Observations on IPv6 Addressing

(draft-struik-6lo-on-ipv6-addressing-00)

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Outline

1. IPv6 Addressing
   - Problems with IPv6 Addressing using Modified EUI-64 Addresses
   - Opaque Interface Identifiers (RFC 7217) to the Rescue
   - Does this address stated privacy and security issues?
   - Layering aspects
   - What about susceptibility to Big Brother-esque subliminal channels?
2. Subliminal channels in Big-Brother-esque world

IPv6 Addressing Using Modified EUI-64 Hardware Addresses

Issues:

- *Fixed IIDs over time*.
  Correlation of activities over time.
- *Fixed IIDs across networks*.
  Tracking/correlation across different networks.
- *Encoding of device characteristics via IID*.
  Leakage of device properties (including potential device-specific shortcomings).
- *Device-specific addresses*.
  Device replacement causes change of IPv6 address.

Suggested remedy (RFC 7217): semantically opaque IIDs (RIDs).

Random IID (RID) = *F*(*secret device key*, *public parameters*), where

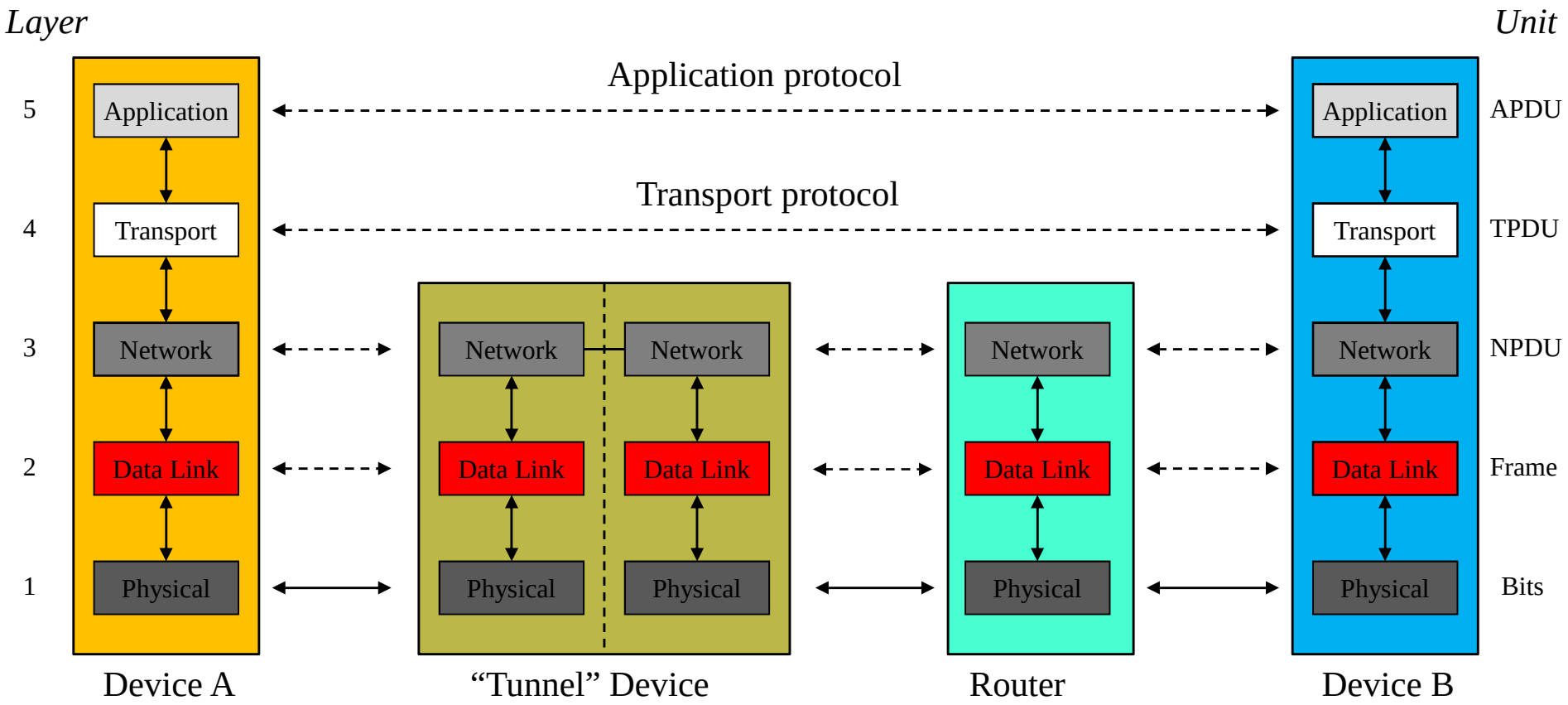
- *F* hard to invert;
- *F* difficult to compute without *secret key;*
- Output size *F* at least 64 bits.
- *Public parameters = {Prefix, Net_Iface, Network Id}*

IPv6 Addressing Using Opaque IIDs to the Rescue?

How this addresses identified issues:

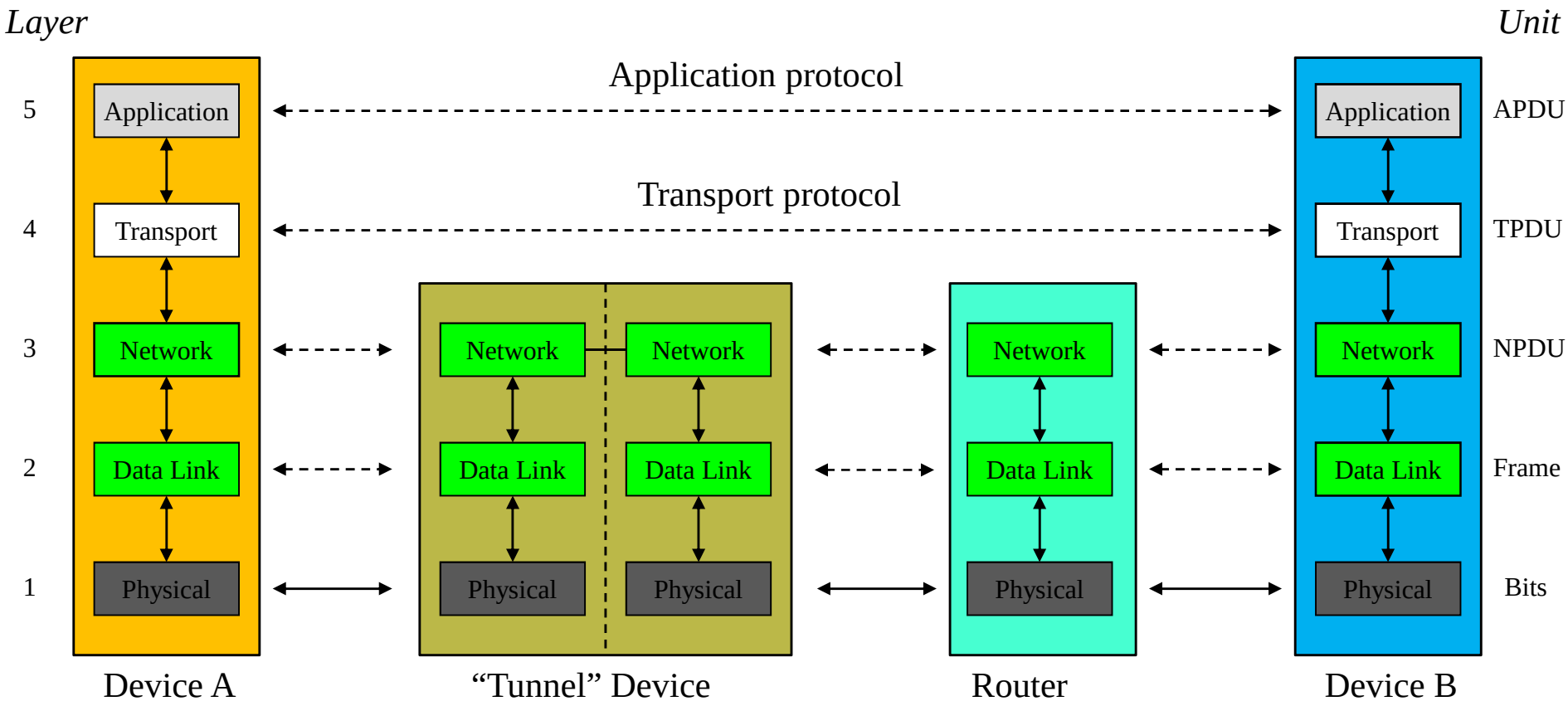
- *Fixed IIDs over time*. Not addressed
  Still tracking/correlation within same network (both temporal and spatial).
- *Fixed IIDs across networks*. Addressed
  No tracking/correlation across different networks.
- *Encoding of device characteristics via IID*. Addressed
  No logical dependency between EUI-64 hardware address and opaque ID
  NOTE1: Also realized by deriving IID from randomly generated MAC address.
  NOTE2: Compression benefits, which are also realized other way around (i.e., if MAC address derived from opaque IID)
- *Device-specific addresses*. Addressed
  However, this does require cloning of *secret device key* to replacement device).
  NOTE: Not clear whether "device cloning" would be desirable at all (since presenting a security event – and new device is logically different security entity)

Layering Aspects of Addressing (1)



Per-hop traceability if MAC addresses 'fixed', no matter whether IPv6 IIDs randomized or not

Layering Aspects of Addressing (2)



No address traceability if MAC addresses 'random' and IPv6 IIDs randomized (or one derived from other)

Layering Aspects of Addressing (3)

Layer address traceability undoes effect of Layer 3 address randomization (on per-hop level)

Potentially better approaches than opaque IIDs:

1. Derive IID from randomly generated MAC address;
2. Derive MAC address from random IID (that does not have any of remaining caveats Opaque IIDs)

Note on Susceptibility of Address Randomization (1)

Random IID (RID) = *F*(*secret device key*, *public parameters*), where

- *F* hard to invert;
- *F* difficult to compute without *secret key;*
- Output size *F* at least 64 bits.
- *Public parameters* = {*Prefix*, *Net_Iface*, *Network Id*}

Administrator access to *secret device key* (for device cloning) presents potential security vulnerability.

Opaque interface identifier serves as subliminal channel for leakage of keying material:

- Proper implementation of *F* cannot be detected without close examination of entire device implementation
- *F* could have been implemented so as to leak 64 bits (or more) of device-internal information, e.g., by setting $F:=E_{KM}(k) \pmod{2^{64}}$, where *k* is device-internal secret (seed random number generator, private key, etc.) and where *KM* is key escrow key
  NOTE: This is based on concepts CRYPTO 2014 paper [9]; some details omitted

Note on Susceptibility of Address Randomization (2)

How to detect subliminal channels in generation of opaque-style interface identifiers?

If generated with

- *symmetric keys*:
  Not possible to detect without close scrutiny entire device implementation
- *public keys*:
  Might be possible to detect via variant of Cryptographically Generated Addresses (RFC 3972)
  NOTE: here, larger-size IIDs (i.e., more than 64 bits [7]) help.

Conclusions & Recommendations

- It is not clear how useful RFC 7217 is in addressing privacy issues
- Any approach ignoring Layer 2 traceability aspects mostly undoes benefits
- Not necessary to logically untie Layer 2 and Layer 3 addressing, if chosen with care (thus, allowing compression using cross-layer info)
- Beware of subliminal channels…
- Subliminal channels may be thwarted by using cryptographically generated addresses (CGAs) that can be verified. This requires more work

Further Reading

1. RFC 7217, ‘A Method for Generating Semantically Opaque Interface Identifiers with IPv6 Stateless Address Autoconfiguration (SLAAC),’ April 2014.
2. RFC 3972, ‘Cryptographically Generated Addresses (CGA),’ March 2005.
3. RFC 6282, ‘Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks,’ September 2011.
4. RFC 4944, ‘Transmission of IPv6 Packets over IEEE 802.15.4 Networks,’ September 2007.
5. RFC 6775, Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LowPANs), November 2012.
6. F. Gont, A. Cooper, D. Thaler, W. Will, ‘Recommendation on Stable IPv6 Interface Identifiers,’ draft-ietf-6man-default-iids-01, October 2014.
7. B. Carpenter, T. Chown, F. Gont, S. Jiang, A. Petrescu, A. Yourtchenko, ‘Analysis of the 64-bit Boundary in IPv6 Addressing,’ draft-ietf-6man-why64-08, October 2014.
8. B. Sarikaya, F. Xia, ‘Lightweight and Secure Neighbor Discovery for Low-power and Lossy Networks", draftsarikaya-6lo-cga-nd-01, October 2014.
9. M. Bellare, K.G. Paterson, Ph. Rogaway, ‘Security of Symmetric Encryption Against Mass-Surveillance,’ CRYPTO 2014, IACR ePrint 2014-438, 2014.