The Engineered Smarthome

Richard Farthing, CEng MIET

“To define it rudely but not ineptly, engineering is the art of doing for 10 shillings what any fool can do for a pound”

(Duke of Wellington, c. 1800)
Contents

• What is / not a engineered Smarthome ?
• Where might you start? Requirements
• Setting the Scene:
  • Design philosophies
  • Open Source Software
  • Enabling Technologies
  • Non-functionals
  • Adaptability, Interfaces, Integration & Wires!
• My Smarthome implementation
  • Let’s talk WIRES
  • Controller
  • Lighting, Heating, TV & Multimedia, Security & CCTV, Horticulture!
  • Integration examples
• Cybersecurity
• Smarthome top/bottom 10
• What would I do differently now ?
Back... in 1984

The prequel... 1977-78

3rd year project: The “F.C.L.B.”
Student life
A short picture history

1986 - Moving lights
1990 - MX console
1992 - LD90 low cost dimmers
1995 - EC90/CD80 EU/US (patents)
1998 - USA, architectural ctrl
2001: Singapore, North East Line
2003-2012: T5, T5 5C, T2
2013-2014: Bangkok, Purple Line
What is an *engineered* Smarthome?

- A Smarthome is...
  - “A home equipped with *lighting*, *heating*, and *electronic devices* that can be *controlled remotely* by smartphone or *computer*.” - *OED*
  - A home automation system will *monitor* and/or *control* home attributes such as lighting, climate, *entertainment systems*, and *appliances*. It may also include home *security* such as *access control* and *alarm systems*. - *Wikipedia*

- What’s missing? **INTEGRATION**

- Where did it start? Sir Stirling Moss set a good example in 1979, Many custom switch plates, mostly electromechanical. (Video)
Inspiration - Stirling Moss, 1979
Some learning points...

- Well defined requirements – designed for user
- “I enjoy the benefits of it every day”
- What’s useful vs. a toy may only be understood after commissioning
- The “All off” function for lights etc. is essential. As is, fairly obviously, status indication
- “Already out of date”. Need to design for upgrades!
- *Too much personalisation may be a problem when considering resale!*
What isn’t an engineered Smarthome?

- A collection of non-integrated Apps on a smartphone, tablet, computer etc operating independently, especially if they rely on non-deterministic web servers/services or non-generic cloud services. A typical marketing clue might be: “...offers HomeKit, Google Home, Alexa and IFTTT support...”
- A “system” bought from anyone except a handful of top-tier integrators
- Why?
  - Tech timescales are a poor match with home ownership. Change every year or three, even five, are likely to defeat meaningful integration and cause poor WAF or PAF! A better match for renting, but that limits many of the concepts presented here
  - Specialist vendors sadly go bust or change significantly in 10-20 yrs. Even Google’s, Amazon’s, Apple’s can lose interest over time
    https://killedbygoogle.com
  - “Smart TV’s” aren’t perhaps quite so “Smart” after about 5 years
  - My timeframe is extreme - 20-25 years+!
Fragmentation - a current scenario
Where might YOU start?

- Write some requirements, YOUR requirements!
- “Writing Good Requirements” by Ivy Hooks, INCOSE 1994
  - **Banned terms:** Minimise, Maximise, Rapid, User-friendly, Easy, Sufficient, Adequate, Quick, Etc, “But not limited to”, “And/Or”
- What do I want it to do? (more than what it can do)
- What might others want it to do - PAF
- It’s difficult to be totally pure with a URD / SRD “V&V” approach, you’ll have to ground requirements in little reality to get it done, but be S.M.A.R.T.
- Examples shown later are from my 2003 spec - unchanged
Setting the Scene: Design philosophies

- Create some!
  - Think about meeting your needs, with room to grow, rather than latest whizz tech/box that might lock you into a vendor and/or dead-end
  - Think about your use cases – and – general usability, visitors, PAF
  - Think about useful integrations, so the system works for you
- Here are some that I made earlier:
  - Maintain an independent system as far as is practicable, don't plan to rely on 'cloud services' for mission-critical functions
  - 100% Open Source to ensure longevity and independence
  - Server-based applications at the core, user interface clients use core config
  - User interface strategy: JEUI AKA JEOS: Just enough to support required integrations
  - Environment & cost matters: Recycle hardware where economic (but consider whole life power consumption, e.g. Large disks vs. expensive SSD’s). 100khrs = 70% life left in my case
  - Don't compromise on quality where it matters TO YOU
  - Performance matters! Aim for decent system performance (undefined!).
  - Include manual overrides / backups for critical functions where possible (lighting, heating...)
  - BUT always KISS - Keep it as simple, stupid - where you can
Setting the Scene: Open Source Software

- 100% Open Source guarantees long life, but involves some more work. Your reward is independence
- Key skills worth learning:
  - Linux (with long term support: Debian, SuSe, [Centos, Ubuntu])
  - Installing & updating packages
  - Configuring (also using config tools such as Webmin, Cpanel, Plesk and workalikes)
  - Development: scripting, compiling, version control (Git)
- **GIYF**: Github Is Your Friend, though documentation often weak.
- SourceForge also has useful software, but fading
- Google can be your friend too – research before rolling your own! DIH!
Setting the Scene: Enabling Technologies

- Networking – wired & wireless
- Re-purposing / recycling / upcycling of existing products and hardware by open-source enthusiasts
- Cheap, reliable PC’s, with low-ish energy consumption
- Raspberry Pi
- Low cost modules like ESP2866: TASMOTA*
- Wake-On-LAN, Sleep-On-LAN, Intel AMT
- Internet/RSS data feeds (e.g. weather)
- XML
- IBM’s MQTT*
- UDP xPL protocol – now EOL – but open source
- eBay and similar marketplaces

* Not used
Setting the Scene: Non-functionals

- Set an Availability target. Mine is 3 or 4 ‘nines’ (99.95% = 4hr unscheduled downtime / year)
- Power saving – consider in every aspect of the design – unquantified! Often tradeoffs: lower power vs. longer bootup
- EMC compatibility – interference to radio / TV / Wi-Fi...
- Performance? Safety? (Response times, optical isolation...)
- Reduce entropy! Too many disparate services: Aim to bring order to the multimedia world!
Setting the Scene: Adaptability, Interfaces, Integration & Wires!

- Key to a successful, long-lived system
- Adaptability:
  - What’s achievable now
  - What’s likely to be achievable in 5-10 years+
  - What provides multiple or most options for future upgrades?
- What interfaces might you need? Where?
- What wires support the most interfaces?
- **Resale!** Not everyone wants a ‘Smarthome’!
  Will you be able to sell it with your perfectly engineered solution – how might you revert it to “SmartHome-ready”?
- It’s **INTEGRATION** that makes the home SMART
My Smarthome implementation

WIRES,
Controller,
Lighting,
Heating,
TV & Multimedia,
Security & CCTV,
Horticulture!
Let’s talk WIRES

- Wires are really important. They power things, and transmit data faster and more reliably than anything else. 99.9999% availability!
- Often they’ll do both, or can when required, e.g. CAT5E / 6+
  - Gigabit network (now 2.5Gb)
  - Wired phones
  - HDMI (via converters)*
  - Serial RS-232
  - 12V DC
  - Old-Skool video (SD composite) using baluns
- So... flood with Cat5E / 6+ Ethernet if you can. 32 ports in a 2-bed house? Use duals & label them!
- Refer to Automated Home wiring guide: https://www.automatedhome.co.uk/content/wiring-guide.html

* Not used
Critical Spot – the living room TV

- Power (more off-camera)
- 2A Controlled socket (lighting)
- Aerial
- Ethernet, maybe 4?
- SCART – really *!?!*
- HDMI (MIA) : First products 2004
- Speakers
Controller
Controller requirements [13-Jun-2003]

- The controller shall be a commercial computing device with standard interfaces (see *interfaces*)
- A web-based control interface shall be provided, with password protection restricting ability of visitors to change states
- The HA shall include an "always on" connection to the Internet, providing at least 512k download, 256k upload speeds
- A mechanism to compress and backup data to an external device or network device shall be provided
- The fileserver shall include a Windows share
- VPN services shall be provided to allow secure access to machines on the internal network running VPN servers
2010: ‘The Green Open Source House’
(www.automatedhome.co.uk)
‘Node ZERO’ : A PC under the stairs

Controller & network

- HP8300, dual-core i3, ~50W
- Ideal match for req’d interfaces – all used! Ultra-efficient PSU option (90% efficient)
- 12TB RAID 5 = 8TB usable
- ‘Green’ 16 port switch (<5W)
- Router / VOIP / phone distribution
- Aerial distribution
- TV receivers
- OpenSuse Linux, providing:
  - Automation / integration & web access
  - Lighting & heating controls
  - File & email server, OpenVPN & OwnCloud
  - Wi-Fi base station
  - CCTV server
  - Streaming multimedia servers (TV/Audio)
  - Zimbra email server (in Centos/LXC container)
Lighting

Incandescent, LED, dimmers etc
Lighting Requirements

- All lighting circuits shall be controlled by the HA
- It shall be possible to review status of the HA controlled circuits
- It shall be possible to group circuits together to be controlled as a single named entity
- Timed functions shall be supported
- Schedules shall contain lighting levels, such that dimmers may be supported
- It shall be possible to provide alternate uses of momentary light switches by the duration of the button press. E.g. hold down for 3s in the bedroom turns all house lights off, or dimmer up/down.
Lighting, Switch & control interfaces
Lighting and I/O functions

- Self-written ‘xPLk8000’ daemon samples, debounces inputs, scales analogue I/O @20Hz, communicates over I2C & xPL.
- All lights have a timeout, minutes... hours as req’d, warn-before-off (USA standard office function)
- Timed events - hardcoded and scheduled via Web UI
- Individual lights – Click On/Off, long press to cycle level up/down (auto-save):
  \[
  \text{light\_statemachine}($\text{Courtyard\_lights},$\text{Study\_switch\_3}, '8\ h', 40); \\
  \]
- Scenes group specified lights + fade times. A long press cycles through scenes, reverts to default scene after timeout, auto-fade scenes (pseudo-random mood lighting).
  \[
  \text{scene\_statemachine}($\text{Living\_scenes}, $\text{Living\_switch\_5}, '6\ h', 0); \\
  \]
Lighting – What's new?

• “Warmtone”, “Dimtone”... “Dim-to-warm” LED’s - now viable and comparable to halogen, work with above dimmers to ~10%, but some are noisy!

• Philips ‘Hue’ and cheaper lookalike bulbs – WiZ, Ikea TRÅDFRI (Zigbee based), Tuya (Lidl), Smart+, Kasa, Wyze...

• MiHome (Energenie), sockets, dimmers etc: 433MHz
  • Mostly non-interoperable, require hubs, apps, Wi-Fi or Bluetooth and Cloud
  5GHz NOT SUPPORTED
  • Limited integration, usually via Google Assistant, Alexa, IFTTT or Siri
  • A work in progress!
Heating

Underfloor heating downstairs
Radiators upstairs
Heating

- It shall be possible to vary temperature settings by time of day, and day of week.
- There shall be no specific "system" on or off control, control shall be via temperature variation over time.
- Under Floor Heating requires complex control, few refs!

![Remote Temperature Sensor with Voltage Output](image)

<table>
<thead>
<tr>
<th>Study</th>
<th>Kitchen-living</th>
<th>Upstairs</th>
<th>Domestic Hot Water</th>
<th>Setup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone heated for 45 minutes and 40 seconds today, and cycled 3 time(s)</td>
<td>Zone is currently OFF and has been since 7:46 on Friday, Jan 08</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Status</th>
<th>-- Temperatures --</th>
<th>-- Upcoming Changes --</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedroom</td>
<td>Setback</td>
<td>Current: 18.22</td>
<td>Status: Occupied, Time: 23:15 on Friday, Jan 08</td>
</tr>
</tbody>
</table>
Internal temp monitoring

**Temperatures last 5 years**

<table>
<thead>
<tr>
<th>Location</th>
<th>Min</th>
<th>Max</th>
<th>Avg</th>
<th>Last</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living Room</td>
<td>11.0</td>
<td>31.8</td>
<td>21.3</td>
<td>21.2</td>
<td>2022</td>
</tr>
<tr>
<td>Bedroom 1</td>
<td>10.4</td>
<td>35.4</td>
<td>21.9</td>
<td>22.2</td>
<td>2022</td>
</tr>
<tr>
<td>Study</td>
<td>0.0</td>
<td>34.6</td>
<td>21.9</td>
<td>21.9</td>
<td>2022</td>
</tr>
<tr>
<td>Study sensor</td>
<td>11.5</td>
<td>34.6</td>
<td>21.7</td>
<td>21.9</td>
<td>2022</td>
</tr>
<tr>
<td>No data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Start time: Tue May 30 01:00:00 2017  Step size: 6d  Data points: 326
Updated 30/09/2022 15:30:00
External Temp monitoring

Temperatures last 1 month

- Dew Point: Min: 0.9, Max: 17.0, Avg: 10.6, Last: 9.8
- Courtyard: Min: 10.0, Max: 32.5, Avg: 17.1, Last: 15.7

Start time: Tue Aug 30 08:45:00 2022  Step size: 1h 15min  Data points: 601
Updated 30/09/2022 14:40:00
TV recording, network streaming, radio and recorded music streaming

*Multimedia represents the most work of all subsystems*
TV & Multimedia requirements (part)

- A TV digital video recording facility shall be provided which shall interface to the HA system to provide offline storage and editing of video over the internal network. Interface to be developed
- It shall be possible to feed all rooms from the same source via the audio matrix
- Local amplification shall be provided in the following locations: Study, living room, bedroom1
- Living room amplifier/speakers: Home theatre amp, using Tannoy spkrs, with wiring provision for rear spks for home theatre
- Kitchen: New amplifier 2 x 20W spkrs (like Tannoys)
TV & Multimedia implementation

- VDR “Video Disk Recorder” core: records files as Transport Streams (.ts)
- Streamdev plugin converts/streams TS, ES, PES
- DVB-T2 USB & PCI receivers
- Multiple KODI (XBMC) clients for live streaming or recording playback – Raspberry pi x 2, PC’s, laptops: Debian & Windows
- XMLTV EPG metadata (episode data, actors etc – see later examples)
- Web & App remotes for VDR
- Logitech Media Server (“SqueezeServer”) for audio & radio
- Whole-house fully synchronised radio or recorded media, up to NINE different players (3 jogglers [Squeezeplay], Squeezelite on server and PiCorePlayer, Squeezeplay on PC and 3 laptop[s] – Windows & Linux)
- Tight integration to achieve off-air streaming radio, podcasts etc.
- Web & App remotes for players – Android + Apple IOS
Kodi: Live/recorded TV + video via VDR

Big crowds are back and one city centre hotel team has to deal with two contrasting events over the same weekend: an international boxing ringside supper and the annual Miss Northern Ireland pageant. No sooner is that done, Next: Sensationalists: The Bad Girls and Boys of British Art
EPG Search setup
### EPG Search example (daily email)

<table>
<thead>
<tr>
<th>Title</th>
<th>Our Friends in the North</th>
<th>IMDb search: <a href="#">simple</a></th>
<th><a href="#">advanced</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtitle</td>
<td>1984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start/End</td>
<td>Wed 28.09.22 22:00-23:05 (Timer: 22:00-23:05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel</td>
<td>BBC FOUR HD [8]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>File</td>
<td>Our Friends in the North-1984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Search</td>
<td>Our friends in the north (73)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td>In 1984, the miners' strike dominates the country. Mary and Tosker clash with with their policeman son on the picket lines and Nicky returns to Newcastle.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Director</td>
<td>Simon Cellan Jones, Pedr James</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writers</td>
<td>Peter Flannery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producers</td>
<td>Melanie Howard, Charles Pattinson, Nicola Shindler, Michael Wearing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Drama</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Episode</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Episode Code</td>
<td>EP029240520003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Format</td>
<td>HDTV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtitles</td>
<td>Info Not Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeat</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Info Not Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Premiere</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Title</td>
<td>Our Friends in the North</td>
<td>IMDb search: <a href="#">simple</a></td>
<td><a href="#">advanced</a></td>
</tr>
<tr>
<td>Subtitle</td>
<td>1987</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Living Room – Surround Sound

Integration – but look – no visible wires!

- Denon AVR serially controlled over CAT5
- SPDIF surround sound over SCART + composite “setup screen” back to TV
- Raspberry Pi 1 based PiCorePlayer buried behind LP’s, on CAT5. + Networked Vinyl sampler, using FLAC. 100% digital (optical), 100% recycled!
PiCorePlayer
Kitchen Audio

£100, 100W recycled Hi-Fi

- Squeezeplayer on ‘O2 Joggler’ (1 GHz Intel Atom-based Linux touch screen tablet)
- 50 + 50W installation amp.
- Q-Acoustics 2020i
- Improves the cooking!
Multimedia Apps
Security & CCTV
Security requirements (part)

- A video camera shall be provided for monitoring of the front door
- The camera shall be digitised and may be routed to the internal network for viewing by an appropriate software package on a remote PC, web device, or the Internet
- The system shall support an alarm function by monitoring PIR movement sensors
- The alarm shall trigger the sending of an SMS message via email to SMS gateway, or directly to an attached mobile phone.
CCTV Implementation

- Currently 2 analogue (SD) cameras, 3 remote IP cameras (HD)
- Door-cam and Street-cam, movement sensing
- ‘ZoneMinder’, slightly customised, e.g. Quotas
- Remote streaming via web client, (TV, via Kodi)
- Email alerts
- Offsite ftp storage for alarmed events
- **Integration** with alarm system
- Privacy Zones
Gardening leave
Horticulture!

- Mi Flora “Flower Care” monitors (by Xiaomi):
  - Bluetooth Low Energy
  - Moisture, conductivity, temperature, light, battery
  - Daily alarming by email (above example)
  - Limited range, 2.4GHz interference
- Future integration:
  - Automatic watering, using rainfall data, temperature and moisture values from monitors

Weekly status report:

Bamboo: Temp=13.9C, Moisture=18, Conductivity=145uS/cm, Battery=22% (19.0 hrs ago)
Box: Temp=16.9C, Moisture=44, Conductivity=257uS/cm, Battery=89% (721.0 hrs ago - WARNING!)
D_Marginata: Temp=16.1C, Moisture=21, Conductivity=1715uS/cm, Battery=99% (1.0 hrs ago)
D_Mass: Temp=16.9C, Moisture=69, Conductivity=2275uS/cm, Battery=86% (7.0 hrs ago)
Montbretia: Temp=14.3C, Moisture=15, Conductivity=116uS/cm, Battery=13% (19.0 hrs ago)
Rose: Temp=12.3C, Moisture=30, Conductivity=164uS/cm, Battery=88% (1.0 hrs ago)
Control software

‘Misterhouse’
Why Misterhouse?

- 100% Open Source and virtually unstoppable
- Excellent startup / shutdown / maintenance / power fail / soft-start recovery characteristics – never loses data or config
- OO Perl – better than it sounds!
- Perl not going obsolete any time soon, all platforms support it
- Interfaces to many things, including current ones such Google Home, Philips Hue, Alexa... but also serial, TCP ports, X10, xPL, xAP, LMS, TTS (e.g festival). “Voice Commands” are native.
- Graphing + logging of all events allows diagnosis, debugging
- Code & config data amenable to standard version control tools
- Infinitely customisable basis for engineering an automation solution
- In the real world, HA logic isn’t simplistic “If This Then That”
  Mh has methods like time_idle, setby, and core variables such as time of day, sunset, sunrise to match real-world human activities...

```perl
$mode_guests->set (OFF, '1 week timeout') if $mode_guests->time_idle('7 d on') && $New.Hour;
$PC_shutdown_override->set (OFF, 'Security unarmed') if state $PC_shutdown_override eq ON && $mode_security->time_idle('10 m armed');
```
Misterhouse user interfaces

Original Html interface (‘ia5’)
- Simple, dated, but works quickly. Does the job!

New (‘ia7’)
- Interactive with live status updates
System Integration
Example Integrations

- Security: Alarm set > Switch off / sleep everything when leaving, simulated occupancy when dark (lights, TV). Unset > lights on at night
- Security: Alarm trigger > lights + CCTV
- Whole House Audio sync/unsync on demand, schedule or automatically using MH, LMS, and a variety of up to 6 heterogeneous players
- TV + AVR + lights + media players, both on & off, using VDR’s broadcast status > syslog > MH <> TV+AVR+LMS > Squeezeplayer(s)
- VDR(streamdev) > TS2shout > Apache > LMS > Squeezeplayer
  = Freeview Radio with program metadata, only 5s delay
- Auto-radio – LMS favourites played at configured volumes, depending on time of day and day of week: MH <> LMS > Squeezeplayer(s)
- APS: “Archers Protection System™”, extended to other programmes. VDR > syslog > MH <> LMS > Squeezeplayer(s), also uses metadata feed for reliability
Nullius in verba
(take nobody's word for it)
Cyber Security

- Always-on + available on the Net means always a target!
- ‘Cyber Essentials’ is a useful baseline:
  - Firewall(s)
  - Automated updates / patching on a cron (and monitor them!)
  - Use known packages
  - Remove unnecessary packages & services
  - Minimal number of external open ports. I only allow SSL
  - Switching ports off when not needed (e.g. 465, 587)
  - Secure, non-shared passwords for services, or certificates/keys (e.g. VPN)
  - Automated virus scans
- Use Apache virtual servers/reverse proxies to front untrusted services, then use basic auth or OpenID/Oauth...
- Add monitors for critical functions (Webmin can provide), and use logwatch or similar. Include automated periodic process restarts.
- Subscribe to CISA alerts
And finally...
What’s coming?

- IPTV
- Smartmeter integration
- Whole house power control: power cuts? (inverter+batteries: part of a solar PV system?)
- Boiler / Heat pump integration
- ‘Matter 1.0’ protocol
Smarthome top/bottom 10

- Best decision: Ethernet everywhere
- Most important input: Alarm set state
- Most satisfying features:
  - Lights on at dusk or when returning home
  - Power on/off devices & PC's when home/away, different times of day (Wake-on-LAN, Sleep-on-LAN)
  - Whole house audio, sync / unsync on demand, schedule, or automatically, auto-play favourites based on time of day, and APS!
  - Security functions (simulated occupancy) – TV, lights, CCTV
  - Automatic EPG searches, TV recordings + podcasts made automatically
  - TV recordings that start at the beginning with minimal, if any, continuity (using running status), +advert skip
- Most troublesome hardware: USB TV receivers & Bluetooth plant sensors (BLE)
- Most troublesome software: OwnCloud & NTP
What would I do differently?

- Dimmer per circuit is expensive, but alternatives depend on critical technology such potentially unreliable/interruptable 2.4Gig Wi-Fi/BT etc. A wired data equivalent (X10+++ ) would make the choice a lot easier.
- Similarly, wire-per-switch is expensive to install. Same arguments apply, but consider ‘smarthome-ready’ alternatives – with an eye on resale.
- Alternative switches might be:
  - Leviton (US only), US wall plates
  - Beware system lock-in
  - EnOcean “kinetic” batteryless
  - Legrand - Netatmo etc: 2.4Ghz Zigbee.
  - Questions of reliability. Zwave better?
- Fewer aerial connections!
The Engineered Smarthome

Thank you.
Any questions?

Demonstrations
Synchronised media players - over a VPN
A live glimpse of the smarthome