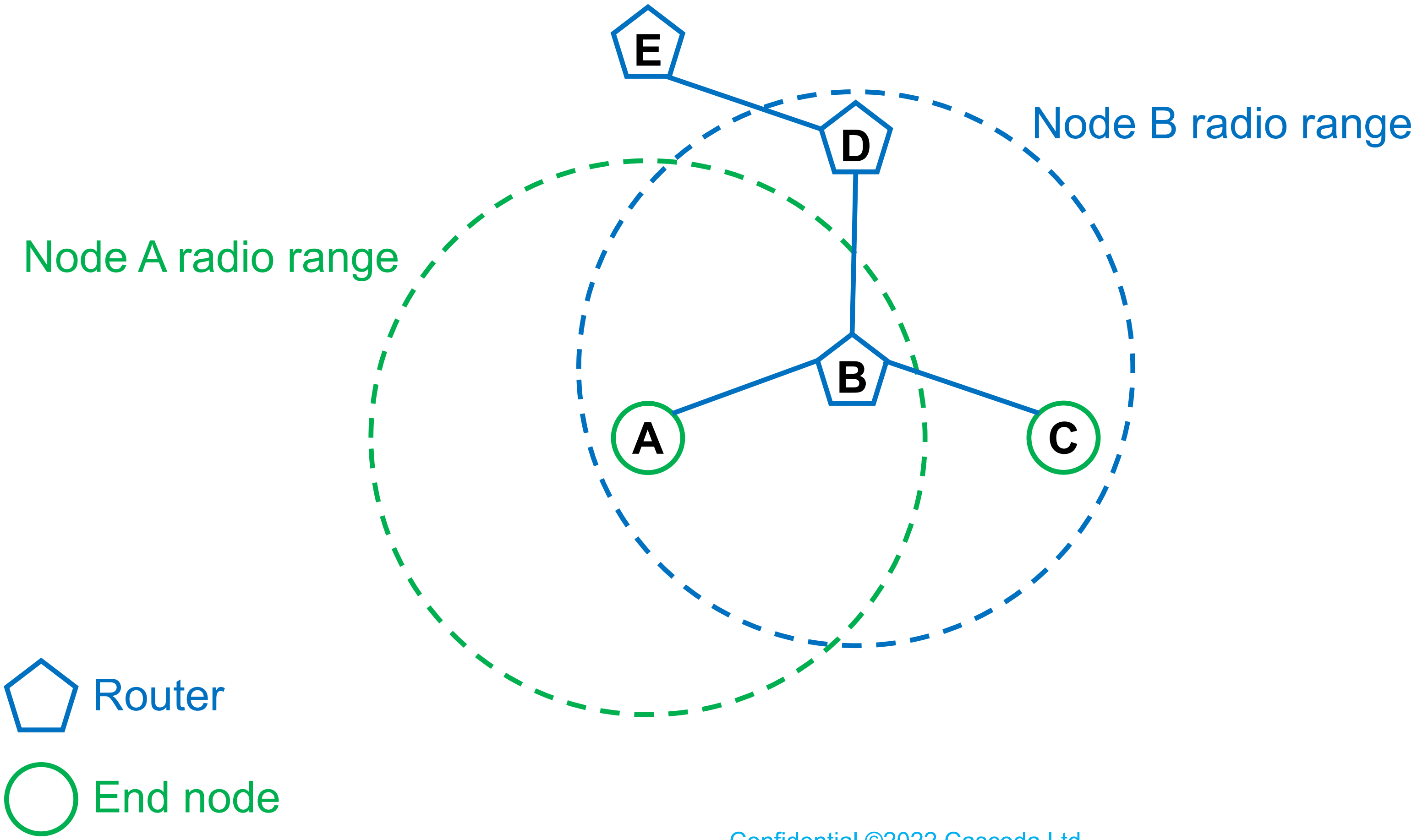
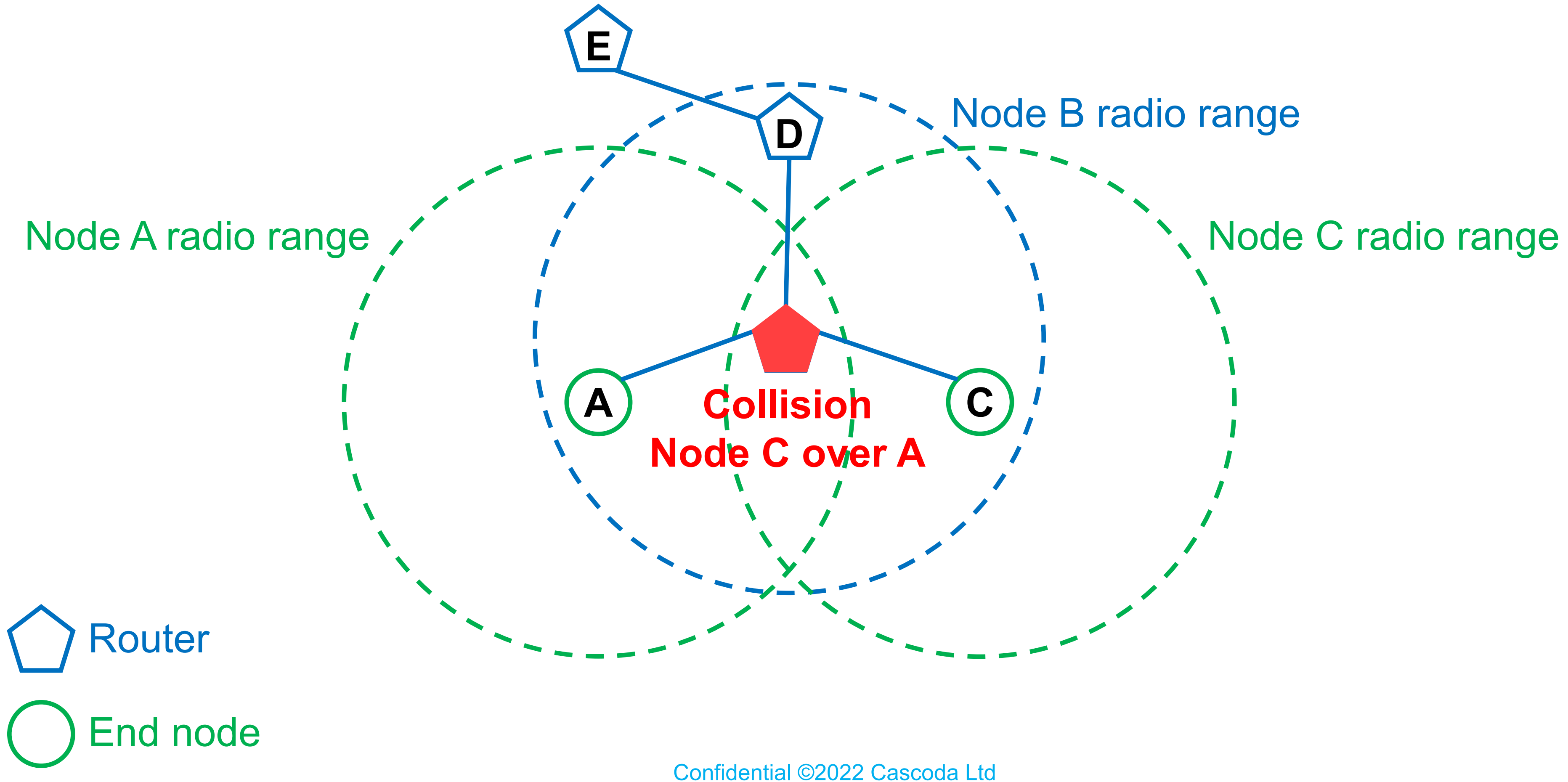
The invention of a new type of radio demodulator for low power wireless

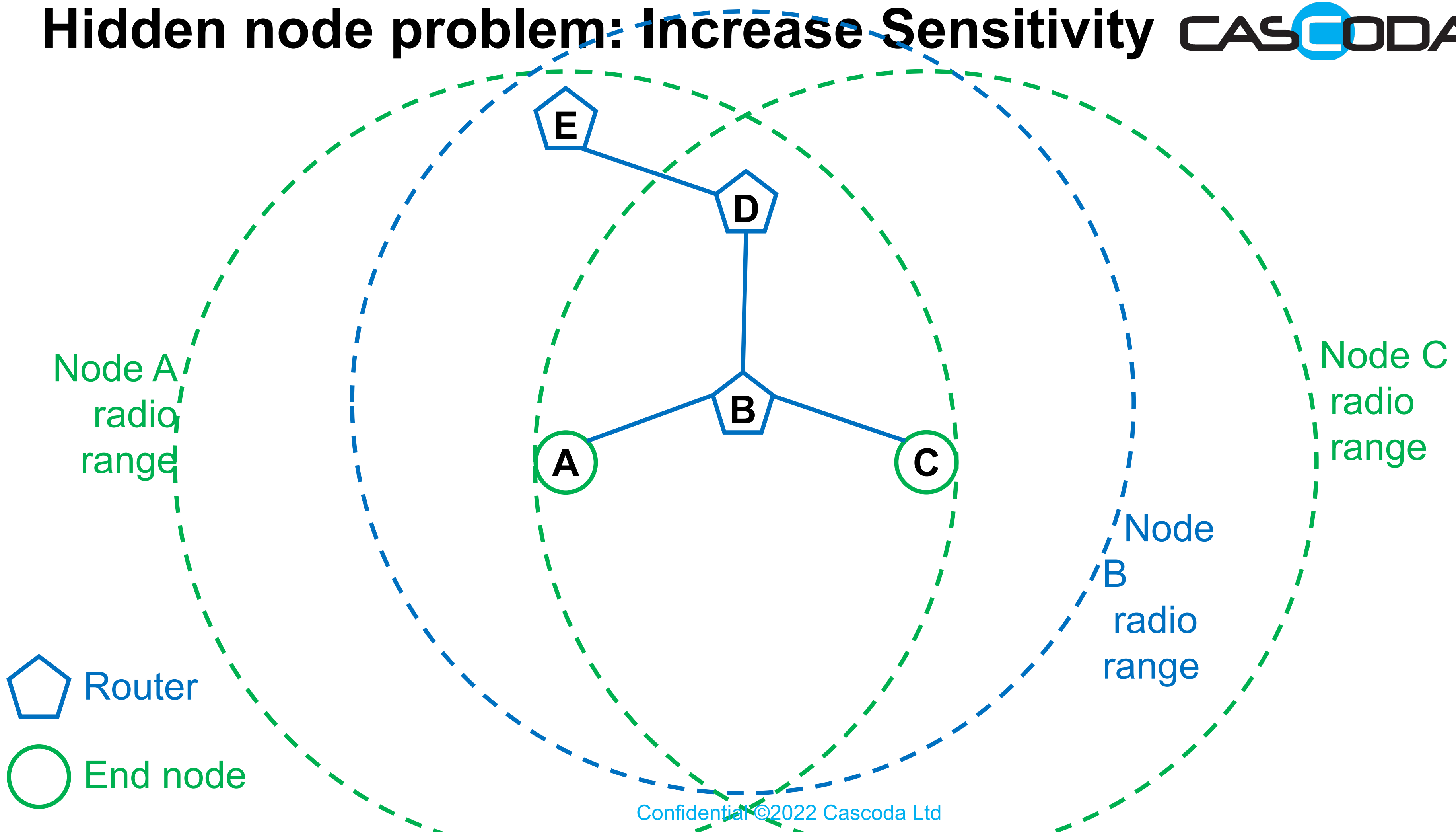
Hidden node problem (CSMA-CA):



Hidden node problem (CSMA-CA):



Hidden node problem: Increase Sensitivity



Improving link-budget in IEEE802.15.4

- **Increase transmit power**
  - National regulations limit transmit power
    - 10dBm worldwide
    - 100dBm with local restrictions (US)
  - Power amplifiers inherently inefficient
    - Typically 15% efficiency at 0dBm
22% efficiency at 10bBm
  - Inexpensive CMOS process
    - Voltage swing limits output power
  - External PA often used
    - Delivers better efficiency using specialist processes, but at a cost
- **Need to increase receive sensitivity**
  - What are the implications?

Improving link-budget in IEEE802.15.4

Receiver Sensitivity, P_{min}

$$P_{min} = kT.W.nf.SNR_{min}$$

kT: k is Boltzmann's constant, T is absolute temperature (=–174dBm)

W: communication channel bandwidth (2MHz)

nf: noise figure of the receiver

SNR_{min}: minimum ratio of baseband signal power to noise power at the demodulator (for specified PER)

Ideal Sensitivity @ 2.4GHz

Ideal receiver sensitivity, in IEEE802.15.4, P_{min_i} [1]

$$P_{min\_i} = kT.W.nf.SNR_{min}$$

$$= -174dBm + 63dB + 0dB - 2.2dB$$

$$= -113.2dBm$$

[1] S. Lanzisera et al., "Theoretical and Practical Limits to Sensitivity in IEEE 802.15.4 Receivers," International Conference on Electronics, Circuits and Systems. Dec. 11-14, 2007

Power Consumption & Sensitivity @ 2.4GHz

	Above Ideal		Receiver Sensitivity (dBm)	Receiver Current (mA)
	Front-end nf(dB)	*Demodulator SNR_{min}(dB)*		
NonCoherent	5.7 [2]	6.5	-101	15
Coherent	11.7	2.5 [3]	-99	16+

- Non-coherent demodulation:
  - Allows for a low-power receiver implementation, at the expense of losses in the demodulator (high SNR_{min})
- Coherent demodulation
  - Requires a high-power demodulator due to the requirements of the phase/frequency detection algorithm
  - To keep power consumption down, the front-end is starved of power, hence a high noise figure
- We need to do a *LOT* better than this!

[2] W. Kluge et al., "A Fully Integrated IEEE 802.15.4 Compliant Transceiver for Zigbee Applications," IEEE J. of Solid-State Circuits, vol. 41, no. 12, Dec. 2006.
[3] Assuming coherent demodulation, with an average 2.5dB loss due to phase/frequency rotation inaccuracies affecting SNRmin
[4] Typical power consumption for a device of this type, assuming 3V supply

Possible improvements

- **Lowering front-end nf:**

  $nf=1+\alpha/P_{LNA}$ [4]

  nf: noise figure of the receiver

  α : process related factor (bigger for smaller geometries)

  P_{LNA}: power consumed in the LNA

  - There are limits:
    - As *nf* tends to 1, P_{LNA} tends to infinity
- **Lowering demodulator power consumption:**
  - IEEE802.15.4 demodulation only needs 4 bits in the ADC
  - Extra resolution only needed for phase/frequency correction
    - Coherent schemes need ~8 bits to be sufficiently free of timing errors

Cascoda's patented invention: Double-correlation demodulator

- **Improvements over coherent:**
  - Frequency detection performed after correlation
    - No complex phase/frequency computation required
    - Reduced power WRT coherent
  - Only 4 bits required in the ADC
    - Reduced power WRT coherent
- **RF front-end improvements:**
  - Demodulator improvements allow more power to be supplied to the RF front-end, lowering *nf*
    - Careful LNA design required

Cascoda's implementation

	Above Ideal		Receiver Sensitivity (dBm)	Receiver Current (mA)
	Front-end nf(dB)	*Demod-ulator SNR_{min}(dB)*		
LowIF, NonCoherent	5.7	6.5	-101	15
LowIF -> b-band, Coherent	11.7	2.5	-99	16+
Cascoda	5.7	2.5	-105	14

Best of both worlds:

Power consumption of non-coherent
Demodulator performance of Coherent

Certified Module Platform – Chili2

CASCODA

THREAD CERTIFIED COMPONENT

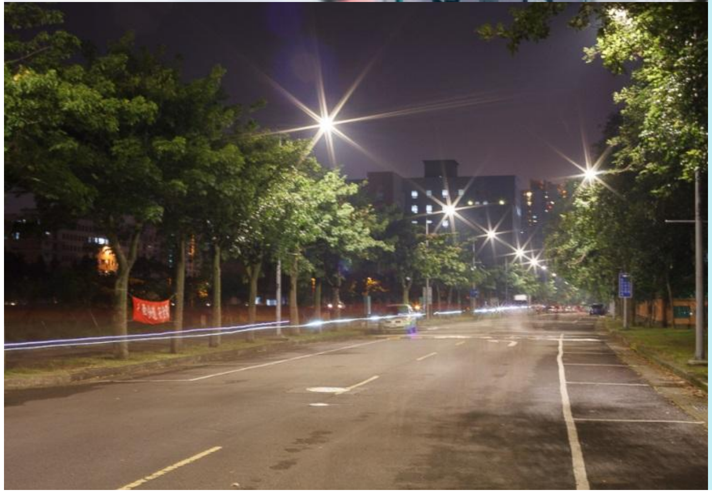
arm TRUSTZONE

- **Design:** Cascoda CA-8211 modem & M23 TrustZone® MCU
  The world first standards-based secure ultra-low-power IoT module
- **Long Range:** ~1 Km outdoor range, 50m indoor range
  Patented radio innovation. Greater reliability lower installation cost
- **Ultra-low-power:** 20mA in transmit, 15mA in receive, ~1µA sleep
  Minimization of maintenance cost as battery lasts longer
- **Security:** Crypto engine, secure boot, memory protection, TRNG
  Highest level of security in both M23 TrustZone® hardware and software
- **Scalability:** Intelligent IPv6 mesh-networking technology
  Allows scalability to achieve massive-IoT deployment
- **Certified:** FCC, CE, IC, Thread, OCF
  Deployed in smart-infrastructure in Europe & Asia
- **Ready for Matter:** In development by Cascoda

IPv6

Use case – Smart City

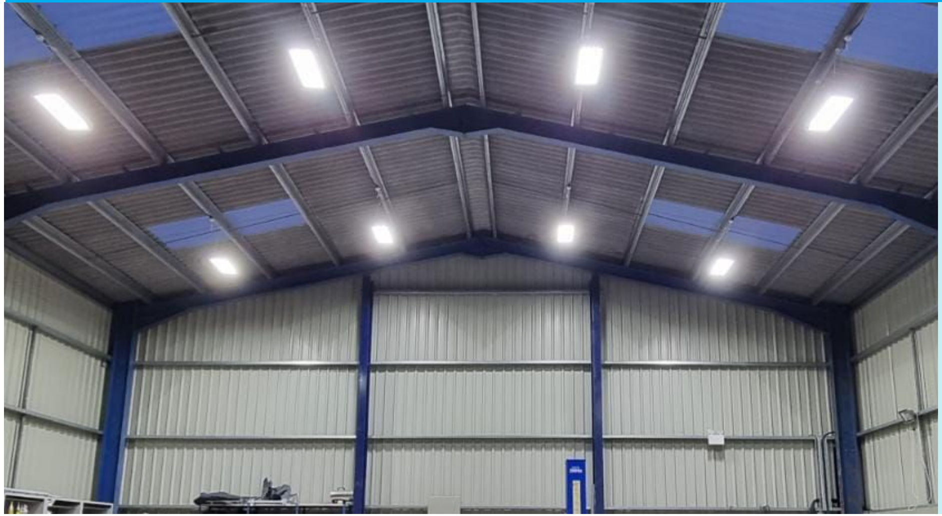
Taiwan, Hong Kong, Macau



- **Smart parking meters**
  - Single/Dual bay
  - Built-in camera
  - Contactless payment
- **Smart street lighting**
  - Pollution monitoring
  - Flood monitoring
  - Integration with:
    - Traffic systems
    - Weather systems
    - Safety systems

Use case – Smart Building

UK



- **Smart warehouse lighting**
  - Local (app control)
  - Cloud BMS control
  - Certificate-based access control
- **Integration with:**
  - Office lighting system
  - Safety systems

Contact us

CASCODA®

Innovation in IoT

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