Using NuttX RTOS for Industrial IoT Solutions

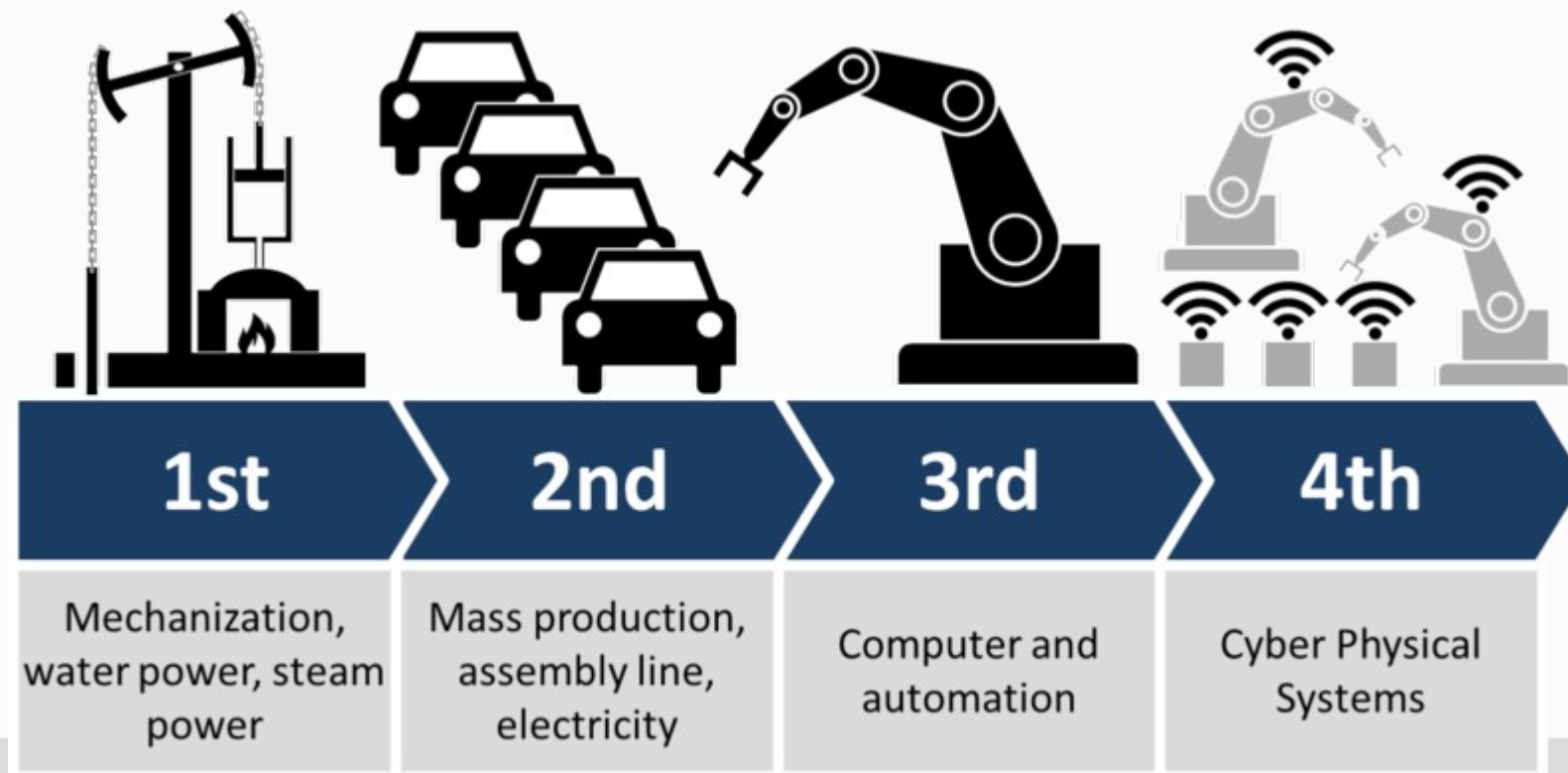Alan Carvalho de Assis, MSXi / Keenix

Agenda:

- Introduction to IIoT (or Industry 4.0)
- Introduction to NuttX RTOS
- Comparing Linux with NuttX
- Why to use NuttX for Industrial Applications?
- How to get involved?

The Industrial Revolutions …

1st	2nd	3rd	4th
Mechanization, water power, steam power	Mass production, assembly line, electricity	Computer and automation	Cyber Physical Systems

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The 4th Industrial Revolution

- Decentralized control;
- Driven by the Internet of Things (IoT);
- Manufacturing plant becomes smart;
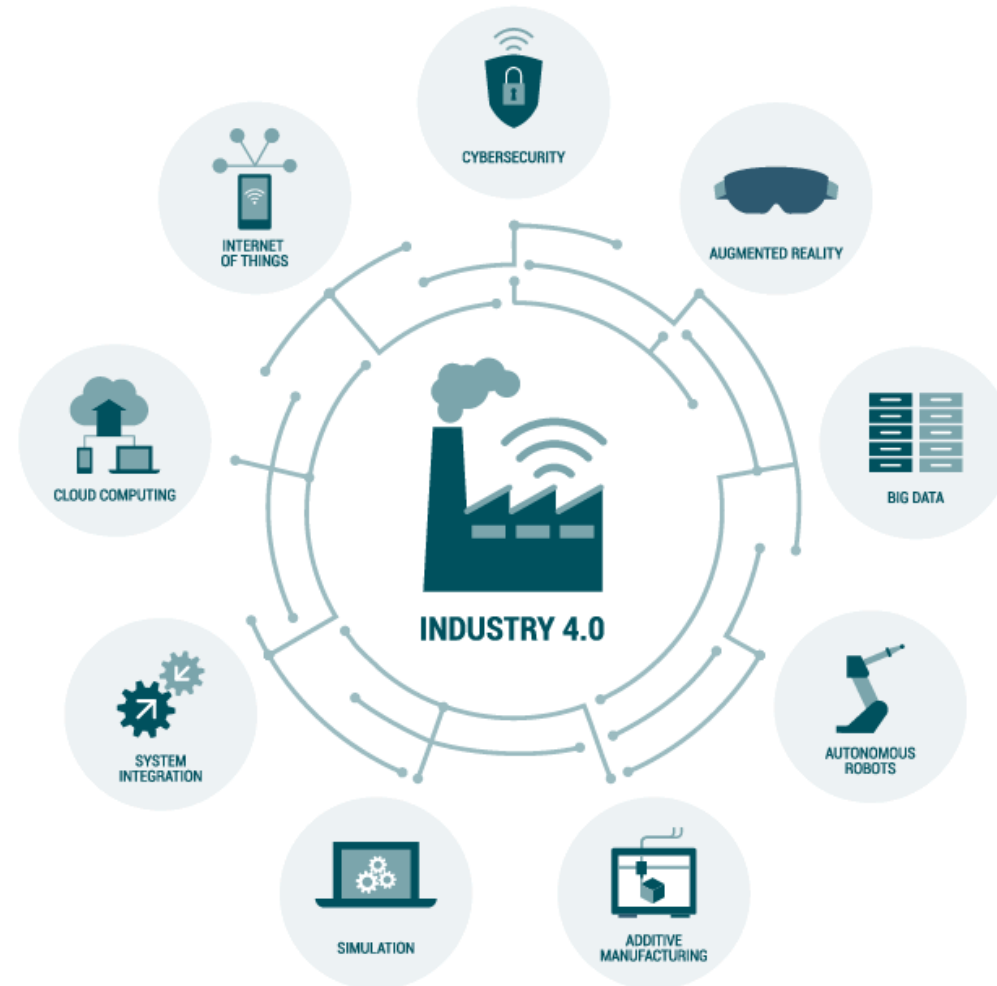- Since devices are connected to the Internet cyberattack is a real issue.

Industry 4.0 Principles:

- Interoperability;
- Information transparency;
- Service-Orientation;
- Decentralization;
- Virtualization;
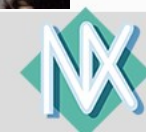- Modularity

Main components:

I.E.: Fiat Chrysler Automobiles's Jeep Factory

- 700 robots mount almost everything in the car;
- Every single piece of the car is traceable;
- The factory system is integrated with supplier;
- This is the first FCA factory built following the Industry 4.0 concepts.

Source: https://motor1.uol.com.br/news/143970/fabrica-da-fca-em-pernambuco-alcanca-220-mil-unidades-produzidas/

What an OS/RTOS needs to support IIoT:

- Network support: IPv4, IPv6, 6LoWPAN, MQTT, etc);
- Connectivity: WiFi, Bluetooth, RFID/NFC, etc;
- Industrial interfaces: RS485, CAN-Bus, EtherCAT, etc;
- Realtime support for processes and robot control;

What an OS/RTOS needs to support IIoT: (cont)

- Program Languages: C/C++, Java, Python, Lua, etc;
- AI library/tools (libdeep, MPlib, Torch, TensorFlow, etc);
- Image Recognition libraries (OpenCV, libccv, etc);
- Security: Crypto AES, DTLS, TLS, etc.

Here comes NuttX RTOS!

What is the NuttX RTOS?

- Created by Gregory E. Nutt;
- First public release: Feb 2007;
- Supports 8 to 32 bits uCs/uPs;
- Release under BSD License!

What is the NuttX RTOS? (cont)

- Small footprint;
- Very customizable;
- Inspiration from Linux/Unix:
  - VFS;
  - MTD;
  - PROCFS;
  - NuttShell;
  - Etc.

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What is the NuttX RTOS? (cont)

- Supports:
  - ARM (ARM7, ARM9, ARM11, Cortex-Mx, Cortex-Rx, Cortex-Ax);
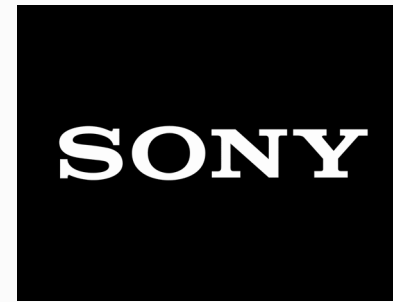 - AVR
  - MIPS
  - LM32
  - RISC-V
  - X86
  - Xtensa, Z80, etc;

Companies using NuttX

- Sony;
- Samsung;
- Motorola Mobility;
- Haltian;
- 3DRobotics;
- Daruma;
- VergeAero;
- Many others.

NuttX's key features:

- POSIX complaint;
- Fully preemptible;
- Virtual File System (VFS);
- Loadable kernel modules;
- Symmetric Multi-Processing (SMP);
- Realtime scheduling (FIFO, RR, SPORADIC);
- Tickless operation support (lower power consumption);
- Pseudo-terminals (PTY) and I/O redirection;

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NuttX's key features: (cont)

- Memory modes:
  - FLAT (no MMU),
  - PROTECTED (with MPU),
  - KERNEL (with MMU).
- High Performance/Zero Latency Interrupts (ARM);
- Native debug log support (INFO, WARN, ERR);
- Power Management;
- System log support.

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File Systems support:

- FAT12/16/32;
- NFS;
- BINFS;
- SMARTFS;
- ROMFS;
- PROCFS;
- UnionFS;
- TMPFS;

Network Support:

- Multiple network interfaces support;
- Network routing support;
- Support to IPv4, IPv6, TCP, UDP, ICMP, etc;
- Unix socket;
- DNS name resolution;
- IEEE 802.11 (WiFi) FullMac;
- IEEE 802.15.4 (MAC, 6LoWPAN);
- SLIP (Serial), PPP (GSM Modem);

Graphical Support:

- Framebuffer support (similar to Linux FB);
- LCD Support (Parallel / Serial);
- NX Graphics server (similar to X server idea);
- NX Graphics lib (fonts, lines, rectangles, etc);
- NXWidgets: high level user interface;
- Foreign graphics supported (i.e.LittlevGL);
- VNC Server support.

Audio Support:

- Audio Tone Generator;
- Audio codecs: VS1053 SPI, CS43L22, WM8776, WM8904;
- NXPlayer audio player w/ HTTP download stream.

USB Host Classes supported:

- USB CDC/ACM Modem Class (i.e.: ttyACM0);
- USB Mass Storage Class (pen-driver);
- USB HID Keyboard Class;
- USB HID Mouse Class;
- USB HUB Support.

USB Devices Classes supported:

- USB CDC/ACM Modem Class (i.e.: ttyACM0);
- USB Mass Storage Class (pen-driver);
- USB RNDIS Ethernet-over-USB;
- USB Composite Device Support;
- USB Prolific PL2303 USB/Serial Emulation.

Microcontrollers with better support:

- STMicro STM32;
- Microchip SAM3/SAM4;
- Microchip SAMV7;
- NXP LPC17xx;
- NXP LPC43xx;
- NXP i.MX RT 10xx.

Comparing Linux vs NuttX:

- Linux:
  - High-end processors
    - MMU (except uClinux);
    - 32-bit (except ELKS);
  - Requires 8MB+ RAM;
  - Requires 2MB+ Flash;
- Started for PC and was adapted for embedded;
- No initial support for Realtime;
- Power hungry.

Comparing Linux vs NuttX: (cont)

- NuttX:
  - Low/Mid-end microcontrollers/microprocessors
    - no MMU required;
    - 8/16/32-bit;
  - Requires 8KB+ RAM;
  - Requires 16KB+ Flash;
- Started for 8-bit MCU;
- Realtime from scratch;
- Low power consumption.

Why to use NuttX for IIoT:

- Linux compatibility;
- Broad range of features;
- POSIX compliance (easy to port applications);
- Easy to move to high-end OS in the future;
- Flexibility to move among supported MCUs;

Linux applications ported to NuttX:

- FreeModBus;
- BACnet stack;
- LLVM libc++;
- SQLite;
- Many others;

Contact

- Alan Carvalho de Assis
- Email: acassis@gmail.com
- Blog: acassis.wordpress.com