# NXP's Arm® Cortex®-M33 based LPC551x MCU Family **Enhanced Security & Performance Efficiency**

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May 2020

SECURE CONNECTIONS FOR A SMARTER WORLD


PUBLIC

# Agenda

- Microcontroller Introduction
- Cortex-M33 based LPC5500 MCUs
- Security & Efficiency Benefits of LPC551x MCU Family

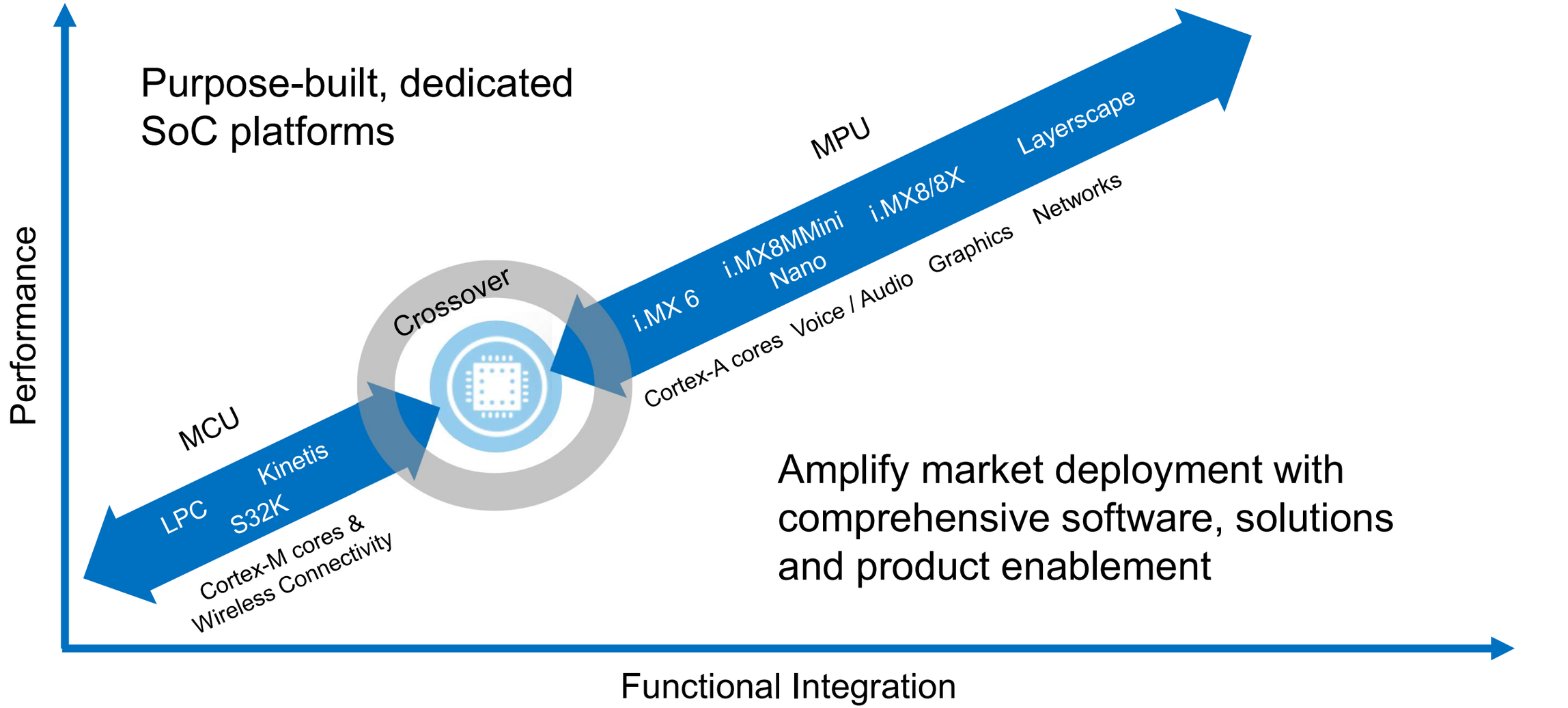
# NXP Edge Processing Introduction

SECURE CONNECTIONS FOR A SMARTER WORLD

PUBLIC

## NXP'S EDGE PROCESSING LEADERSHIP

DIFFERENTIATED PLATFORMS ADDRESSING BROAD RANGE OF MARKET REQUIREMENTS



# Industrial & IoT
# EDGE PROCESSING BUSINESS

| | |
|---|---|
| Product Innovation | High-performance crossover processors to Low-power secure and connected MCUs |
| Expansive Ecosystem | Common software platform combined with large partner network |
| Customer Driven Commitment | Total product quality, longevity and support for 10,000s end customers across thousands of diverse applications |

# Industrial & IoT
# MICROCONTROLLERS


25K+ Customers


## Numerous industry firsts

First Arm-based MCU, First Crossover MCU, First Cortex-M33 MCU, …

## 46 Years in business

## NXP MICROCONTROLLERS
SERVING NUMEROUS END MARKETS

- Factory Automation & Building Control
- Smart City Power & Energy
- Secure Transactions

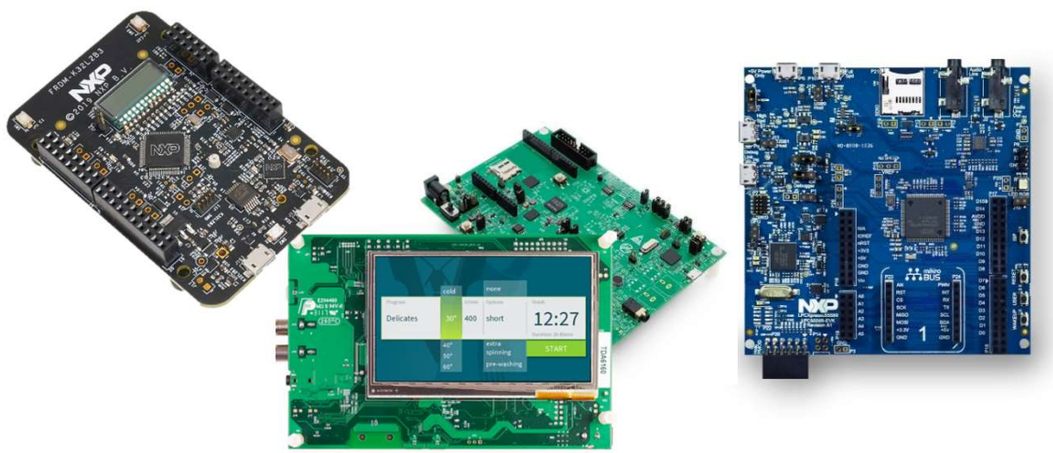
- Consumer Products
- Compute & Gaming

- Smart Home
- White Goods
- Lifestyle Devices

# NXP MICROCONTROLLER ECOSYSTEM

Online Community | Online Documentation | Online SW & Tools

- Software compatibility across NXP's broad Cortex-M portfolio
- Cost effective evaluation boards with on-board debug probe and various expansion options



## THE MCUXPRESSO ECOSYSTEM


**Core Technologies from NXP**
- MCUXpresso IDE
- MCUXpresso SDK
- MCUXpresso Config Tools
- MCUXpresso Secure Provisioning Tool

**Enabling Software Technologies**
- Run time software libraries and middleware
- Enable customers to focus on differentiation
- From NXP and partners

**Enabling Tools Technologies**
- Partner IDEs
- Debug Probes
- Development Boards
- From NXP and partners

# LONGEVITY EXTENDED TO 15 YEARS FOR OVER 1,000 MCU DEVICES

NXP has decades long experience and a longstanding track record of **providing continuity of production supply** of our MCU products.

**Recently Extended:**

- LPC5500 Series MCUs
- LPC54000 Series MCUs[2]
- LPC4300 Series MCUs
- LPC4000 Series MCUs
- LPC800 Series MCUs
- LPC1100 Series MCUs[2]
- LPC1800 Series MCUs
- i.MX RT1010 Crossover MCUs
- i.MX RT1015 Crossover MCUs
- i.MX RT1020 Crossover MCUs
- i.MX RT1050 Crossover MCUs
- i.MX RT1060 Crossover MCUs

**Already extended to 15 years:**

- KE Series
- KL Series
- KV Series
- KE Series
- KM Series
- LPC1700 Series
- LPC2000 Series

*[1] Extension to 15 years starts from original date of launch. Visit www.nxp.com/productlongevity for the complete list and details.*

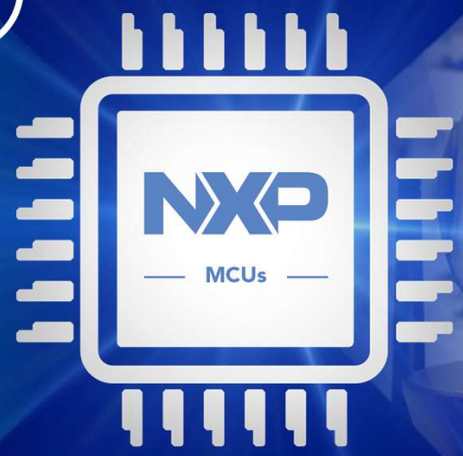
*[2] Extension excludes LPC11C22FBD48, LPC11C24FBD48, LPC54018JxM and LPC54S018JxM.*


# Arm Cortex-M33
# **LPC5500 MCU**
# Spotlight

# LPC5500 MCU Series

## Single and dual-core Arm® Cortex®-M33 MCU Series

- Ultra-efficient 40nm flash technology
- Mixed-signal interfaces to sense, connect, control
- Enhanced safety and security
- IEC60730 library support for Smart Appliance and Safety applications.
- MCUXpresso developer ecosystem



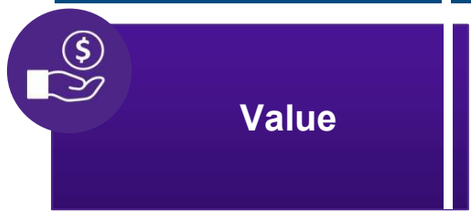

NXP.COM/LPC5500

# NXP'S ARM® CORTEX®-M AND FOCUS MCU PORTFOLIO


Cortex-M7 based **i.MX RT Crossover MCUs** for Ultimate Performance & Integration


Cortex-M3/-M4 based MCUs and *introducing* **Cortex-M33 based LPC5500 MCU Series**


Cortex-M0+ based MCUs and *introducing* **K32 L for Cost-, Power- sensitive use cases**




**S08 (8-bit)** and **LPC800 (Cortex-M0+) for Entry-level applications**


**KE (Industrial)** & **S32K (Automotive)** for Safe and Reliable 5V MCU Applications

**DSC/KV** for Motor Control & Digital Power & **KM** for Metering Applications

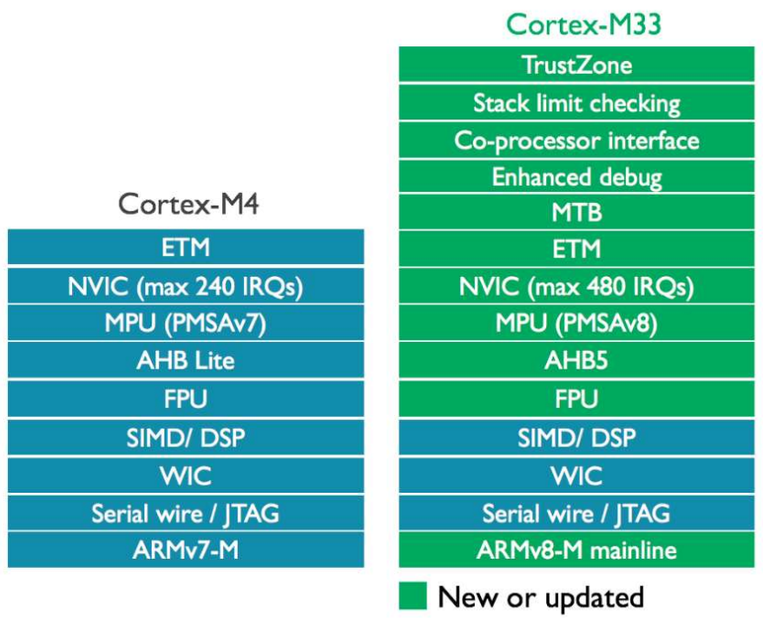
## Key Features and Comparisons

- **Nearly 20% performance improvement over Cortex-M4 based MCUs** (over 60% vs Cortex-M0) with redesigned pipeline - up to two instructions per clock cycle

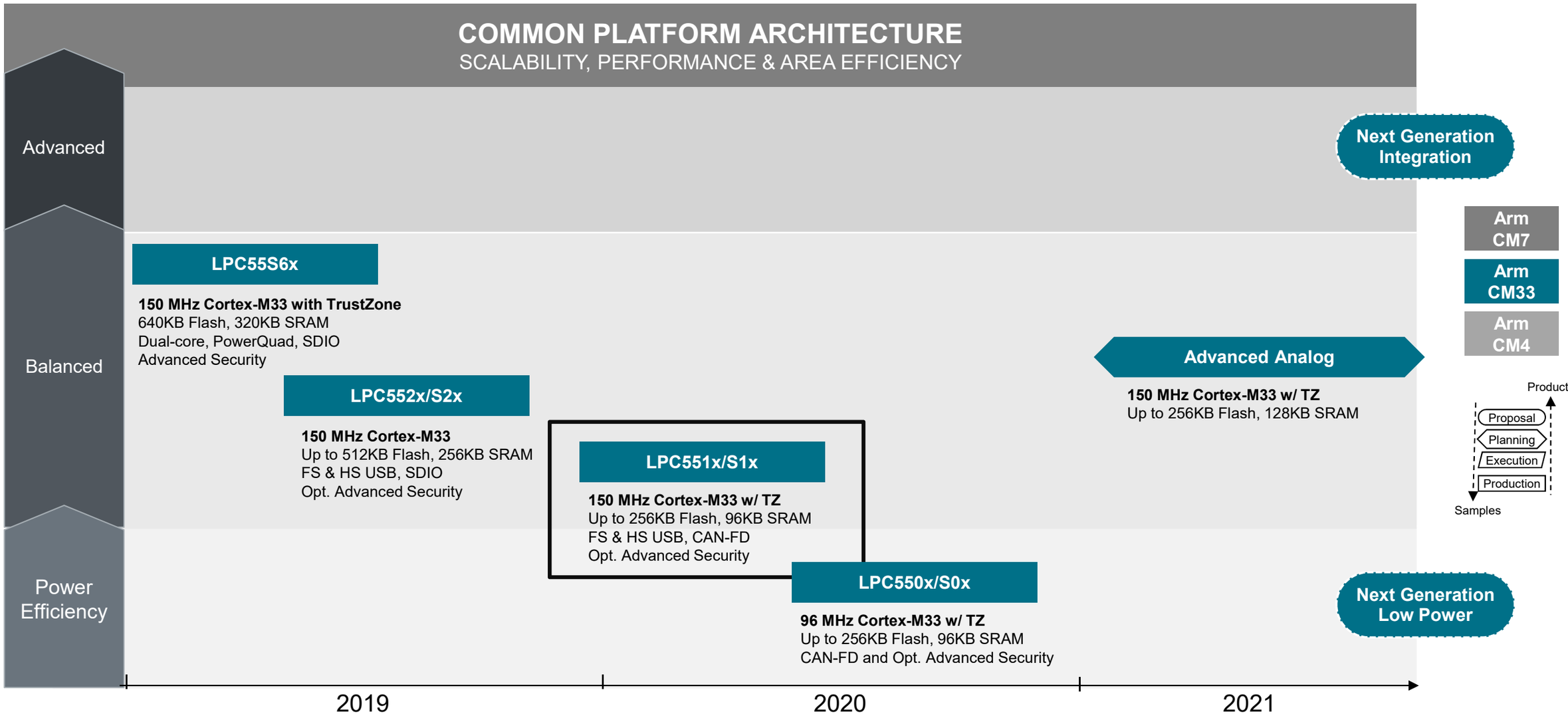
| | Cortex-M0+ | Cortex-M23 | Cortex-M3 | Cortex-M4 | Cortex-M33 |
|---|---|---|---|---|---|
| DMIPS/MHz | 0.95 | 0.98 | 1.25 | 1.25 | 1.50 |
| CoreMark®/MHz | 2.46 | 2.50 | 3.32 | 3.40 | 4.02 |

- **TrustZone for system-wide, secure resource isolation** enabling trusted runtime execution and physical protection in embedded MCU applications

- **Tightly coupled accelerators with coprocessor interface & extensions** (Arm's single precision FPU along with NXP accelerators)



# LPC5500 MCU SERIES ROADMAP



# LPC551x/S1x MCU Series

## Arm® Cortex®-M33 MCU Series from $0.97 (USD) at 10Ku

- Ultra-efficient 40-nm flash technology:
  - Over 600 CoreMarks[1] and as low as 32uA/MHz[2]
- System Integration for Industrial and IoT Markets
  - High-Precision ADCs
  - CAN-FD for industrial control
  - HS USB with On-Chip PHY
- Enhanced safety and security with Arm TrustZone-M technology
- Comprehensive enablement with MCUXpresso Ecosystem


NXP.COM/LPC5500

# ADDRESSING COMMON INDUSTRIAL & IOT EMBEDDED SYSTEM CHALLENGES

- **Time to Market**
- **Balancing Power, Performance Efficiency & System Cost**
- **System Vulnerability Protection**
  - Counterfeit Protection
  - Onboarding
  - System Integrity
  - Secure Communication
  - Data Confidentiality
  - Remote Firmware Update

## Hardware Platform for Ease of Development

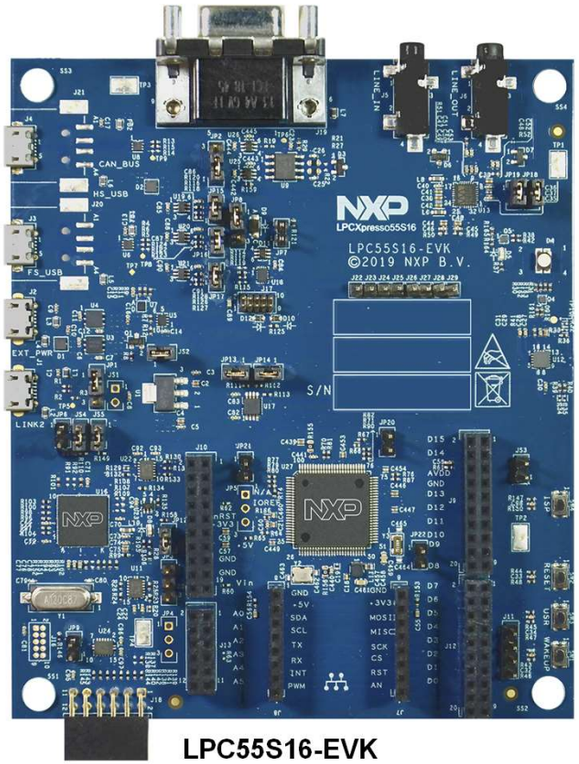
- **LPC5500 MCU Series EVKs**
  - LPC55S16JBD100 Cortex-M33 microcontroller running at up to 150 MHz
  - High and full speed USB ports with micro A/B connector for host or device functionality.
  - High- and full-speed USB ports
  - NXP TJA1044GTJ High-Speed CAN Transceiver
  - NXP Accelerometer
  - MikroEletronika click expansion option
- On-board debug circuit
- PCB layout, schematic and board files available

## Complimentary with Extensive Support

MCUXpresso SDK

MCUXpresso IDE

MCUXpresso Config Tools




LPC55S16-EVK

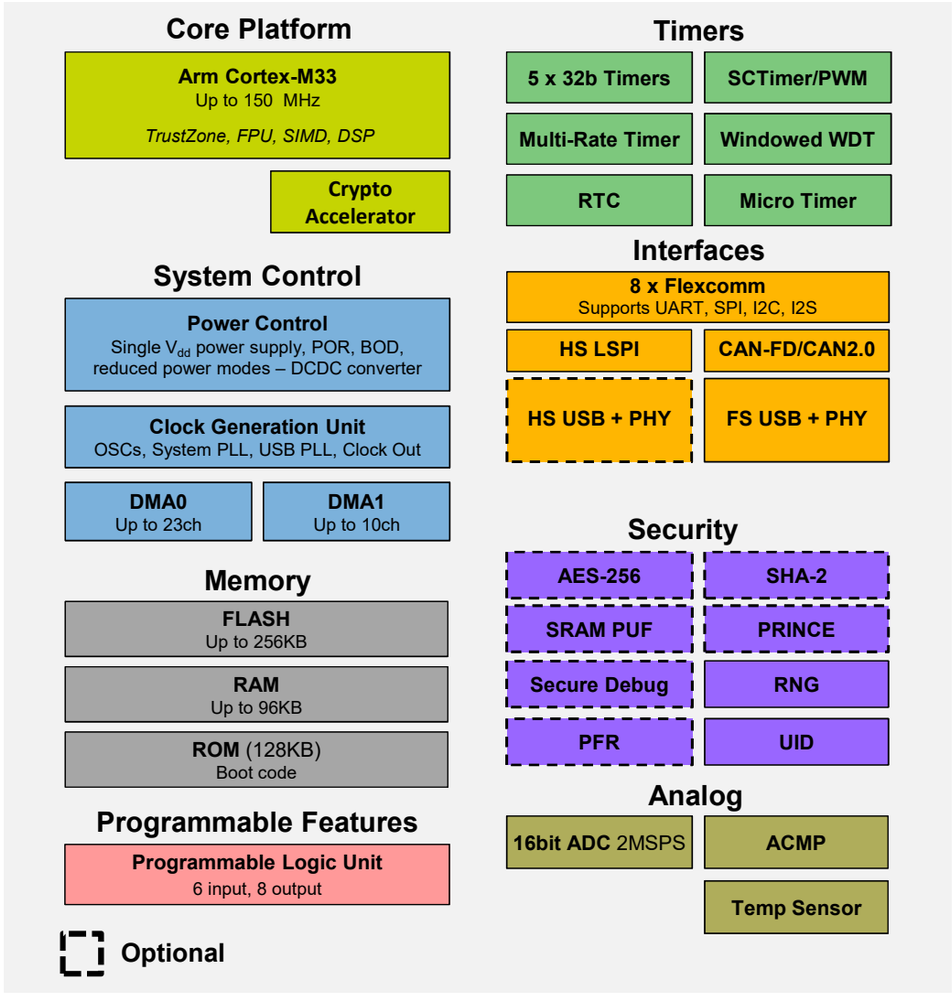
ARM KEIL Microcontroller Tools

IAR SYSTEMS

SEGGER

| Development Board | S/R Price (USD) |
|---|---|
| LPC55S16-EVK: LPCXpresso55S16 Development Board | $41 |

# LPC551X MCU FAMILY BLOCK DIAGRAM




# Target Applications

## Industrial & Building Automation

- Remote IO and Sensor Nodes
- Elevators and Lifts
- Smart Lighting and Utilities

## Consumer Products

- Gaming and PC Peripherals
- Vehicle/Asset Tracking Systems
- Cordless Power Tools and Appliances

## Smart Home

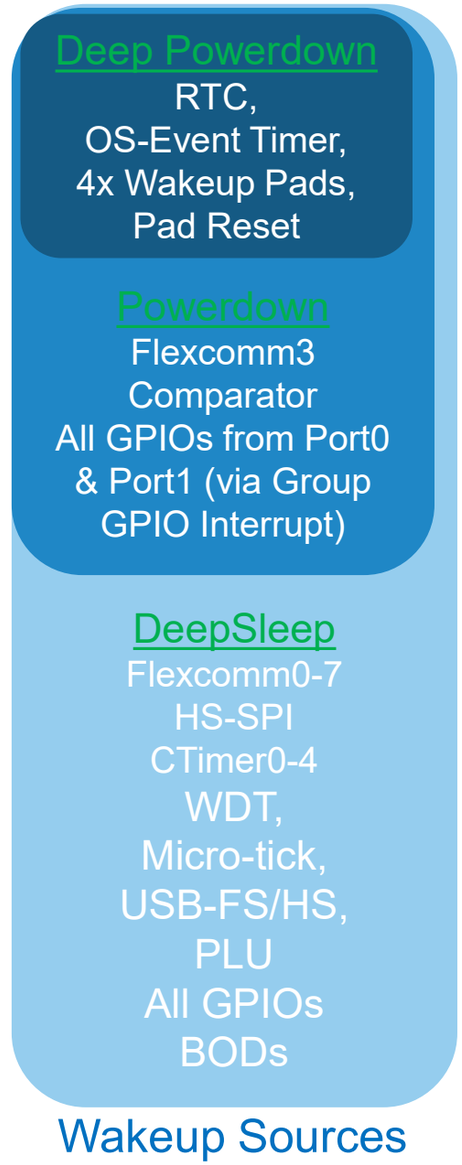
- Secure/Biometric Access Control
- Security Systems
- Sensor Nodes

# LPC5500 MCU SERIES
## COMMON PLATFORM ARCHITECTURE FOR COMPLETE SCALABILITY

| | LPC551x/S1x | LPC552x/S2x | LPC55S6x |
|---|---|---|---|
| **Cortex-M33 Max Frequency** | Up to 150MHz | Up to 150MHz | Up to 150MHz |
| **Cortex-M33 Co-processor** | - | - | Yes (Up to 150MHz) |
| **Accelerators/ Co-proccessors** | Crypto Accelerator | Crypto Accelerator | PowerQuad DSP, Crypto Accelerator |
| **Flash** | Up to 256 KB | Up to 512KB | Up to 640KB |
| **SRAM** | Up to 96KB | Up to 256KB | Up to 320 KB |
| **Security** | TrustZone, HW SRAM PUF, Debug Authentication, real-time encryption/ decryption, TRNG, Secure boot, SHA-2, AES-256, PFR | HW SRAM PUF, Debug Authentication, real-time encryption/ decryption, TRNG, Secure boot, SHA-2, AES-256, PFR | TrustZone, HW SRAM PUF, Debug Authentication, real-time encryption/ decryption, TRNG, Secure boot, SHA-2, AES-256, PFR |
| **CoreMarks** | 600 | 600 | 1150+ (Dual-core) |
| **Serial Interfaces** | Up to 9 FlexComm supporting USART, SPI, I2C and I2S. 1x HS LSPI | Up to 9 FlexComm supporting USART, SPI, I2C and I2S. 1x HS LSPI | Up to 9 FlexComm supporting USART, SPI, I2C and I2S. 1x HS LSPI |
| **USB** | USB FS w/PHY, USB HS w/PHY | USB FS w/PHY, USB HS w/PHY | USB FS w/PHY, USB HS w/PHY |
| **SDIO** | - | SDIO/SD/MMC | SDIO/SD/MMC |
| **CAN** | CAN FD/CAN 2.0 | - | - |
| **ADC** | 16b 2 Msps | 16b 1 Msps | 16b 1 Msps |
| **GPIO** | Up to 64 | Up to 64 | Up to 64 |
| **Active Power Consumption** | 32uA/MHz | 32uA/MHz | 32uA/MHz |
| **Packages** | HTQFP64, HLQFP100, VFBGA98 | HTQFP64, HLQFP100, VFBGA98 | HTQFP64, HLQFP100, VFBGA98 |

# HIGH PERFORMANCE MCU WITHOUT COMPRISING POWER

| Power Mode | Current VBAT@3V | Wake Time | Description |
|---|---|---|---|
| Active mode<br>96 MHz | 3.2mA - 34uA/MHz<br>3.4mA – 36uA/MHz | - | CoreMark from flash (7 WS)<br>CoreMark from SRAM (0 WS) |
| Active mode<br>150 MHz | 4.9mA - 33uA/MHz<br>5.8mA – 39uA/MHz | - | CoreMark from flash (11 WS)<br>CoreMark from SRAM (0 WS) |
| Deepsleep<br>(All 320kB SRAM retained) | 70uA | 77us | |
| Powerdown with Retention<br>(with 8kB SRAM retained) | 2.4uA | 385us | DCDC off, RAM/Padring on, CPU0 and some periph. retained |
| Deep Powerdown<br>(with 4kB retained) | 475nA | 4.6ms | DCDC off, RAM, Wakeup pin 4x, reset pad, and PD_AO (PMC, OS timer, PMU) are powered |

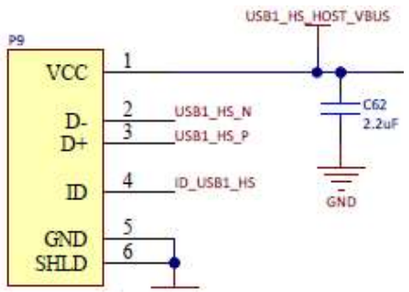



Wakeup Sources

# LPC551X INTEGRATES HIGH-SPEED USB WITH INTEGRATED PHYSICAL TRANSCEIVER

## BOM benefits

- Integrated 480MHz PLL
- Dedicated USB RAM
- No need for external PHY




## SDK Examples

- Device *audio, cdc, hid, msc, phdc, printer, video*
- Host *audio, cdc, hid, msd, phdc, printer*

## Increased throughput

USB FS 12Mbps  USB HS 480 Mbps

Higher data payload (max endpoint size)

| Transfers | HS (bytes) | FS (bytes) |
|---|---|---|
| Isochronous | 1024 | 1023 |
| Interrupt | 1024 | 64 |
| Bulk | 512 | 64 |

# CAN v 2.0 A/B
# CAN-FD v 1.0

CAN with Flexible Data-Rate offers  major benefits over Classical CAN:

## Increased data length

- CAN FD supports up to 64 data bytes per data frame, compared to 8 data bytes for Classical CAN
- Leads to a reduction in protocol overhead, and improved protocol efficiency

## Increased speed

- CAN FD supports dual bit rates:
  - Nominal bit-rate limited to 1Mbit/s as given in Classical CAN
  - Data bit-rate, which is dependent on network topology and transceivers
- Data bits rates up to 5Mbit/s are achievable in practice

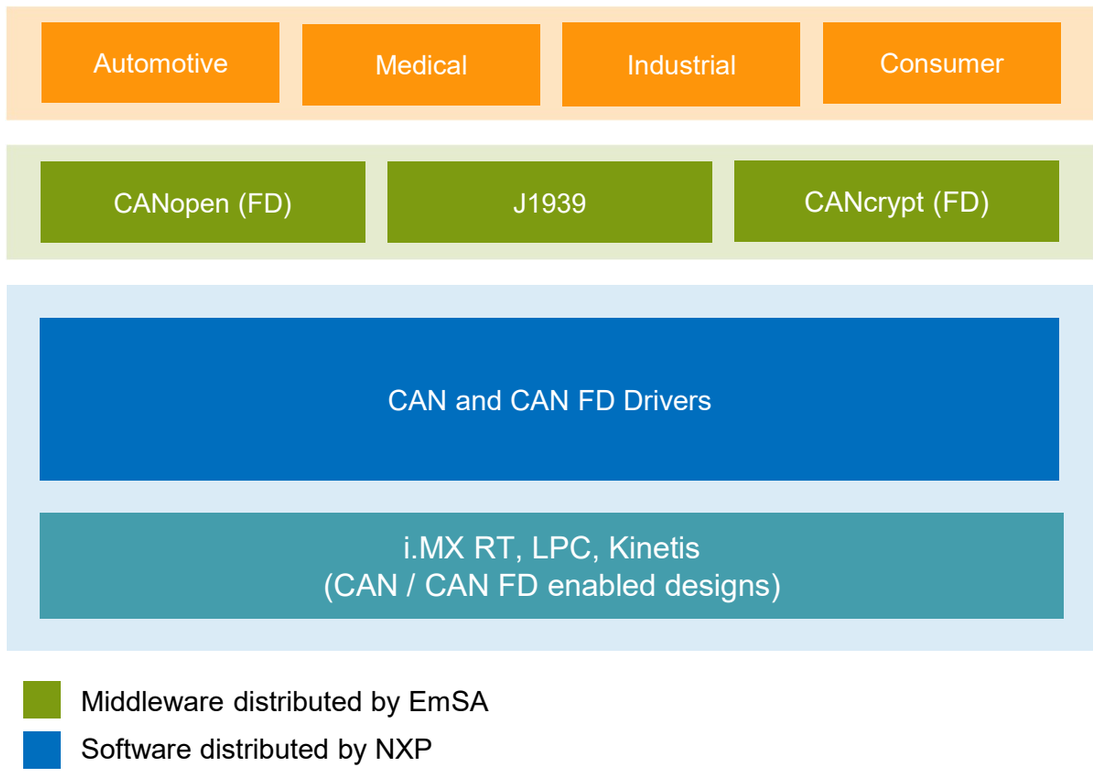
## Improved reliability

- CAN FD uses an improved cyclic redundancy check and the “protected stuff-bit counter” to lower the risk of unprotected errors

# LPC551X CAN-FD SOFTWARE ENABLEMENT

- NXP provides CAN and CAN FD drivers through the MCUXpresso SDK for enabled designs
- Long-time NXP partner EmSA provides middleware for CAN-based higher-layer protocol
  - CANopen and CANopen FD
  - J1939
  - CANcrypt and CANcrypt FD
- CAN related development tools are also available from EmSA
  - CANopen Magic
  - Flash Magic

**www.em-sa.com/nxp**



# ENHANCED SECURITY WITH LPC55S1X MCUs


**HashCrypt** symmetric AES and SHA, **PRINCE** on-the-fly FLASH encryption/decryption, **CASPER** asymmetric cryptography, Random Number Generator **(RNG)**


Secure keys and data using SRAM Physical Unclonable Function **(SRAM PUF)**, Protected Flash Region **(PFR)**


**ROM** based boot that executes only authorized software


Isolated Secure & Non-Secure worlds with **ARM TrustZone** plus NXP implementation **IDAU**, **Secure Bus Control**, **Secure DMA**, **Secure GPIO**


**Debug Authentication** to authenticate the debugger and grant it access to the device

# LPC551X ADDRESSES SECURITY STANDARDS & CERTIFICATIONS


NXP has partnered with industry leading hardware and software partners to offer 3rd party compliance to industry standards, making certified security solutions more accessible, streamlining development and accelerating time to market.

## Addressing Accessibility with Additional Enablement

- **MCU Secure Boot ROM & SW Tools** (elftosb, blhost)
- **Accelerated MbedTLS library**
- **Mbed Crypto**
  - reference implementation of the ARM PSA Crypto API (Q2)
- **Trusted Firmware-M (TF-M)**
  - reference implementation of secure software for ARMv8-M (Q2)

psacertified™

**PSA Level 2**
*Planned Early Q3-2020*

SESIP

**SESIP Assurance Level 2 (SESIP2)**
*Planned Early Q3-2020*

# PACKAGE SCALABILITY WITH LPC551X MCUs

**Common features across families**

- FS/HS USB with PHY, 50MHz SPI, up to 8/10 Serial Interfaces (FlexComm), plus I3C interface (LPC557x/8x families)
- Up to 2Msps 16-bit SAR ADC, Comparator, Temperature Sensor and RTC
- 1.8 to 3.6V, -40 to 105 °C

| LPC5500 Family | Memory | QFN 48 | QFP 64 | QFP 100 | QFP 144 | BGA 98 |
|---|---|---|---|---|---|---|
| **Efficiency** LPC55S6x | Up to 640KB Flash, 320KB SRAM | | X | X | (X) | X |
| **Mainstream** LPC552x/S2x | Up to 512KB Flash, 256KB SRAM | | X | X | | X |
| **Entry** LPC551x/S1x | 256KB Flash, 96KB SRAM | (X) | X | X | | X |

Pin Compatibility

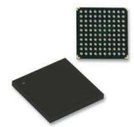
(X) Package development under scoping

## LQFP

**HLQFP100**
14x14mm-x,y, 1.4mm- z
0.5mm pitch

**HTQFP64**
10x10mm-x,y, 1.0mm- z
0.5mm pitch

## BGA



**VFBGA98**
7x7mm-x,y, 0.86mm- z
0.5mm pitch

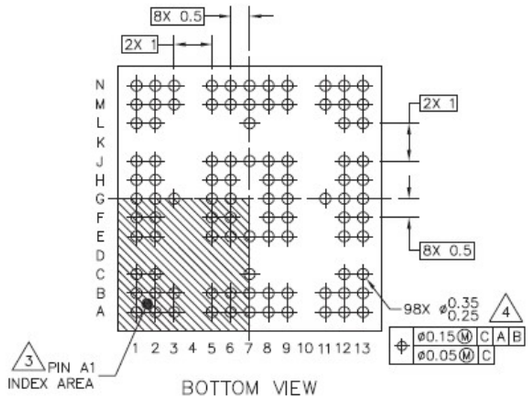
## QFN

**QFN48**
7x7mm-x,y, 1.0mm- z
0.5mm pitch

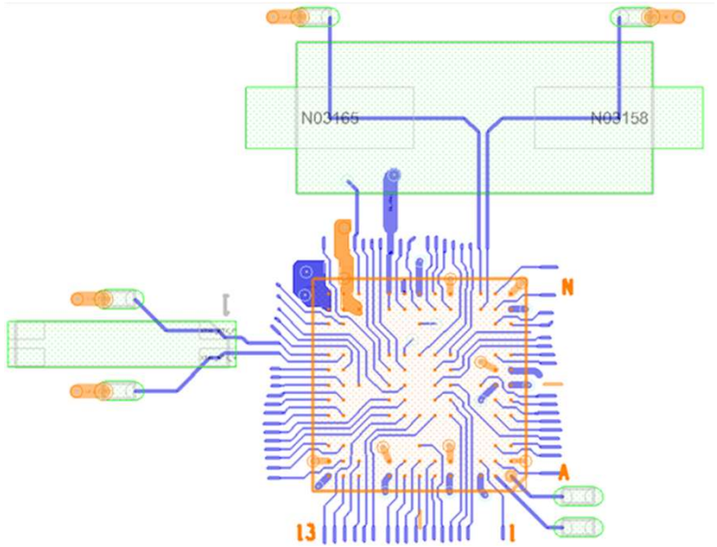
# LPC551X OFFERS SMALL PACKAGES WITH EASY PCB ROUTING

## VFBGA98 7X7MM (0.5MM PITCH) SUPPORTS 2-LAYER PCB LAYOUT

Special Pop-up Ball Pattern




Top Layer Routing View




Bottom Layer Routing View


**Cost Saving Estimate:**

| LPC5500 VFBGA98 (Compares with 4-layer-3.2mil) | 2-layer-3.2mil width | 2-layer-5mil width |
|---|---|---|
| **PCB NRE fees** | 45% cheaper | 57%-87% cheaper |
| **PCB unit cost** | 45% cheaper per pc | 57%-87 % cheaper per pc |

# Need More Information?

Technical Support
https://community.nxp.com/welcome

Visit NXP MCUs Online
www.NXP.com/MCU

**LEARN MORE**

- NXP LPC55S16-EVK: Unboxing and First Impressions | Read On >
- LPC55S16-EVK: How fast does it go? How much current does it take? | Read On >
- Extend MCU Security Capabilities Beyond Trusted Execution with Hardware Crypto Acceleration and Protection | Read One >


**E1 – The New LPC55S69 MCU-Based Board from OKdo**

Release this week, this small form factor LPC55S6x-based board offers a high-performance, secure low-cost entry to the IoT, enabling users, from makers to industrialists, to develop connected solutions that are robust and secure.

**UPCOMING WEBINAR**

May 27 10 a.m. Central

**REGISTER NOW >>**

# Additional Resources

### Videos

- MCU Tech Minutes | Exploring the Dual-Core Feature on LPC5500 Series MCUs
- MCU Tech Minutes | Exploring the SCTimer Feature on LPC5500 Series MCUs
- MCU Tech Minutes | Exploring the Available Wi-Fi Enablement Options on LPC5500 Series MCUs
- MCU Tech Minutes | Exploring the Arm® TrustZone® Feature on LPC5500 Series MCUs

### Blogs

- LPC5500 MCU Series: There's a lot under the hood (Part 1 of 3)
- LPC5500 Series: There's a lot under the hood  (Part 2 of 3) - Dual USB and Lots of RAM
- LPC5500 MCU Series: There's a lot under the hood  (Part 3 of 3) - SCT, "Programmable Logic" and Boot ROM
- "Mini-Monkey" Part 1: How to design with the LPC55S69 in the VFBGA98 package
- "Mini-Monkey" Part 2: Using MCUXpresso to Accelerate the PCB Design Process
- LPC55S69 Mini-Monkey Build Update – Off to Fabrication!

### On-Demand Training

- CANopen and NXP Microcontrollers: Proliferating robust network communication with fast evaluation and deployment
- Secure Provisioning and Programming Using Embedded Trust and the Security-enabled LPC55S6x MCU
- Enabling Secure, NB-IoT End Nodes with MCUXpresso Enablement and PSA-certified MCUs to Address the Growing Industrial IoT Market
- Enabling Next-Gen IoT Applications With Secure-enabled NXP MCUs with TrustZone®-M Technology
- Enabling Motor Control Across a Range of NXP MCUs with MCUXpresso and FreeMASTER Visualization Tools
- Exploring the Latest Features of MCUXpresso v11.1
- Accelerate Development of Robust Network Communications with CANopen and CANopen FD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SECURE CONNECTIONS
FOR A SMARTER WORLD