficient computing
- System optimization

More Security
- Software Security
- Embedded Hardware security
- Physical robustness

More Robustness
- Physical robustness
- Function Safety (SIL)

More Connectivity
- More protocols
- Higher speed
- Wired and Wireless

More Local Autonomy
- Environmental analysis
- Distributed processing
- Artificial Intelligence

Broader & more inclusive ecosystems
More Computing Power & Memory

- Better performance
- New features or functionality
- Improved safety
- More reliable
Control Unit Evolution in Automotive

Vehicle Control Unit

- ENGINE CONTROL
  ICE Engine Management

- e-TRACTION
  Electric Motor Powertrain

- TRANSMISSION
  Vehicle transmission control

Technology enablers

FD-SOI Technology
- Low Power Consumption

28 nm lithography
- Higher operating frequency

PCM memory
- High-speed high-density memory

arm™ Cortex™ -R52
- Performance and virtualization
Improving power consumption at every level

- Technology
- Integration
- Software (including AI)
- System

Lower Power Consumption
Machine Learning Core
Embedded in a Sensor

Sensor Data
A wide set of inputs selectable
Data coming from Accelerometer, Gyroscope and External sensor

Computation Block
Filter block and computation
Advanced computation features: Mean, Variance, Energy, Peak, etc

Decision Tree
Activity recognition

Data coming from:
- Accelerometer: $a_x$, $a_y$, $a_z$, $[a_v]$, $[a^2_v]$
- Gyroscope: $g_x$, $g_y$, $g_z$, $[g_v]$, $[g^2_v]$
- External sensor: $m_x$, $m_y$, $m_z$, $[m_v]$, $[m^2_v]$

$V = \sqrt{X^2 + Y^2 + Z^2}$
More Security

Authenticity verification

Secure data exchanges

Secure data storage

Secure code execution
Secure Firmware Update

Backroom tools

- Application Firmware
  - Hash & Sign
  - FW Signature
  - Private key

Application Firmware Package

- Application Firmware
- FW Signature

End device

- Code
  - Public key
- Application Firmware
  - FW Signature

Signature verification

Public key
AI for Vehicle Security

Cyber Attack From the cloud

Cyber Attack From the vehicle

Intrusion Detection & Prevention

MONITORING

CONTROL

Hardware Security

Cloud node

In-vehicle node
Functional safety for all applications

Automotive

Industrial

Home Appliances
Building in Functional Safety

**General Purpose MCU**
- Dual-watchdog
- Back-up clock circuitry
- Critical register protection
- Memory protection unit
- Multiple flash memory protection levels
- ECC for RAM and Flash memories
- Hardware CRC

**Automotive MCU**

Adding additional features, such as:
- Lock-step cores
- System redundancy
Many connectivity protocols

Short-range to long-range

Variety of features (power, throughput)

Interoperability
More Connectivity

General Purpose MCU

- MCU with software libraries supporting wired connectivity protocols
- MCU with integrated wireless connectivity capabilities

Partners

- Partners providing RF ICs or modules connected to the GP MCU

Multiple chip  System In Package (SiP)  System On Chip (SoC)  Modules
Localized sensing and intelligence
Distributed systems
Edge computing
Artificial Intelligence
High Bandwidth

High centralized computing power

Potentially high latency
Reduced bandwidth
Lower centralized computing power
Real time response
Preserving Privacy
AI Application Processing
Requirements

Low
- Sensor analysis
- Activity recognition (motion sensors)
- Stress analysis or attention analysis

Medium
- Audio & sound
- Speech Recognition
- Object detection

High
- Computer vision
- Multiple objects detection / classification / tracking
- Speech Synthesis

From IP embedded in MCU/MPU to dedicated SOC
Key Steps Behind Neural Networks

1. Capture data
2. Train NN Model
3. Clean, label Data
4. Convert NN into optimized code for target processor
5. Process & analyze new data using trained NN
Neural Networks on General Purpose MCUs

- Input your framework-dependent, pre-trained Neural Network into the conversion tool
- Automatic and fast generation of an MCU-optimized library
- Interoperability with state-of-the-art Deep Learning design frameworks
- Train NN Model
- Convert NN into optimized code for MCU
- Process & analyze new data using trained NN
Broader & More Inclusive Ecosystems

- Development Tools
- Prototyping boards & Reference hardware
- Smartphone applications
- Reference Software
- Cloud connectivity
- Developer Community
- Partner Program
- Open Source
Takeaways

• Major societal trends drive a need for technology to support

• Embedded processing plays a key role in enabling the systems that can support these trends

• Six key trends in embedded processing driving the creation of new solutions for developers

• Need a broad Ecosystem taking into account developer requirements