The Institution of Engineering and Technology

A to Z architecture aspects for Internet of Things

19 January 2023

Welcome

The webinar will start at 7:00pm

Introduction: Kevin Foster CEng FIET, Chair of the IET Anglian Coastal Local Network

Presenter: Andy Fidler, BT Distinguished Engineer & Principal Architect

Questions: via Q&A Messaging in the Zoom session, please type in your questions and these will be taken in a Q&A session at the end of the presentation.

Close: Approximately 8:15pm

The Institution of Engineering and Technology

Thurs 19 Jan 2023 at 7pm

FREE BUT REGISTRATION IS REQUIRED

Venue
The University of Suffolk
Atrium Building Ipswich IP4 1LQ
Or Online via Zoom

Contact
Afolabi Agbede CEng MIET
afolabi.agbede@ietvolunteer.org

Book your place at
shorturl.at/nzFZ0

theiet.org/communities

#ForThoseWhoDoMore

Anglian Coastal Local Network (ACLN)

A-Z architecture aspects for IoT

ANDY FIDLER, Distinguished Engineer & Principal Network Architect (IoT) at BT

Over the next 2 to 3 years, there is expected to be a vast growth in the number of devices connecting to the internet. This talk will cover the A to Z architecture aspects to be considered when building Internet of Things solutions. Starting with an overview of the various connectivity technologies, SIM evolution for mobile devices and device management aspects. Then moving onto the data and application layer in terms of data ingestion, analytics, reporting, mining and sharing capabilities. Finally, the presentation will cover end to end aspects relating to security and the required IT wrap to sell, bill and support IoT services. The talk will also touch on the importance of privacy, security and ethics by design when building IoT capabilities.

Andy has over 25 years' engineering experience covering network architecture, solution design, standards and industry alliance engagement across satellite, mobile, wireless LAN and broadband technologies. His current projects include the development and strategic direction of BT's Internet of Things network architecture and aspects relating to emerging network applications and protocols. Andy is also a member of the Institution of Engineering & Technology (IET), a Chartered Engineer and a BT Distinguished Engineer.

BT Group

A to Z architecture aspects for Internet of Things

IET Anglian Coastal Presentation

19th January 2023

Presented by
Andy Fidler
Principal Network Architect & BT Distinguished Engineer

Introduction & Talk Scope

Introduction:

Andy is a BT Distinguished Engineer and over the last 26 years has architected satellite, mobile, wireless LAN, broadband and fixed mobile convergence solutions.

Andy currently leads the development and strategic direction of the pan BT networks of things architecture roadmap including IoT and emerging network application protocol aspects.

Talk Scope:

An A-to-Z overview of the architecture aspects to be considered when building Internet of Things solutions.

What are IoT & M2M and their forecasted growth

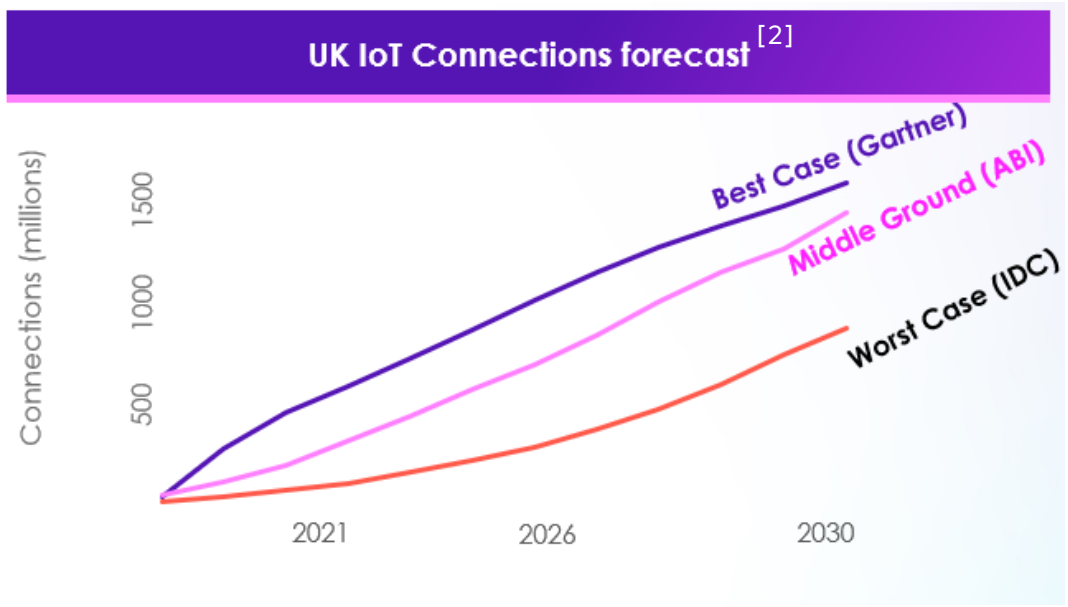
Internet of Things (IoT) is about connecting an ecosystem of things, devices and applications. This may include internet connectivity and support human interaction.

Machine to Machine (M2M) is about devices talking directly to systems or other machines without human interaction.

With both covering the **whole range of device scenarios** from smart household appliances, port cranes, manufacturing robots, transport & logistic asset tracking, remote healthcare and to air quality sensors in smart cities.

Many industry analysts are forecasting **huge IoT/M2M growth** over the next **2-3 years** [1].

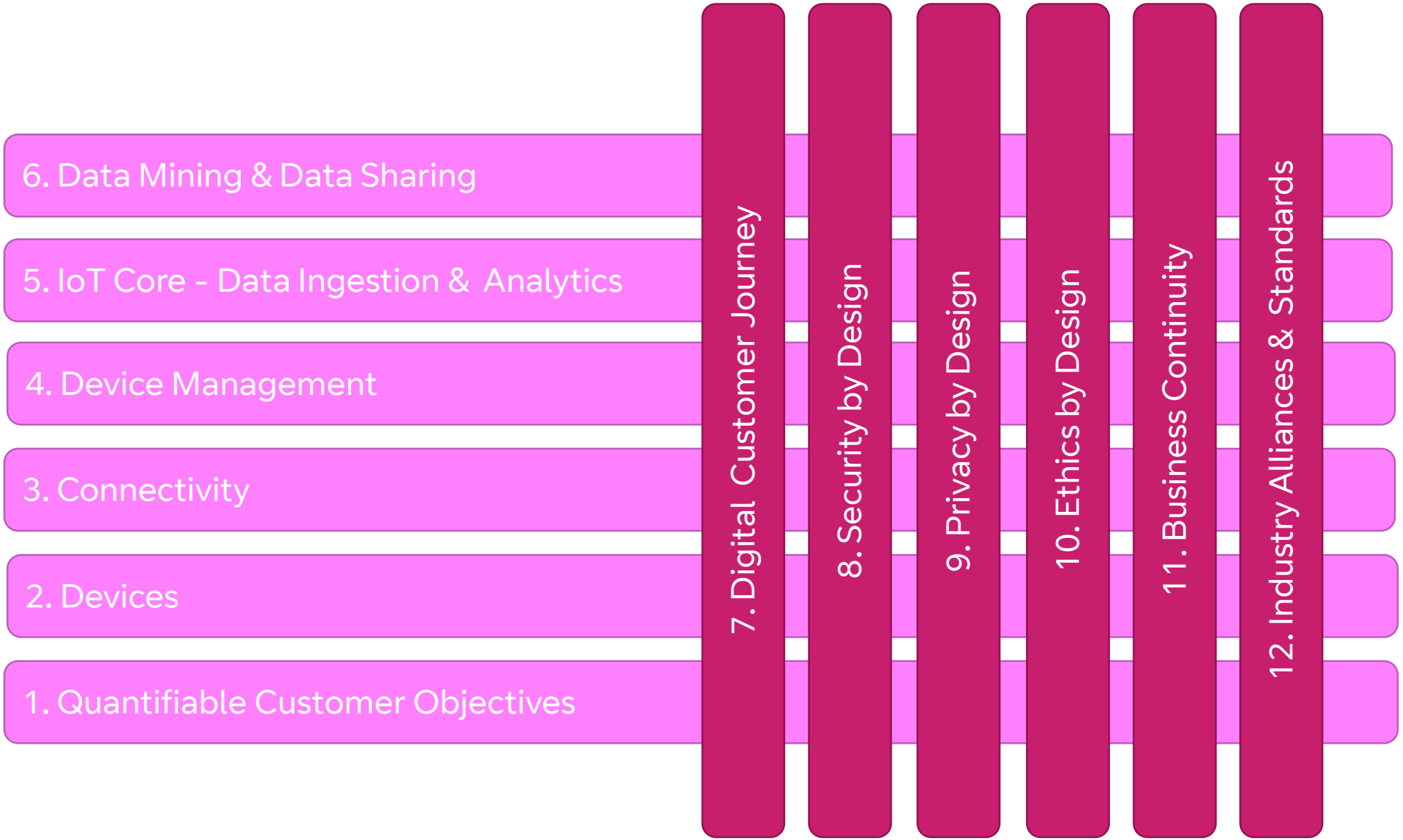
- 30-55 billion IoT devices worldwide
- Generating up to 80 Zettabytes of data



[1] - Future of Industry Ecosystems: Shared Insights & Data | IDC Blog

[2] - ABI IoT Market Tracker, 2020, IDC TAM 2019, Gartner IoT fcst 2021 & Gartner TAM 03/2022 data

Key building blocks and layers to deliver IoT solutions



1. Quantifiable Customer Objectives

- Some IoT projects do not get beyond proof of concept or trials, as they may have focused on just showing the latest technology rather than delivering customer benefits.

- It is a fundamental foundation to define clear and achievable customer objectives, e.g.
  - achieve X% port operation savings through less crane and vehicle downtime.
  - save an NHS Trust Y£ through remote home diagnostics to speed up early discharge and reduce re-admissions.

- Equally due to huge device volumes forecasted, IoT solutions must be designed, from the start, with both scalability and longevity in mind.

Examples of objective focussed trials & capabilities

BT / Innovate UK – “Robot Highways’ project” showing use of IoT and robotics in smart agriculture to drive automation, increased efficiency and sustainability

BT collaborates on the use of robotics and IoT to transform and automate agriculture

Where one of BT partners has used the combination of IoT sensors and AI capabilities to achieve energy savings of between 5-15% across a range of industries including glass, steel, cement, and automotive.

BT partners with QiO to help customers deliver on sustainability commitments

2. Devices – starting architecture principles

- The key starter questions that will derive your device type and technology selection are:
  - How will the device be powered?
  - What are your radio coverage requirements?
  - And how chatty is your device data scenario?
  - Expected device longevity?

- For example:
  - For a water meter, in the ground and battery powered for 10-15 years, requires a very deep coverage and low power connectivity solution such as NB-IoT or LoRaWAN combined with a lightweight data protocol that only collects data hourly / daily.
  - But for a home security video camera which can be mains powered (or rechargeable battery) and only requires in-home coverage, Wi-Fi connectivity and a real-time streaming protocol may be the answer.

Battery powered for 10-15 years

Wide area coverage to meters in the ground.

Low bit rate - hourly / daily updates.

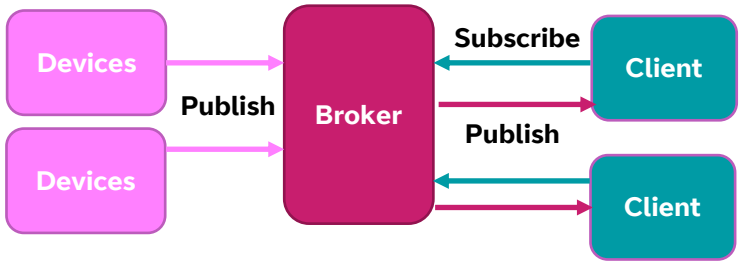
Mains powered

In home coverage

Kbps/Mbps – real time

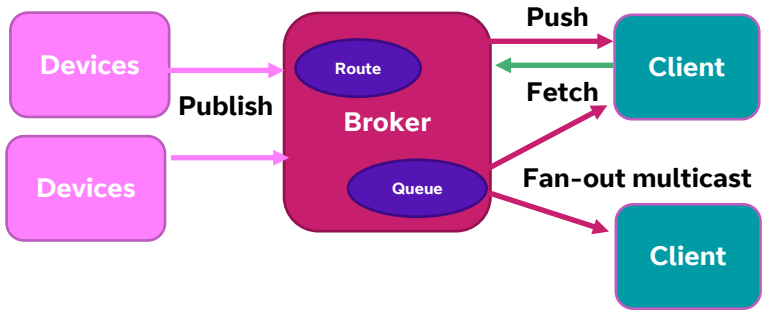
2. Devices – communication architectures

Publish & Subscribe



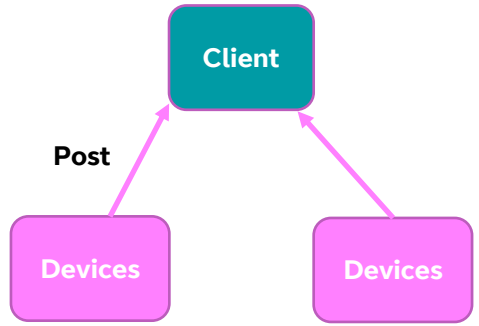
- Devices publish data to broker
- Clients subscribe to broker
- Central broker publishes data to clients
- Broker does not need to store data
- Asynchronous
- MQTT is one example

Route & Queue



- Devices publish data to broker
- Broker then either fans out to clients or makes them available to clients on a push or fetch basis.
- Can be both asynchronous and synchronous.
- AQMP is one example.

Post



- Devices post data to client
- Synchronous
- HTTP post is one example.

2. Devices – IoT Data & Device Management Protocols

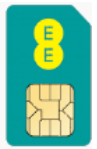
- A good selection of IoT data protocols exists
  - Selection is very much down to data collection frequency/size, device CPU/battery life, reliability and security requirements.

AMQP	MQTT	HTTP	CoAP	DDS	LWM2M	XMPP
• Advanced Messaging Queuing Protocol • Synchronous & Asynchronous message based. • Queue, Multicast and Request Reply options. • Reliability / acknowledgements – high performance • Security options • TCP/IP	• Message Queue Telemetry Transport Protocol. • Asynchronous event based – publish and subscribe. • Aimed at scenarios requiring low bandwidth, low CPU power/battery consumption. • Security via TLS.	• HyperText Transfer Protocol. • Synchronous post based approach. • Longer header and messages.	• Constrained Application Protocol. • UDP based • Aimed at scenarios requiring low bandwidth, low CPU power/battery consumption.	• Data Distribution Service. • Real-time pub/sub based approach. • High end IoT applications.	• Lightweight Machine to Machine Protocol. • Aimed at scenarios requiring low bandwidth, low CPU power/battery consumption. • Can be run over UDP, TCP or SMS. • Also includes device management functions.	• Extensible Messaging and Presence Protocol . • Real-time based. • Structured but extensible data applications.

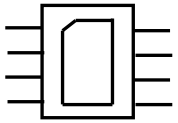
- Similar for Device Management Protocols, various options exist – LWM2M, OMA DM, Broadband Forum TR69/TR369.

2. Devices – SIMs, naming and numbering

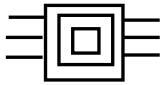
- For Mobile Devices:
  - SIM:



Physical SIM



Embedded SIM (eSIM) via dedicated chip



Integrated SIM (iSIM) SIM integrated into device system on a chip.

eSIM & iSIM recommended to give optimum provisioning

  - MSISDN (Mobile Number)
    - Allocating MSISDNs to IoT/M2M data only devices, risks wasting mobile number ranges
    - Recommend use of MSISDN-less or pseudo MSISDN for data only devices to preserve numbers for voice / SMS.
      - Realised in a simple way through appropriate set-up protocols.

- For IP enabled devices:
  - IP addressing approach – v4, dual v4 / v6, v6 only with latter two recommended.

3. Connectivity options

- **Personal Area Network:**
  - Bluetooth Low Energy
  - 6LoWPAN – IPv6 over Low-Power Wireless Personal Area Networks

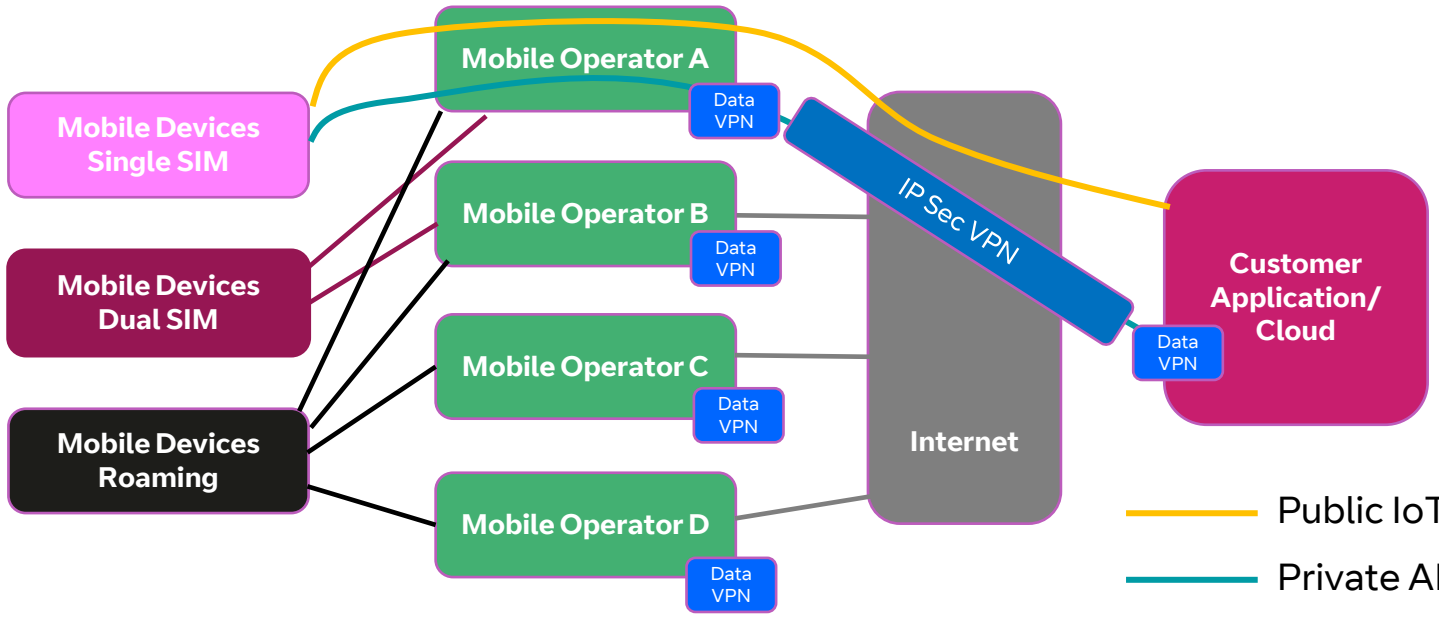
- **Home/Local Area Networks:**
  - Wi-Fi
  - ZigBee
  - Thread
  - Matter
  - Z-Wave

- **Wide Area Networks**
  - Private vs. Public Mobile Networks
  - 2G, 4G, 5G
  - NB-IoT
  - Cat M1
  - Cat 1-bis
  - Redcap
  - LoRaWAN
  - Satellite connectivity to either IoT Gateway or direct to IoT Sensor – growing number of starts up in this space planning NB-IoT and LoRaWAN connectivity.

3. Wide Area Network technology comparisons

	5G Stand Alone	5G Non Stand Alone	4G/LTE	5G RedCap NR	LTE Cat M1 (eMTC)	Cat 1bis	NB-IoT	LoRaWAN
Voice Support	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Real-time Support	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Firmware OTA	Yes	Yes	Yes	Yes	Yes	Yes	Small only	No
Acknowledged message delivery	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Licence	Licensed	Licensed	Licensed	Licensed	Licensed	Licensed	Licensed	Licence Exempt
Coverage	Good	Good	Good	Good	Good	Good to Not as good	Better	Best
Speed (Download)	~50Mbps to ~20Gbps	~50Mbps to ~1 Gbps	Up to 100 Mbps	< 50Mbps	Up to 1Mbps	Up to 10Mbps	Up to 127kbps	Up to 50kbps
Latency	15-30ms	30 – 50ms	30 – 50ms	<500ms	30 – 50ms	30 – 50ms	1.6 to 10s	10s+
Battery life	Fair	Fair	Fair	Good	Fair	Fair	Good	Best
CPE Complexity	High	High	High	Moderate	Moderate+	Moderate	Moderate to Low	Low
Best For	Ultra reliable low latency and real time apps, e.g. autonomous driving, XR devices, drones, telemedicine, etc.	High performance applications needing over the air updates, mobility and voice support, e.g. security alarms, wearables, health monitoring, machine control, smart home, asset tracking, predictive maintenance, point of sale devices, etc.					Applications requiring optimum efficiency e.g. smart cities, metering, agriculture, etc.	

3. Mobile Connectivity Options

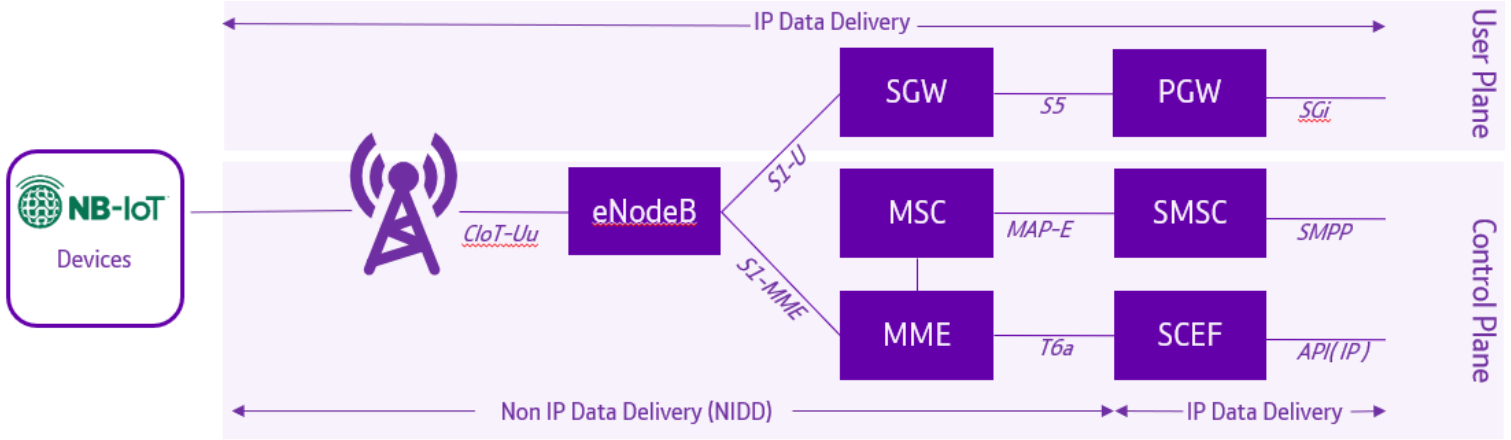


- Public or Private APN
- Internet or Data VPN connectivity
- Single SIM, Dual SIM or Roaming

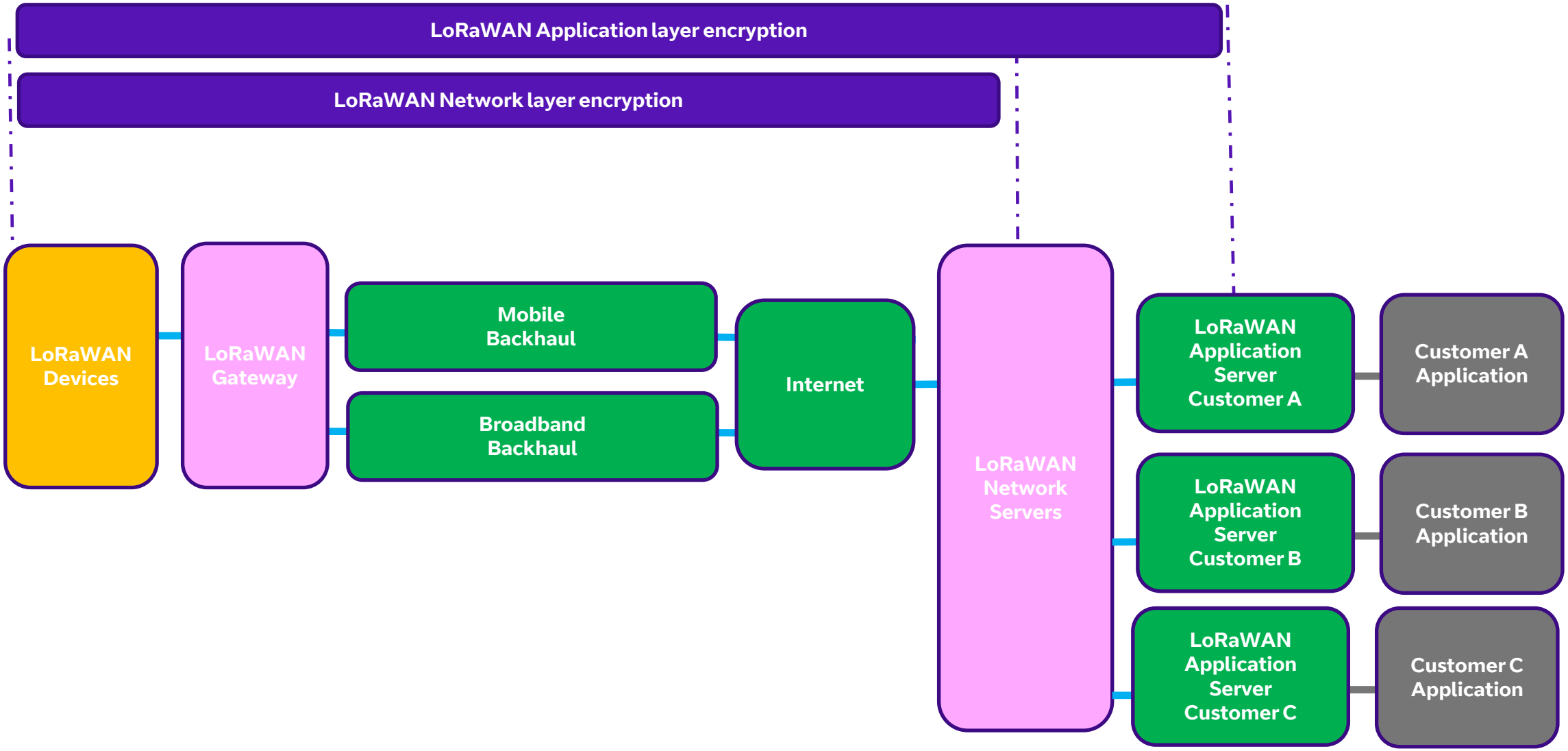
Public IoT / M2M APN

Private APN

- Plus NB-IoT has option of
  - IP Data Delivery or
  - Non IP Data Delivery



3. LoRaWAN Connectivity



4. Device Management

- IoT projects are likely to have 1,000s of IoT/M2M devices that need to be managed.
- All requiring:
  - device management capabilities in terms of OTA firmware, security and configuration updates
  - plus capability to manage/enable device IoT applications
  - connectivity management platform to manage SIMs and eSIMs - activate, cease, bill, device info
- Also worth considering how the following can support the control layer:
  - The use of digital shadows to aid device and application management
    - A digital shadow is a virtual representation of the device, available through APIs.
  - Where feasible the use of common device management standards and move towards zero touch onboarding.

5. IoT Core - Data Ingestion, Analytics and Reporting

A) Where are you going to the ingest your data? Security, latency and data volume considerations?

B) Data Partner – IoT Core Selection

- Hyperscalers, Opensource, System Integrators

C) Data requirements

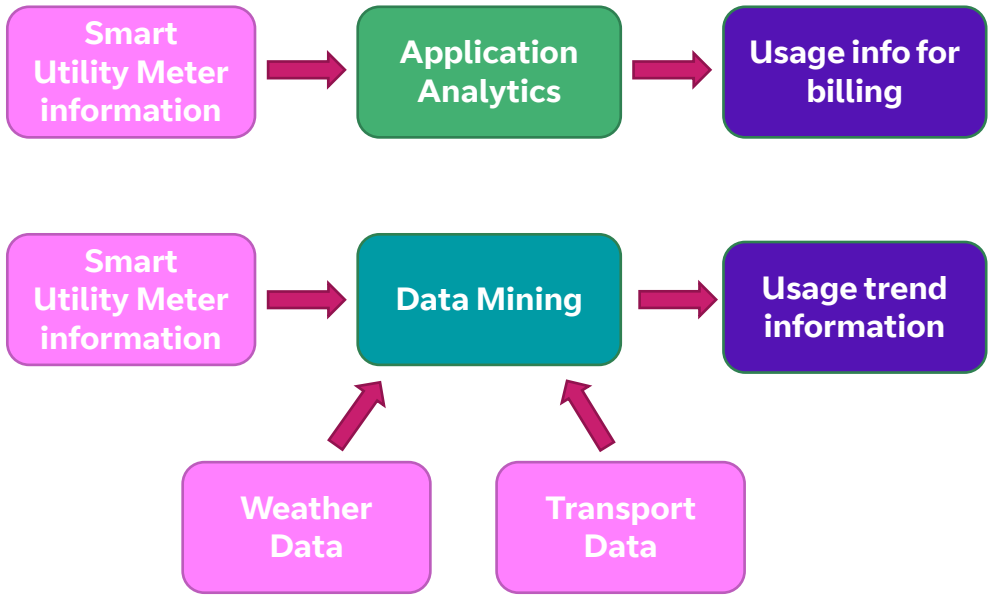
- Ingestion
- Workflow logic and Machine Learning. Also option to do ML on device and at edge.
- Insights and reporting
- APIs, Customer Portals, Alarms
- Use of Digital Twins (virtual digital model of an real-world data point)

D) Whether data requirements can be met through standard IoT core provider features or additional expert application partners are required?

6. Data Mining & Data Sharing

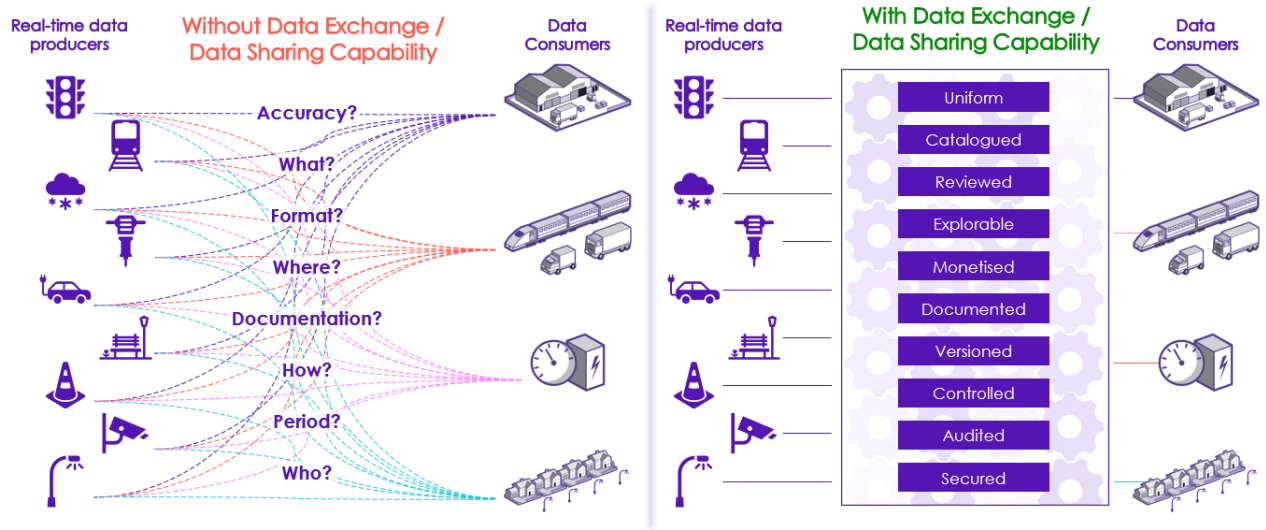
Data Mining:

- Is Application specific data sufficient?
- Or do you need Data Mining?
  - Combining with wider data sets to derive new info?



Data Exchange / Data Sharing:

- Is the IoT / M2M data just for a single entity?
- Or do you need a way to securely share the data across multiple entities?



7. Digital customer journey / Business Support Systems

- With the huge predicted volume of IoT devices in the future, the associated Digital customer journey must be modular and agile.

- "LBGUPS" is one model used to map out required business capabilities.

Learn	Buy	Get	Use	Pay	Support
Customers need to be able to simply learn about IoT propositions and services via all available Digital channels – web sites, apps, etc.	**Clear IoT propositions/services.** **Easy for customers to purchase a range of IoT products and services ranging from:** • **Connectivity only** • **Connectivity + Device Mgmt.** • **Connectivity + Device Mgmt. + Data reporting.** • **Data Mining & Data Sharing / Exchange options.**	**Simple and seamless process for configuring customer SIMs, devices, IoT platform / portal capabilities and ensuring prompt shipment.** **Goal of simply working out of the box and zero touch onboarding.** **If customer interaction needed in set-up, make it simple e.g. scanning of QR codes.** **Keep customer informed on get progress in terms of configuration stage and shipment dates.**	**Single Digital (App & Web experience) for customers to simply manage their SIMs, devices, IoT platform capabilities and view data usage/billing information.** **Single Sign-On support.**	**Simple and flexible billing approach to meet the various future high volume IoT scenarios.** • **Per device billing** • **Group of devices** • **Voice + Data + SMS considerations.** • **Roaming aspects.**	**App, Web, SMS and email service issue notification options.** **Clear support model in terms of call / email support teams to contact.** **Agreed Service Level Agreement covering service availability, support issue acknowledgment and resolution times for various priority levels.**

8. Security by Design

- Many conference presentations last year called out that IoT security is behind that of IT.

- IoT needs to catch up in terms of ensuring security by design from day 0 product development, covering:
  - Device security
  - Data security at all levels – network, application and APIs.
  - Cloud and data centre security.
  - Opportunities to proactively detect and mitigate threats rather than just encrypt/secure.
  - Secure and certified firmware and over the air updates / configuration.
  - Move away from traditional credentials to adopt principles based on zero trust.
  - Quantum compute / crypto aspects and the impact of post quantum crypto on devices and current protocols.
  - Regular software code reviews and security penetration testing.

- Compliance with Product Security & Telecommunications Infrastructure Act 2022 – Royal Assent Dec 22
  - Mandatory security requirements for consumer connectable products sold in the UK.
  - Covering vulnerability disclosure policy, ban on default passwords and transparency on how long a supplier will provide product security updates for.
  - Product Security and Telecommunications Infrastructure Act 2022 - Parliamentary Bills - UK Parliament

- Compliance with Telecommunications (Security) Act 2021 and associated Regulations and Code of Practice
  - Electronic Communications (Security Measures) Regulations and Telecommunications Security Code of Practice - GOV.UK (www.gov.uk)

- Recommend consideration of IoT Security Task Force guidance- Secure IoT – IoT Security Foundation

- Above is purely informal insights to reflect on, companies and individuals should seek their own security & legal advice.

9. Data Protection Considerations

- **Data Protection/Privacy Legislation you may need to consider:**
  - General Data Protection Regulation - GDPR
  - The Data Protection Act 2018 and UK GDPR (UK only)
  - Privacy and Electronic Communications Regulations 2003 (UK only) covering marketing, cookies & usage data

- **Need to consider that GDPR/UK GDPR may apply to IoT / M2M data if the information can be linked back to an individual** e.g. unique IP address, equipment identifier and MAC address.
  - For example a water meter reading may be classed as personal data if mapped to a meter id which is then linkable back to an identifiable individual.

- **Privacy aspects to consider from the outset of a project:**
  - Follow the principle of "**Data protection by design and default**" – i.e. integrate data protection into your activities from the design stage right through the lifecycle.
  - Undertake a Data Protection Impact Assessment to assess what data privacy risks there may be in your project and how to mitigate these risks
    - covering end to end data flows - what the data is, why it is needed, where it is transmitted, processed and at rest?
    - how data is encrypted both in transit and at rest (covering device, cloud/datacentres and back-ups)
    - which countries is the data being transferred to, stored in, or accessed in (including back ups, development and support teams)
  - Can any of the data be anonymised? Can you minimise the amount of data collected?
  - Assess what technical and organisational security measures should be in place, such as level of data encryption
  - Data Retention policy - How long should the data be retained for? How can the data be deleted when no longer required?
  - Are you able to fulfil data subject access requests and other data subject rights?

Above is purely informal insights to reflect on and is not a comprehensive list of what should be considered. Companies and individuals should seek their own legal and data protection/privacy advice.

10. Ethics by Design & Environmental aspects

- **Ethics:**
  - IoT has the opportunity to transform customer life and industries for the better.
  - However it is important that IoT products are developed with Ethics in mind to build public trust in the technology.
  - Especially as IoT solutions may involve Artificial Intelligence, CCTV security and healthcare aspects.
  - Recommend creation of a guiding set of responsible tech principles, built on UN Guiding Principles on Business and Human Rights including Child Rights. For example:
    - Ensure that IoT technologies are developed, brought and sold in a way that benefits people and minimises harm.
    - Take care to avoid and protect against tech misuse, e.g. IoT home movement solutions offer great capabilities for home security and healthcare, but you also need to consider the abusive misuse risk around tracking presence.
  - When using AI, ensure diversity is considered in the data set and algorithms, alongside data quality.
- **Environment:**
  - Also IoT has the opportunity to assist sustainability and energy aspects.

11. Business Continuity

- Given that IoT solutions may support critical applications, business continuity is another key consideration.
- Recommend business continuity plans for IoT solutions.
- Plus consideration of following aspects:
    - Required level of data centre and cloud resilience
    - Consider geographic redundancy and multi cloud provider resilience
    - Redundant and back-up components
    - Data back-up policies
    - Business Continuity testing

12. Standards & Industry Alliances

- Recommend building IoT solutions where feasible off open standards
- Key IoT standards and industry alliances to consider are:
  - 3GPP – The Mobile Broadband Standard Partnership Project
  - Wi-Fi Alliance
  - CSA-IOT - Connectivity Standards Alliance
  - The Internet of Things is Powered by Z-Wave - z-wavealliance
  - Bluetooth® Technology Website – The official website for the Bluetooth wireless technology. Get up to date specifications, news, and development info.
  - Home (threadgroup.org)
  - GSMA - Representing the worldwide mobile communications industry
  - oneM2M Sets Standards For The Internet Of Things & M2M
  - OMA SpecWorks – For a Connected World
  - Shaping the future of Broadband - Broadband Forum (broadband-forum.org)
  - IoT Security Foundation – The Global Home of IoT Cybersecurity
  - ISO - ISO/IEC 27001 and related standards — Information security management

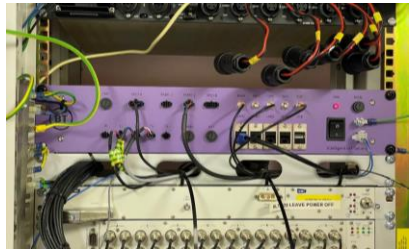
An example of e2e IoT solution – EE remote site monitoring

Power Monitoring

Temperature Sensor

Anemometer

Door Sensor



BT IoT Smart Asset Hub

4G
5G

BT IoT Platform

INGEST → ANALYSE → ACT → SHARE

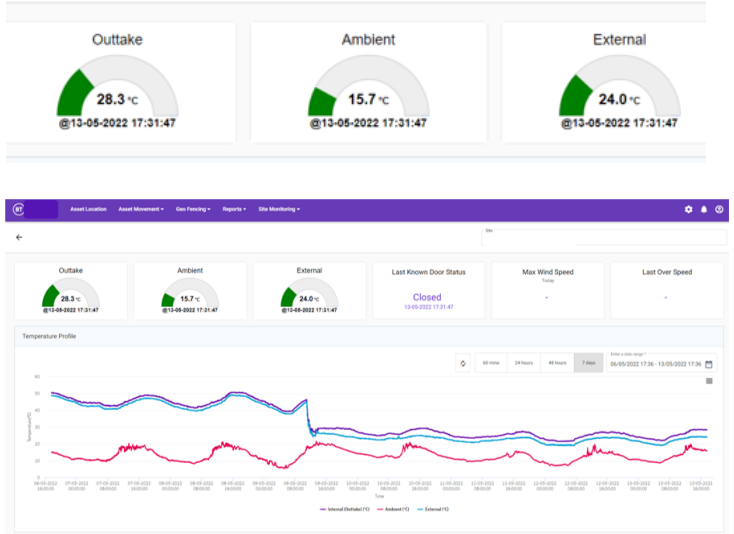
BT aws

Networks

Manage Data

Manage Devices

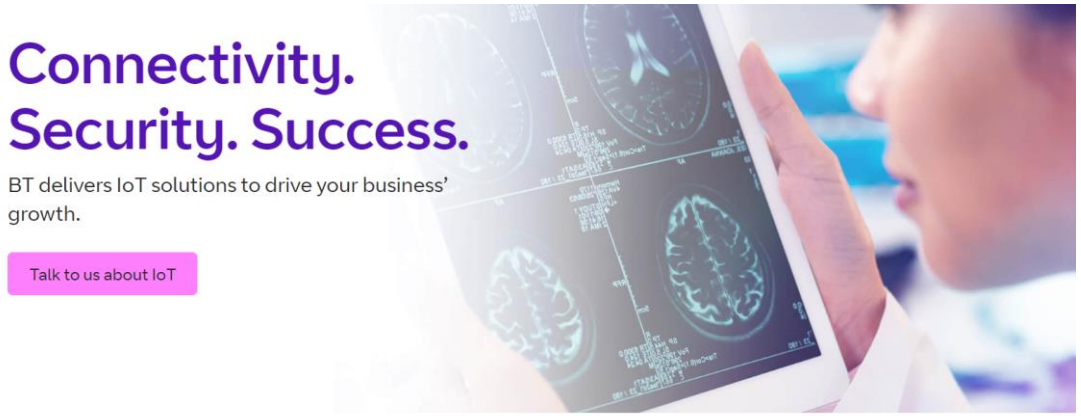
Devices



Objective – proactive site monitoring, improved customer experience and cost savings through reduced downtime and site visits.

BT Business – IoT & M2M products

- To learn about BT offerings in the IoT & M2M space – see www.bt.com/iot, covering:
  - Connectivity
  - Global Asset Tracking & Monitoring
  - Vehicle Telemetry
  - Condition-based Monitoring & Predictive Maintenance
  - Remote operations & immersive spaces
  - Digital Vision and AI
  - Data and Security



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ANDY FIDLER, Distinguished Engineer & Principal Network Architect (IoT) at BT

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