Fitting the Wireless System to the Application - a Case Study

Delivery of a reliable data service in a medical application

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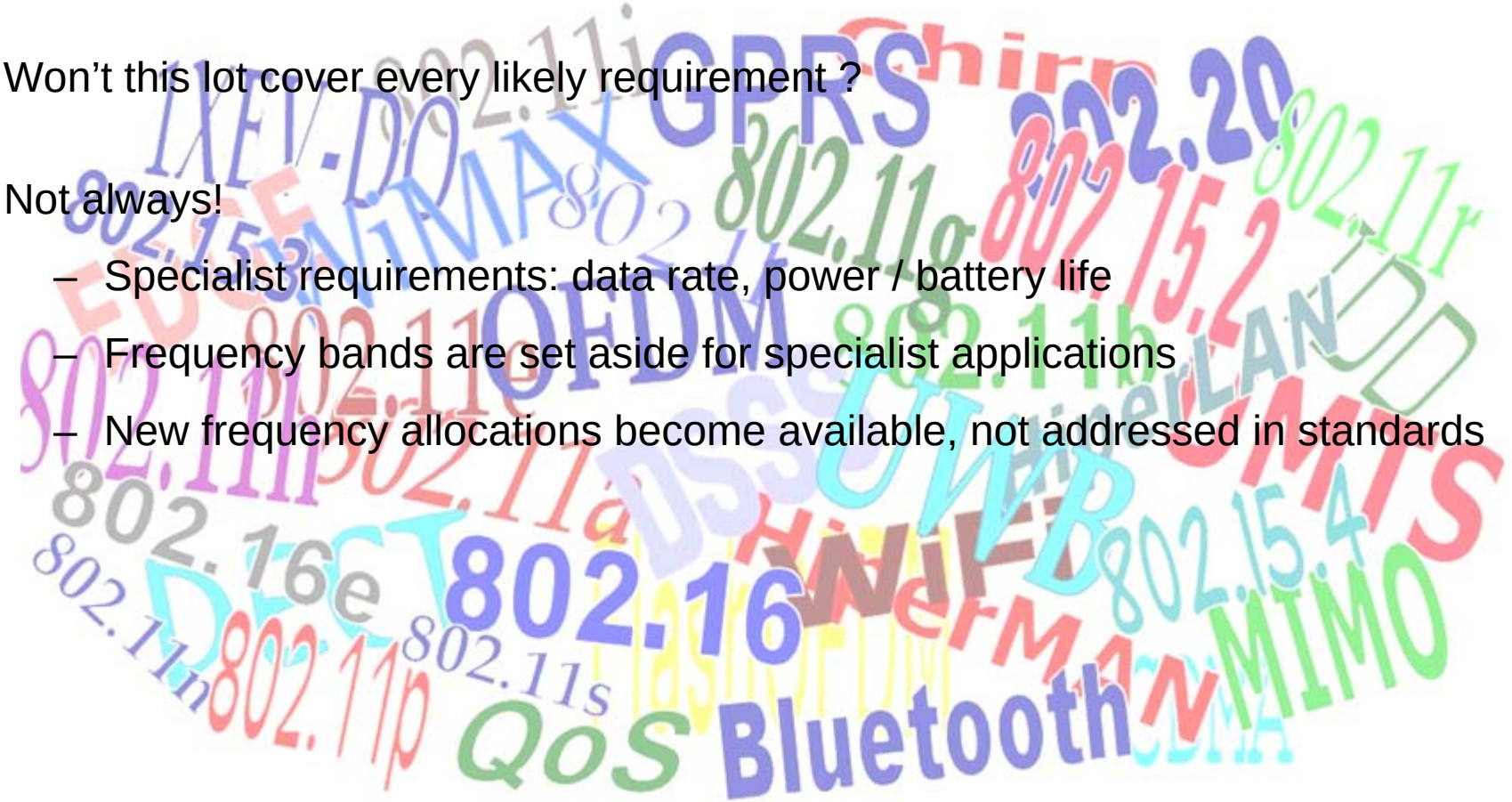
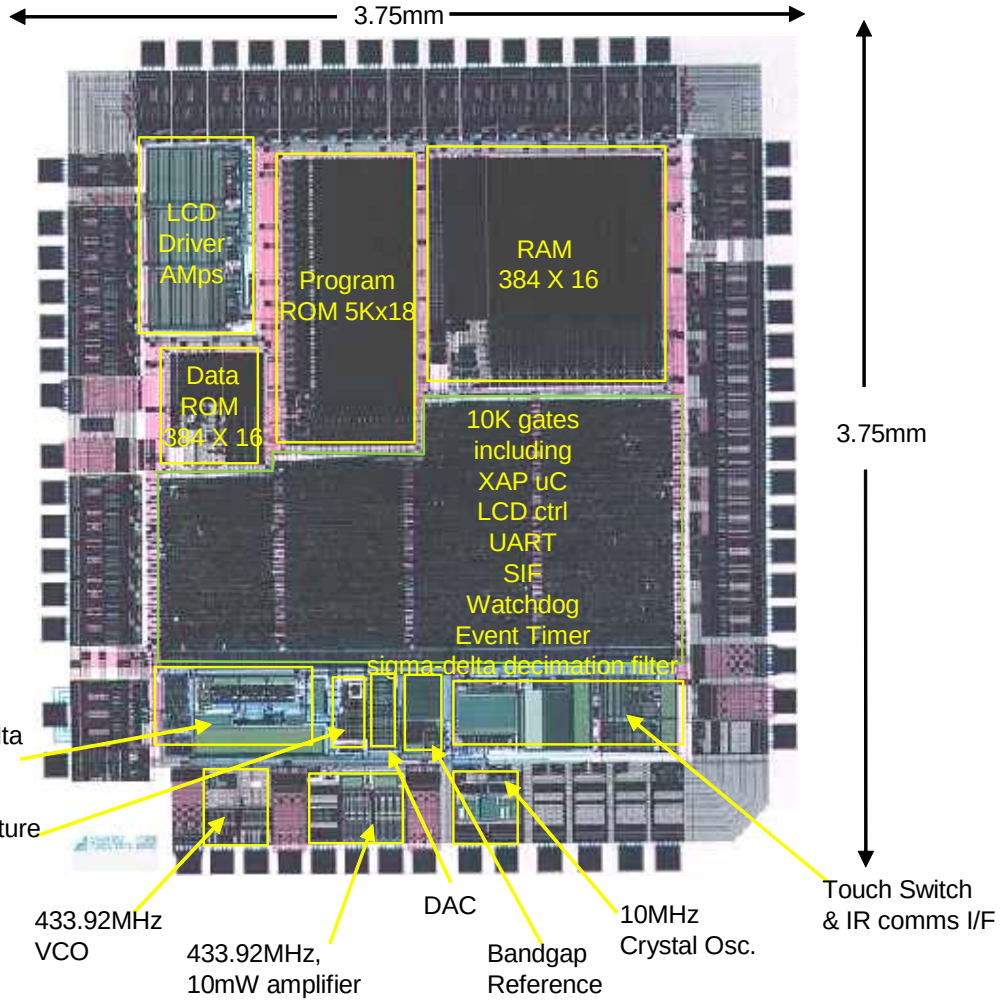
There is a huge range of wireless standards available

- Won't this lot cover every likely requirement ?
- Not always!
  - Specialist requirements: data rate, power / battery life
  - Frequency bands are set aside for specialist applications
  - New frequency allocations become available, not addressed in standards



Sometimes it's appropriate to create a complete wireless system from scratch…

- 0.5um mixed-signal CMOS DLM DLP
- 2.4 - 3.7V -20C to 90C
- CMOS integration of logic + analogue + RF (400MHz)

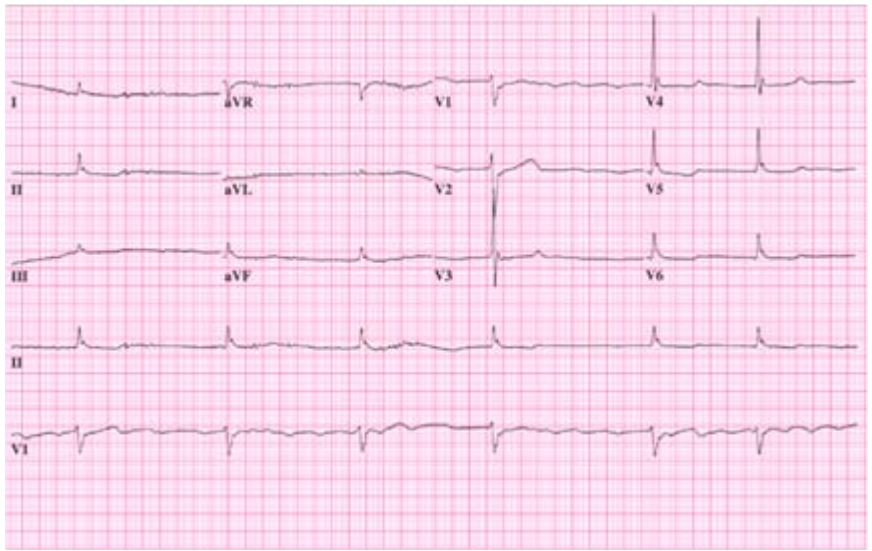


This involves a lot of development work, which is only justified if the projected volumes are very large

- Viterra Energy required a heat cost metering system cheap enough to fit on every radiator
- 10 year life from 2 coin cells
- Achieved with a CMOS mixed-mode System on Chip
  - 433MHz radio transmitter
  - Temperature sensors (1) on-chip; (2) at front of unit
  - Processor core with on-chip RAM/ROM
- Used its own, very simple, radio protocol
  - Cumulative total (and other data) sent
  - ‘Fire and forget’ (receiver is always on)
  - Wait a random time (average 2 hours) and repeat

Another example: ‘untethering’ the patient from traditional massive ECG machines

- ECG is a complex instrument with electronics and a chart recorder or display
- Special functions often add to its complexity and size
  - Signal filters and algorithms
  - Alarms
  - Connection to central systems



Today, heart experts would prefer that post-operative patients get up and walk about

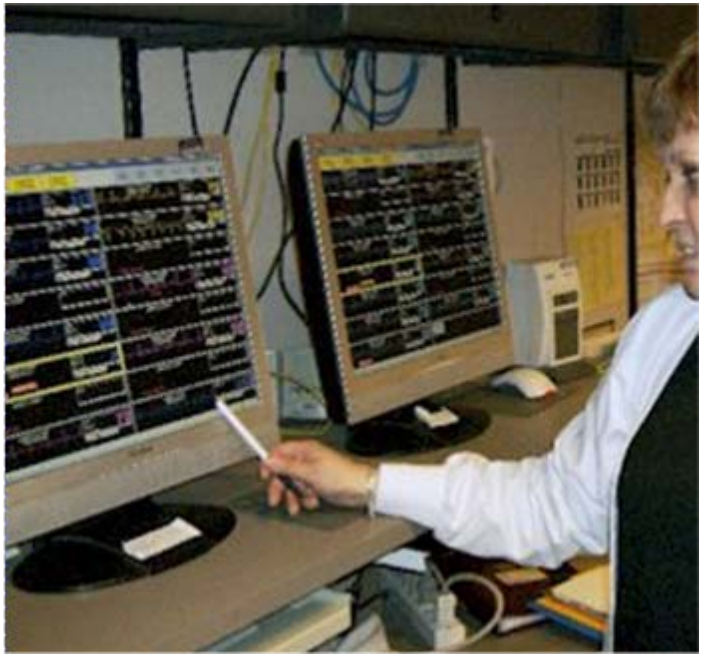
- Recovery is much faster if the patient takes gentle exercise
- But monitoring the patient's heart at all times remains important

Enter the ambulatory cardiac monitor

- Electronics can have sufficiently low-power consumption to provide the signal processing and communication from a small battery
- Many standards-based solutions were available for home, or small to medium clinics / hospitals
- Problem – how to scale for large hospitals?
  - 1000 or more patients in a large facility
  - Potentially high density in exercise or entertainment areas

The challenge: if you had more than 100 radio-monitored heart patients in one area, how would you radio-link them all to a central monitoring station?

- A reliable, streamed data connection is required
- Used to allocate a radio channel to each patient
  - This is expensive in resource
  - Distributed antenna systems complex, unreliable
- What is actually wanted is a cellular system
  - Radio resource is allocated where it is needed
  - Co-existence and anti-interference measures are included in all cellular radio systems
  - Infrastructure can be added to meet loading requirements
- Problem – cellular systems are very complex, and expensive to design

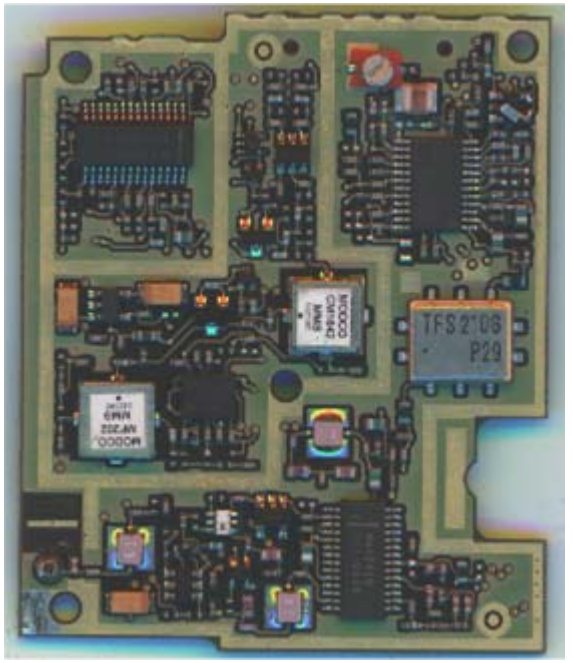


Could we use *parts* of an existing standard to reduce this burden?

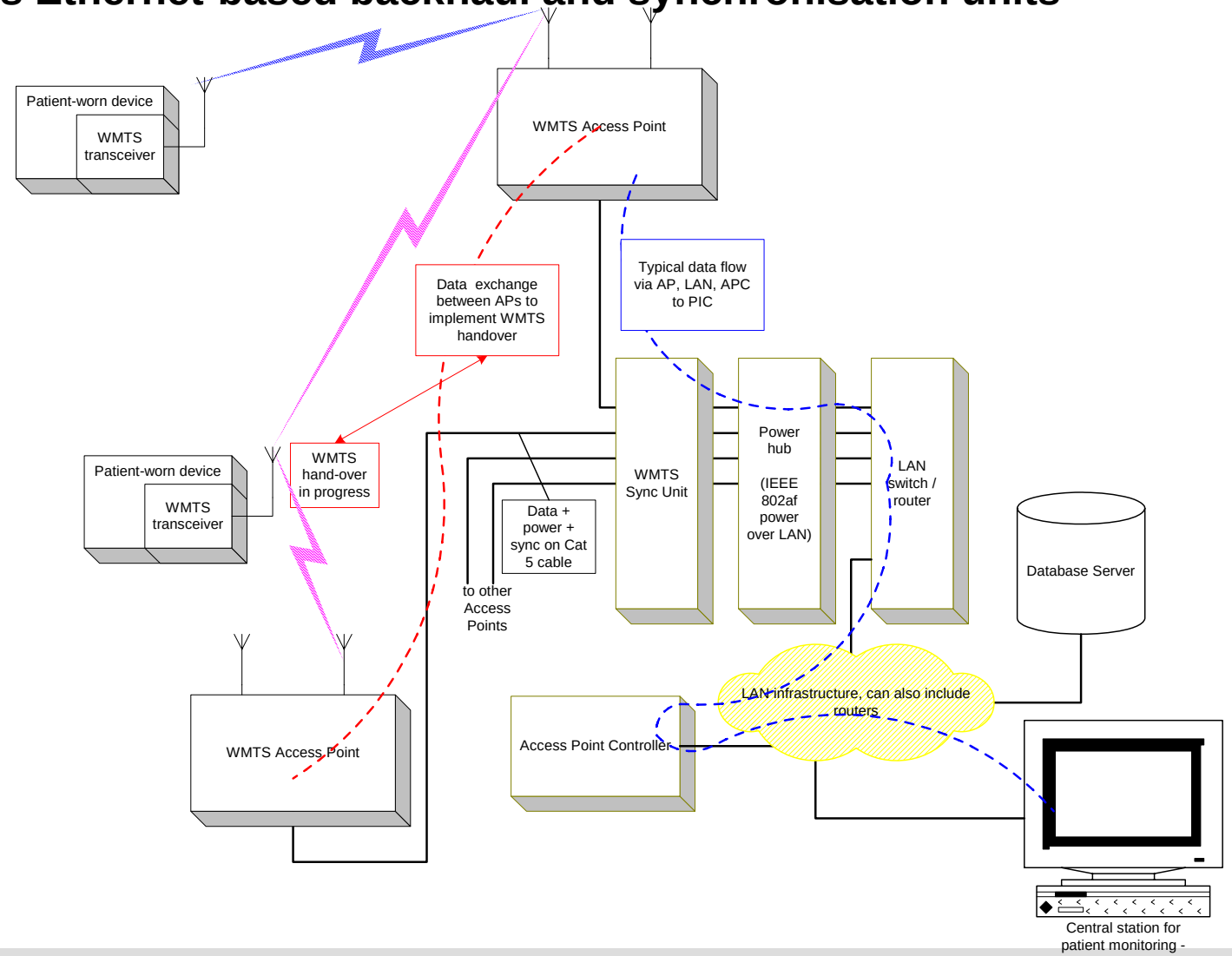
- Our cardiac requirements are rather similar to those for on-site telephony
  - High density of users
  - High ‘erlang’ figures
  - Mobility of users from one access point to another
  - Automatic management of channels, interference and co-existence
- This sounds very like the design brief for the DECT standard
  - Multiple access points (‘RFPs’) and handover included in the standard
  - The portable unit (‘PP’) manages its connections and resource
  - Unbroken data stream due to ‘hitless handover’

We made a few changes

- Our application had some special requirements, and so some changes were appropriate
  - A new radio band, 1395-1400 and 1427-1432 MHz is allocated in America
  - Our data rate requirement is about 10 kbit/s (DECT's atomic rate is 32 kbit/s)
- We took standard DECT baseband hardware and software…
  - New radio at 1400MHz, with 'better' filtering to give 6 radio channels
  - Lower power radio, as the required range is quite low (high density of users)
  - DECT raw bit-rate (1152 kbit/s) used, but the TDMA frame length increased to 64 time-slots
    - This gives a frame period of 10 x 64/24 = 26.67ms
    - Data rate is 320 / 26.67x10-3 = 12 kbit/s



Infrastructure uses Ethernet-based backhaul and synchronisation units



The backhaul system uses a standard WiFi mobility scheme, with additions

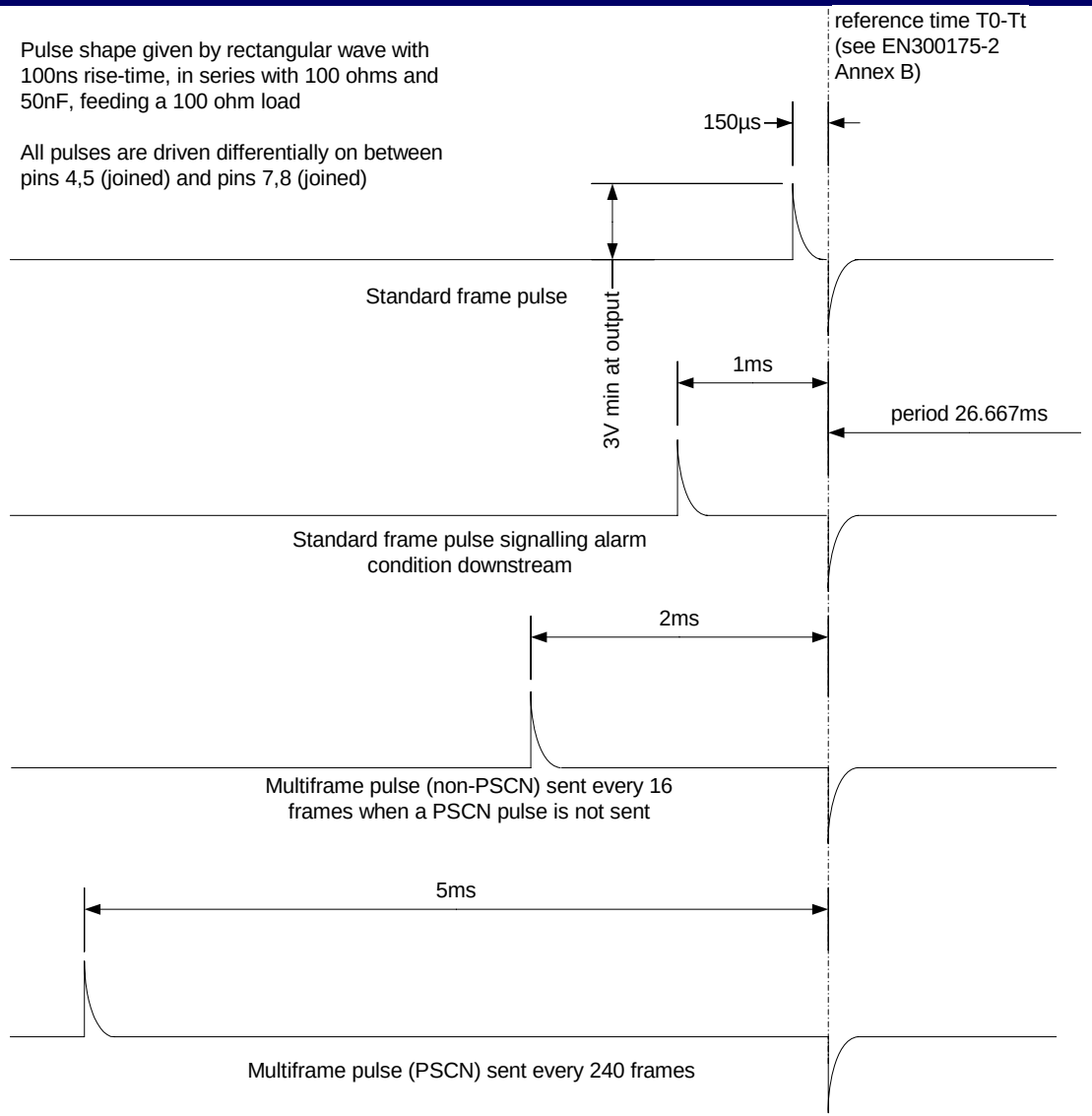
- A combination of Access Points (AP) and an Access Point Controller (APC) form the network
  - Each AP encapsulates the data received from its internal DECT RFP

Ethernet-II Header			Data Unit (46-1500 bytes)						
						Data Unit			
DST	SRC	Type	IP Header	UDP Header	Protocol Header	Ethernet-II Header			Frame Data (46-1500 bytes)
						DST	SRC	Type	
6	6	2	20	8	10	6	6	2	

  - The APC unpacks the frame and sends on the data unit, making each PP look to the central station like a fixed end-point
- Mobility is handled by the APs interchanging data
  - The PP sets up a connection with the new AP
  - The PP then transfers the payload data connection to the new AP
  - The new AP informs the old AP of the change, and takes over the data flow

Infrastructure for mobility

- A DECT-type system needs to be synchronised
  - All APs (which contain DECT RFPs) must be synchronised to allow seamless handover
  - The APs in this system are powered using the 802.3af ‘power over LAN’ system
  - We combine the two, and add sync pulses to the power lines in the CAT5 cable



Battery performance

- The patient monitor needs to have a ‘talk time’ of 48 hours
  - By reducing the duty cycle of the DECT system by a factor 24/64, we can reduce the average power consumption by the same amount
  - We also transmit a lower power (about +12dBm) compared with DECT (+23dBm)
  - There has also been a lot of software effort into duty cycle management and dormant modes in the hardware
- The desired operation time is achieved with two alkaline AA cells!

How do you go about determining the best system design

- Understand the requirement in detail – take your time!
- Understand the radio channel – crucial to getting your design correct
  - Look at the literature if your application is near to a standard one
  - Otherwise, you may need to do some surveying
- See if there are any radio standards near to meeting these
  - Determine the changes (if any) needed
  - Try to maximise hardware and software re-use
    - Leads to a considerable reduction in commercial risk
    - Take advantage of study work already done (by others)
    - DECT part is a software licence, not a full development
    - IP mobility solution licensed from a WiFi equipment manufacturer
    - High-volume (= low cost) silicon solution for baseband

Thank you…

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