IEEE 802.15.4 Revision Status Report for IETF 91

Summary of changes to IEEE Std. 802.15.4 revision (12 Nov 2014)

- Latest draft is D2 (not publically available)
- Revision consists of
  - 802.15.4-2011 as the baseline
  - roll up of amendments: 4e, 4f, 4g, 4j, 4k, 4m, 4p
  - approved changes from 802.15 maintenance standing committee
  - Corrigenda and editorial changes
- Still in work group letter ballot - recirculation
- IEEE-SA approval target – 802.15.4-2015 (Aug 2015)

Editorial Changes

- Size reduction: even though D2 is 661 pages, it's consists of 15.4-2011 at 334, 15.4e at 225, 15.4f at 72, 15.4g at 252, 15.4 j at 24, 15.4k at 149, 15.4m at 122, and 15.4p at 45 pages.
- Scrubbing definitions, acronyms, and bibliography for terms/references that are not used
- Added Clause 4 Format conventions
  - Contents of this clause is focused upon bit ordering and such nomenclature
  - Increases all normative clause numbers
- Eliminating duplicative definitions, normative declarations, and behavior descriptions (e.g. state once and refer multiple times)

ID Management Process

IEEE 802.15 WG Assigned Numbers Authority

- The objective of the Assigned Numbers Authority (ANA) is to conserve and allocate identifier values in the IEEE 802.15 standards and approved amendments.
- A limited number of numbers may be assigned to allow non-IEEE 802 standards development organizations (SDO) to extend the use of IEEE 802.15.4
- Only the following categories of IDs may be assigned for IEEE Std. 802.15.4:
  - Frame Extension ID
  - Header Information Element (IE) Element ID
  - Payload IE Group ID
- Only one number shall be assigned to a non-IEEE 802 SDO from an ID category. The non-IEEE 802 SDO is responsible to create a method for sub-typing that would prevent the need for an additional ID.

Frame ID Extension

- 000 Beacon
- 001 Data
- 010 Acknowledgment
- 011 MAC command
- 100 Reserved
- 101 Multipurpose
- 110 Fragment or Frak1 (use limited to LECIM DSSS PHY)
- 111 Extended (indicates next 3 bits are frame extensions
  - 000-011 Reserved
  - 111 Assigned to Telecommunications Industry Association (TIA)

Information Element IDs

- Header IE IDs:
  - 0v00 Vendor Specific
  - 0x01–0x18 reserved
  - 0x7e Header Termination 1 IE
  - 0x7f Header Termination 2 IE
  - 0x80–0xff reserved
- Payload IE IDs:
  - 0x0 Encapsulated Service Data Unit (ESDU)
  - 0x1 MLME (Nested)
  - 0x2 Vendor Specific
  - 0x3–0xe Reserved
  - 0xf Payload termination

Extinct Terms

attributes, constants, PIBs that are gone

- aUnitBackoffPeriod
- phyCCATimeMethod
- macMinLIFSPeriod
- macMinSIFSPeriod
- macEnhAckWaitDuration
- macMaxFrameTotalWaitTime
- macTxControlActiveDuration
- macTxControlPauseDuration

Endangered Terms

attributes, constants, PIBs that are on their way out

- *phyPHRDuration* (not used)
- *phyCCADuration* (used only for 920 MHz band)
- *aMaxMACSafePayloadSize* (not a constant)
- *aMaxMPDUUnsecuredOverhead* (not a constant)
- *aMinMPDUOverhead* (not a constant)
- *macTxTotalDuration* (PIB is defined but not used)

InterFrame Spacing (IFS)

Previously:

- Short IFS (SIFS) and Long IFS (LIFS)

Now: SIFS, LIFS, and Ack IFS (AIFS)

- LIFS = *macLIFSPeriod* = 40 symbols (except RCC)
- SIFS = *macSIFSPeriod* = 12 symbols (except RCC)
- AIFS =
  - 1 ms for the SUN PHYs, LECIM PHYs or TVWS PHYs
  - *macSIFSPeriod* for all other PHYs.

Changes to TSCH Default Values (ID=0, Table 137)

- *macTsRxOffset* –changed from 1120 µs to 1020 µs to align center of *macTsRxOffset* with *macTsTxOffset*
- Added 915 MHz SUN defaults (also ID=0)
  - Numbers based upon 100 kb/s, 1522 byte payload, 1 ms Transmit to Receive turnaround

CSMA-CA Flow Charts and Scope

- CSMA-CA flow chart has been merged with TSCH CSMA-CA flow chart
- New flow chart being drawn to show initiation of transmission for all modes, beginning at:
  - MCPS-DATA.request
  - MLME-BEACON.request
  - MLME-POLL.request

  and concluding at the CSMA-CA flow chart or regulatory procedure or PHY transmission
- Includes test for valid frame size

CSMA-CA Flow Charts and Scope (cont'd)

- CSMA-CA and CCA are now focused only upon peaceful coexistence with other 802.15.4 devices and networks.
- Regulatory compliance such as listen-before-talk along with coexistence with non-802.15.4 protocols is out of scope. But can be done with 802.15.4 elements such as CCA modes 1 – 6
  - New ETSI requirements stretched CCA operation too far, moving regulatory behavior out of standard allows us to maintain original function of CCA
- Text added to end of 10.2.7 CCA modes

NOTE—These modes are used to provide cooperative utilization of the medium in an IEEE 802.15.4 network. They are not designed to provide regulatory compliance, and in some cases only a subset of these modes may meet regulatory requirements.

As an example, EN 300 328 v 1.8.1 and above require energy detect for a minimum of 20 µs. In this case an implementer could choose to use CCA mode 2 within the CSMA-CA algorithm, followed by a 20 µs ED in accordance to the requirements of the ETSI standard in order to achieve regulatory compliance. Implementing a design in this manner would provide an optimized network that would not be disadvantaged in a mixed protocol environment with networks other than IEEE 802.15.4.

TSCH CSMA-CA harmonization with Priority Channel Access (PCA)

- PCA provides mechanism to give priority frames faster access to the medium within shared time-slots compared to lower priority frames
- Priority is assigned by a layer above the MAC
- PCA is complementary to 6top's priority queue mechanism
- Effort underway to modify flow charts such that PCA fits within constraints of TSCH

When is what used and how?

Significant effort is underway to remove ambiguity as to when and how to use added behaviors such as:

- Imm-Ack vs. Enh-Ack
- Data frame vs. Multipurpose frame
- Beacon vs. Enhanced Beacon
- Low Energy: CSL vs. RIT vs. I-RIT vs. ~~TVWSPS~~
- Association vs. FastAssociation vs. do nothing
- DSME vs. GTS

Corrections to IEEE Std. 802.15.4 Security

Third time is the charm?

Note: it is so much easier to do it wrong than to do it right

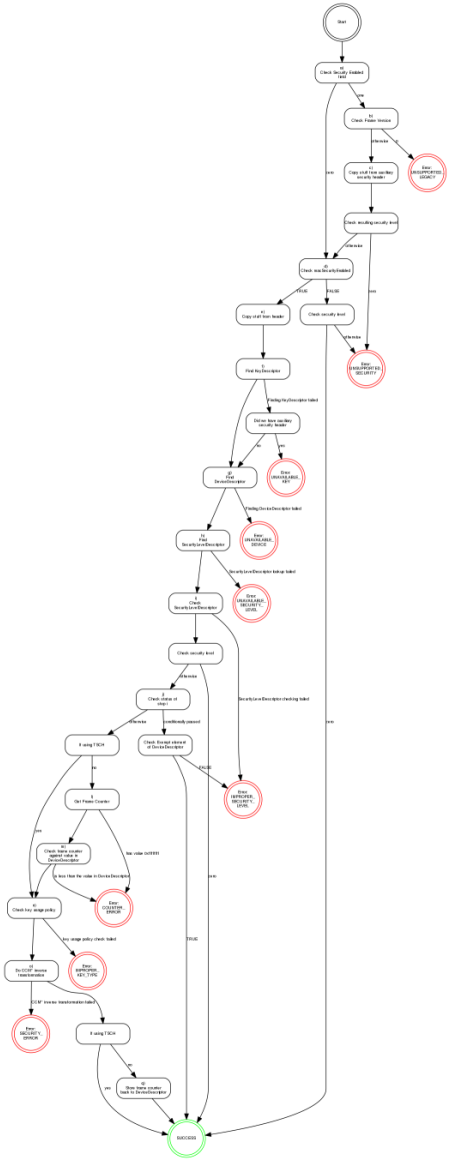
Security Changes

- State machines
  - People found them confusing
- Allowing frame counters to be per key, not per device
  - TG9 KMP wanted this
- Specified how security is done on new frame types
  - i.e. which parts are encrypted and which are not
- Removed security level 4 (encrypt only)
- Special for TSCH
  - Frame counter vs ASN
  - Removed the 5-octet frame counter format from frame (frame counter field in header).

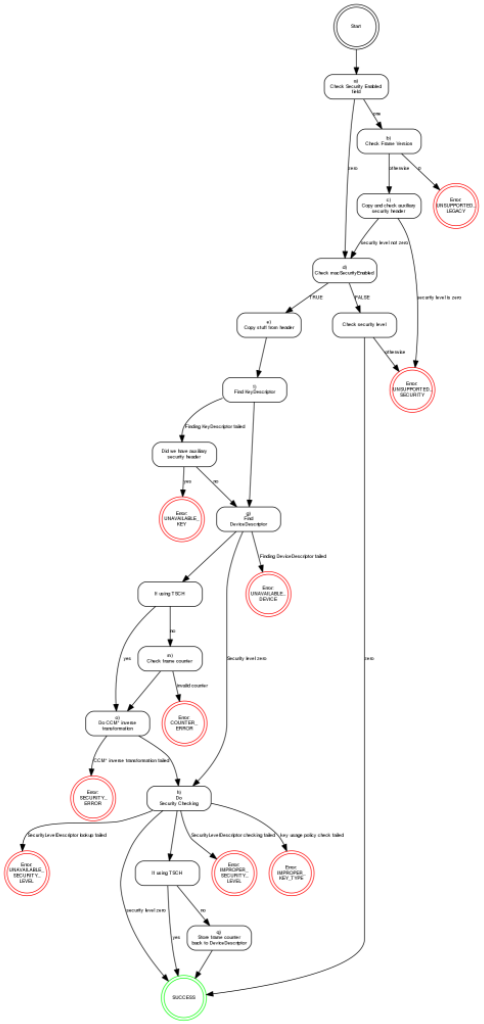
State Machines

- Inbound and outbound state machines are skipping some states that are not needed when using TSCH (all frame counter related things, as TSCH is using ASN)
- Trying to make it clear that security level 0 (no security) and other security level packets can be mixed
  - This was true before, but it was very hard to see from the state machine.
- Cleaning them up
- State Machine figures are shown on next slide

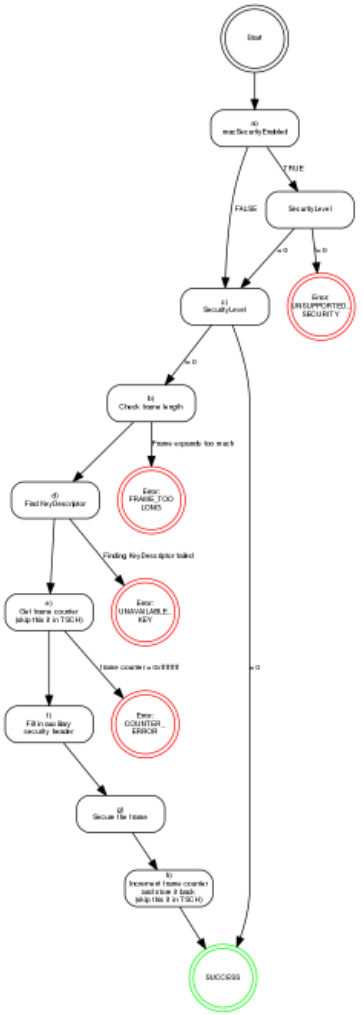
State Machine Figures



Original inbound



Modified inbound (work in progress)



Original outbound

Other Changes

- Added section to describe nonce generation for TSCH
  - Always use 5-octet ASN (absolute slot number)
  - Do not allow short addresses in the address field
- There was 5-octet frame counter option in the security header, but as 5-octet nonce generation is now used only in TSCH, and that always uses ASN, removed the whole 5-octet frame counter field.
- Specified that frame counter suppression can only be used when using ASN or similar (i.e. not copy the frame counter from inbound frame for Enh-Acks)

Protocol Implementation Conformance Statement (PICS)

Annex D: statement of which capabilities and options of the protocol have been implemented

Protocol classifications are:

- M - Mandatory
- O - Optional
- O.n - Optional, but support of at least one of the group of options labeled O.n is required.
- X - Prohibited
- Conditional – status is dependent upon the inclusion of other optional protocol

Unfortunately, this annex is hopelessly dysfunctional, and must be extensively rewritten

Background information

Introduction to IEEE standards process

Principles of the process

- Due process – procedures are publicly available and followed consistently
- Consensus – requiring agreement of a majority (>50%) for procedural decisions or supermajority (>75%) for technical decisions
- Openness – ensuring materially interested and affected parties can participate
- Balance – representation from all interested parties without overwhelming influence from any one party
- Right of appeal – process to ensure due process

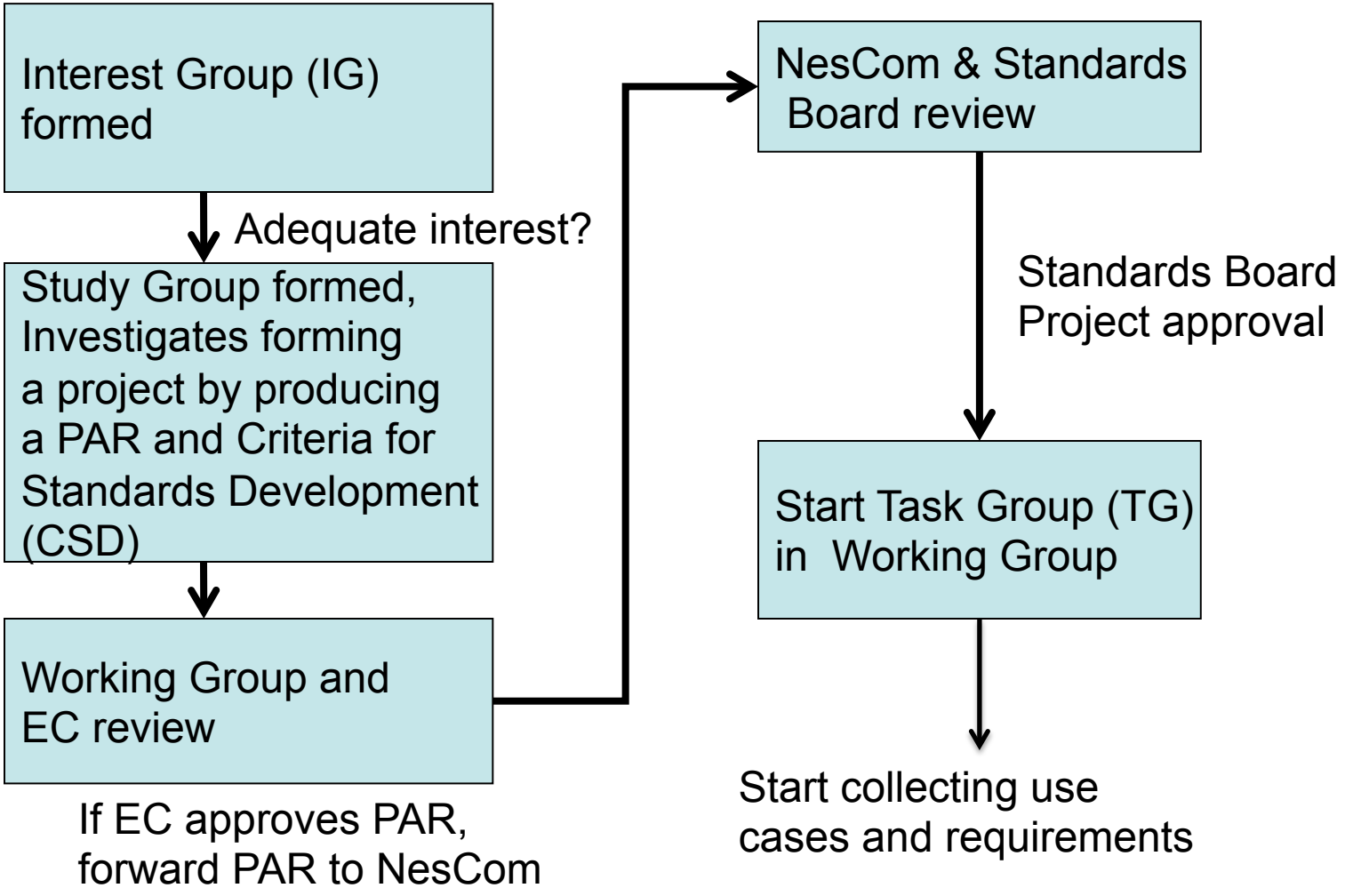
Basic IEEE Acronyms

- PAR – **P**roject **A**uthorization **R**equest – the charter for a standards project
- CSD – Criteria for Standards
- IG – **I**nterest **G**roup – group formed to provide a forum for specific applications or technologies.
- SG – **S**tudy **G**roup – a group formed to investigate a project and produce a PAR
- TG – **T**ask **G**roup – group formed to produce a draft standard, recommended practice, guideline, supplement, or portion of a draft standard

IEEE Project Types

- Amendment
  - Often classified as either MAC or PHY
  - Adds new material/protocols to existing standard
  - Document only contains the changes to standard
- Corrigendum
  - Limited to error correction of existing standard
  - Document only contains the changes to standard
- Revision
  - Maintenance revision rolls up all amendments into a single document
  - Any text in the standard may be changed
  - Document contains all text of the standard

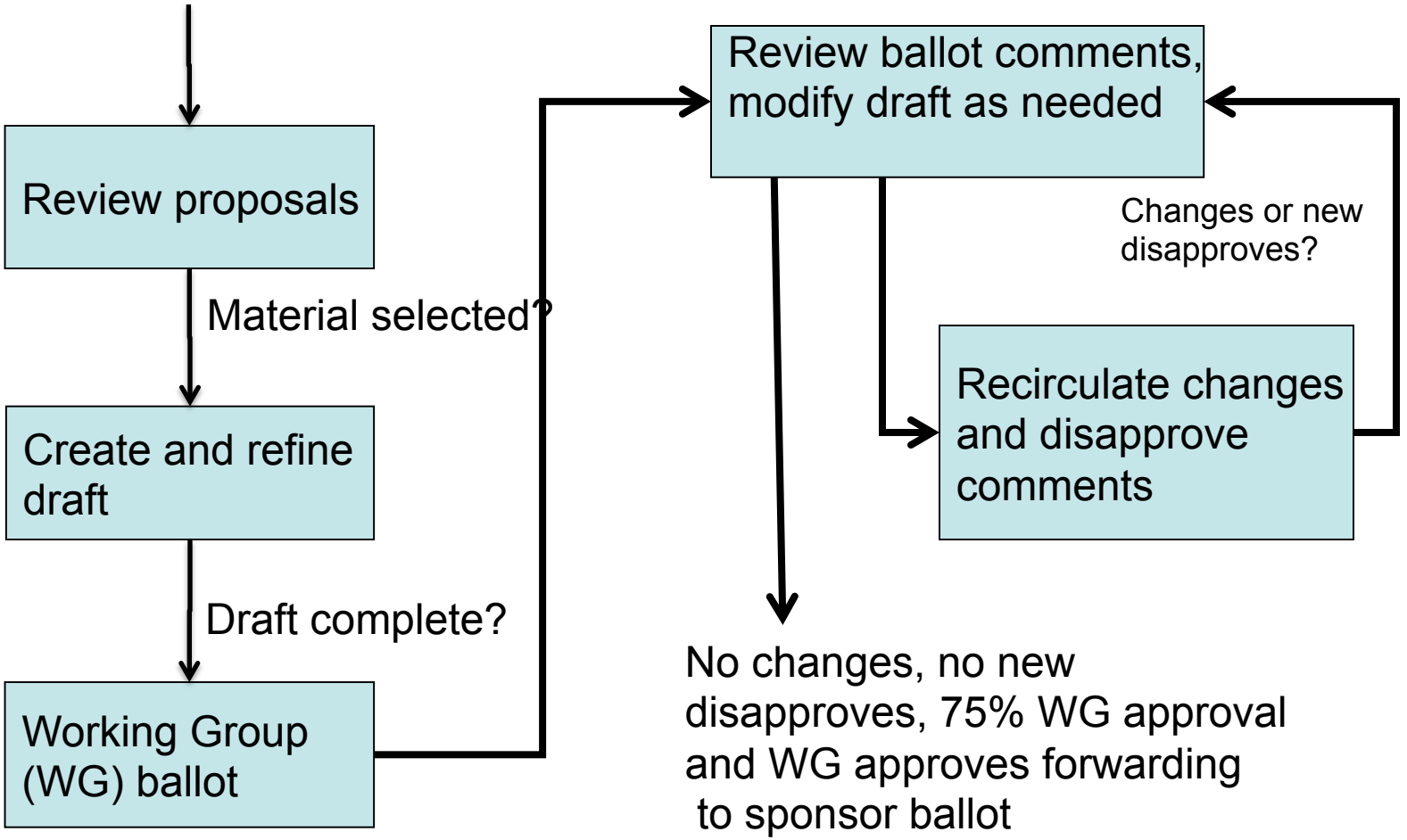
IEEE 802.15 standards development life cycle – part 1



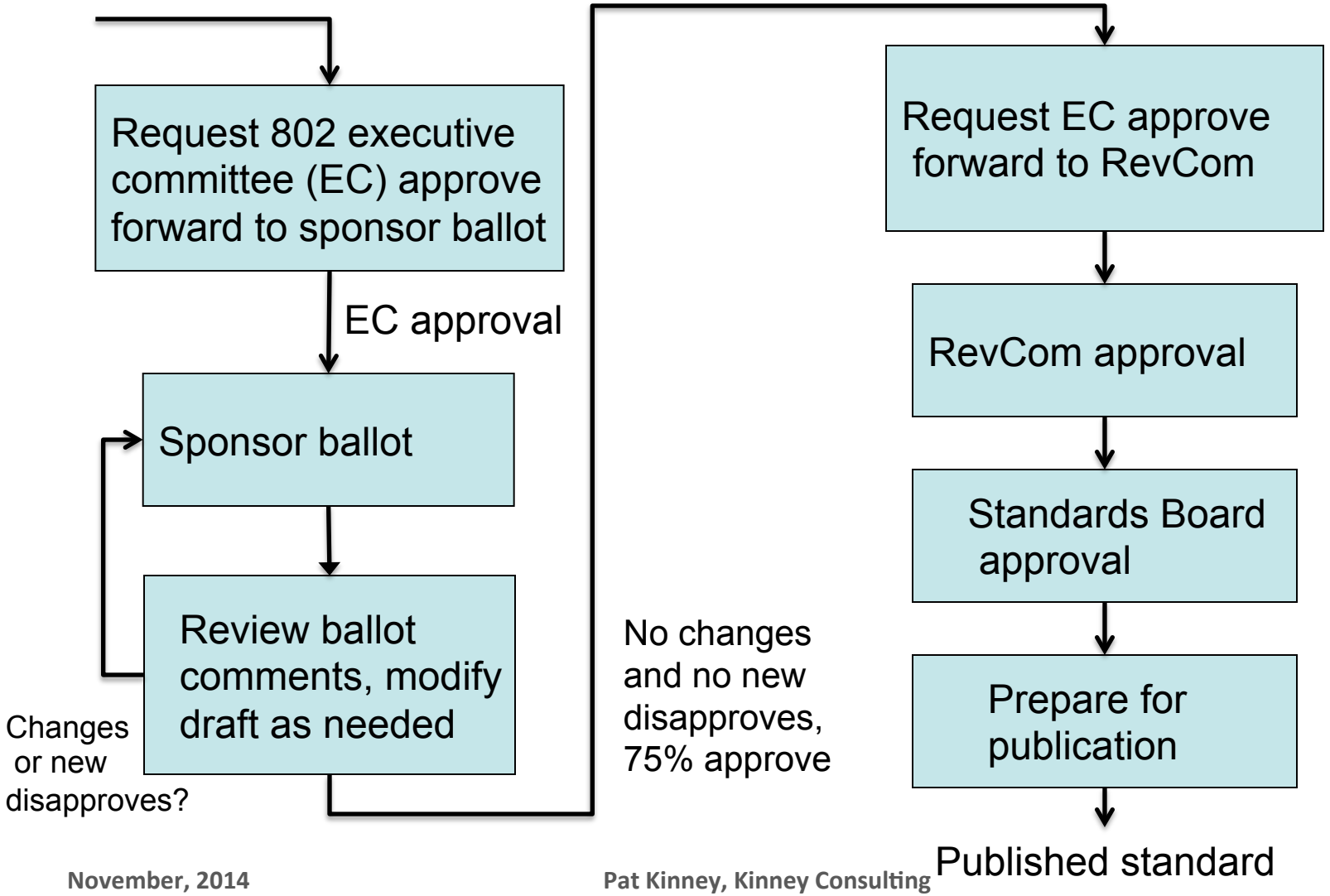
IEEE 802 CSD

- Broad Market Potential
- Compatibility
- Distinct Identity
- Technical Feasibility
- Economic Feasibility
- Coexistence with other 802 standards

IEEE 802 standards development life cycle – part 2



IEEE 802 standards development life cycle – part 3



Standards life cycle – part 4

And then there is maintaining the standard

- Respond to request for interpretation
- Keep the standard current by producing amendments and corrigenda (corrections)
- Renew the life of the standard with reaffirmation or revision
- When the standard is out of date, withdraw it.

Voting and membership

- Voters have responsibility to vote on letter ballots
- Three levels of voting occur in IEEE 802 standards development:
  - Sponsor ballot
    - Open to all interested parties
      - Via IEEE SA-membership or paying a per ballot fee
    - Participation requires an IEEE Web Account
  - Working group
    - Requirements on next page
  - Task force or task group
    - Requirements vary – consult Working group.

Acquiring Working Group voting membership

- Participating at a meeting = at least 75% presence.
- For a new Working Group, persons participating in the initial meeting become members.
- For an existing Working Group, after attending 2 of last 4 plenary sessions or 1 plenary and 1 interim, membership starts at the next plenary attended.

Retaining Working Group voting membership

- **Participate in 2 of the last 4 plenary sessions**
  - An interim may substitute for one of the 2 plenary sessions.
- **Return working Group letter ballots**
  - Membership may be lost for failing to respond or responding abstain for reason other than “lack of technical expertise” to 2 of the last 3 ballots.

BTW: other 802.15.4 efforts underway

- **TG4n**
  - PHY amendment for China medical band (starting Sponsor Ballot)
- **TG4q**
  - Ultra low power PHY – long life from a coin cell battery (WG letter ballot - recirculation)
- **TG4r**
  - Ranging – provide consistent MAC interface, and provide ranging techniques from existing PHYs (hearing use cases and collecting requirements)
- **TG4s**
  - Spectrum resource utilization management (just started)

BTW: other 802.15 efforts underway that are focused on 802.15.4

802.15.9

- This project will provide a Recommended Practice for the transport of KMP datagrams within 802.15.4. It will also provide guidelines for KMPs like IETF's HIP, IKEv2, IEEE Std 802.1X, and 4-Way-Handshake.

802.15.10

- The end work product of TG10, Layer 2 Routing (L2R), is the generation of a recommended practice for routing packets in dynamically changing 802.15.4 wireless networks. Status of this group is that the proposers have merged their proposals into a single document.

IG 6TISCH reflector information

- stds-802-15-ig6t@listserv.ieee.org
- http://grouper.ieee.org/groups/802/15/pub/Subscribe.html
- Next Session: January 11-16, 2015, Hyatt Regency Atlanta, Atlanta, GA