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# CROSS-LAYER AIR INTERFACE OPTIMIZATION

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# TCP AND WIRELESS

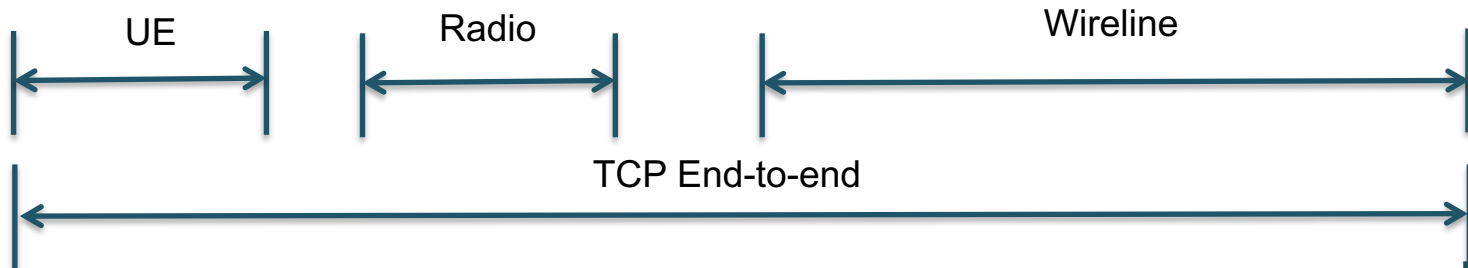
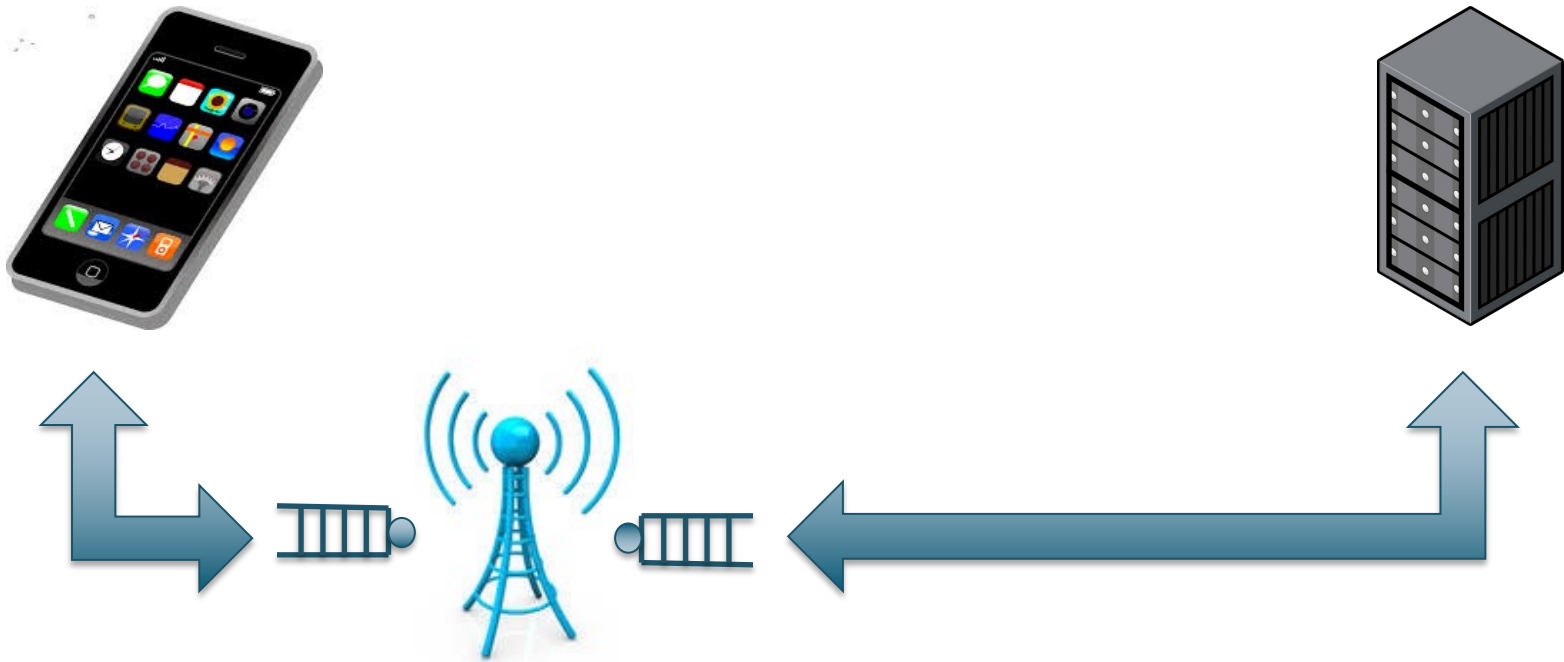
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- TCP has poor performance over wireless [1,2,3]
- Recent studies show
  - Over 71% of large flows under utilize bandwidth by 50% [4]
  - LTE links have high BW variation TCP cannot fully utilize [4]
  - HTTPS is not proxied [5]
  - Large flow split connections improve up to 45% [5]

- [1] R. Yavatkar and N. Bhagawat. 1994. Improving End-to-End Performance of TCP over Mobile Internetworks. In *Proceedings of the 1994 First Workshop on Mobile Computing Systems and Applications (WMCSA '94)*. IEEE Computer Society, Washington, DC, USA, 146-152.
- [2] Balakrishnan, Hari, et al. "A comparison of mechanisms for improving TCP performance over wireless links." *ACM SIGCOMM Computer Communication Review*. Vol. 26. No. 4. ACM, 1996.
- [3] A. Bakre and B. R. Badrinath, "I-TCP: indirect TCP for mobile hosts," *Distributed Computing Systems*, 1995., Proceedings of the 15th International Conference on, Vancouver, BC, 1995, pp. 136-143.
- [4] Huang, Junxian, et al. "An in-depth study of LTE: effect of network protocol and application behavior on performance." *ACM SIGCOMM Computer Communication Review*. Vol. 43. No. 4. ACM, 2013.
- [5] Xu, Xing, et al. "Investigating transparent web proxies in cellular networks." *Passive and Active Measurement*. Springer International Publishing, 2015.

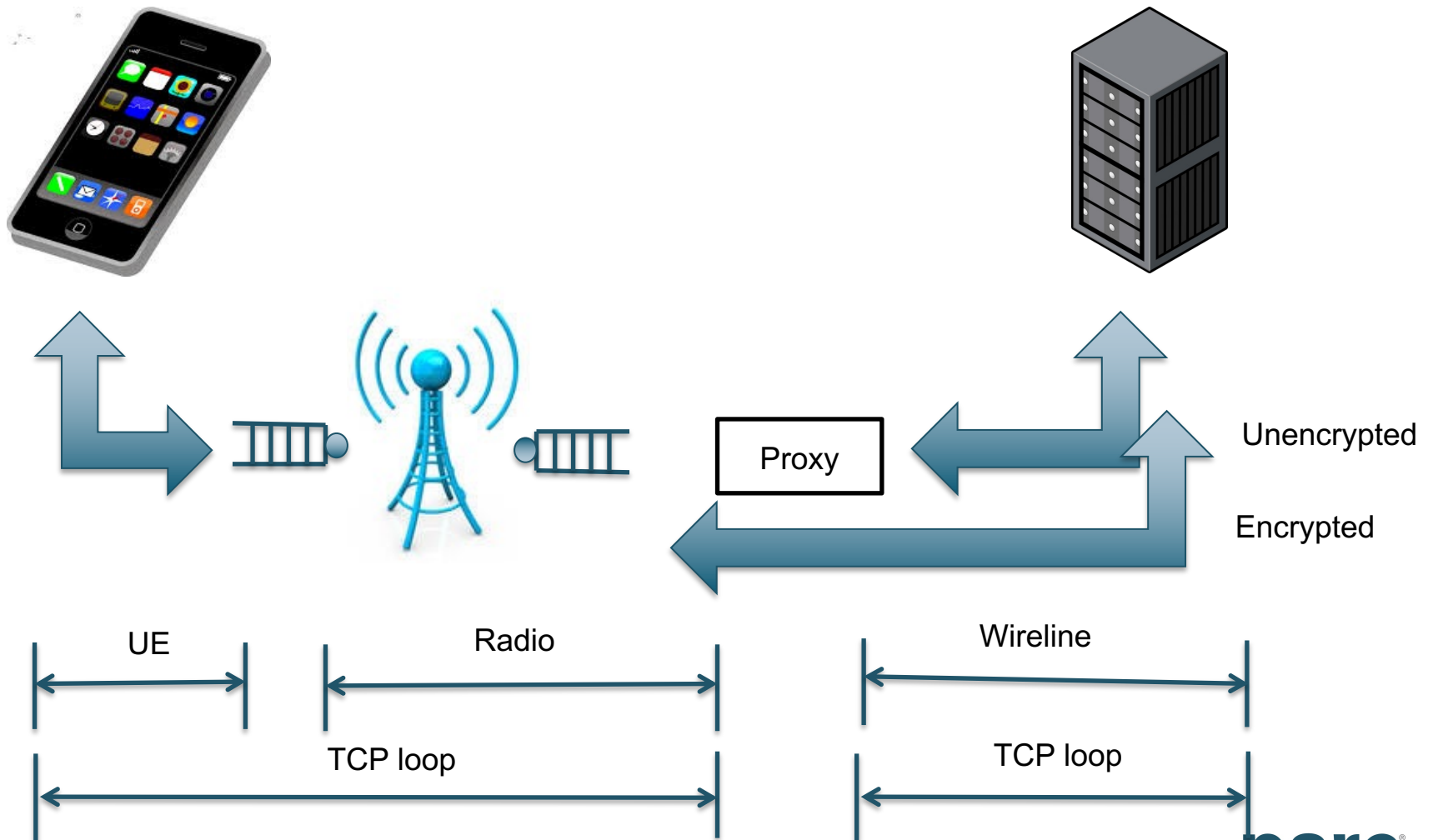
# YESTER YEAR

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# TODAY

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# STORY OF ONE PRODUCT

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- ByteMobile (Citrix) [1]

- Uses TCP proxy, optimizes TCP windows

- Citrix executive comments:

“The underlying premises for the acquisition of ByteMobile have now vanished. We acquired the company for its ability to optimize video traffic, but today a significant amount of the video traffic is encrypted and can no longer be optimized. [...] We will transition some of the capabilities in the NetScaler product but for the most part we are phasing that product line out.” [2]

[1] Citrix, “ByteMobile Virtual Adaptive Traffic Management Solution”, [https://www.citrix.com/content/dam/citrix/en\\_us/documents/products-solutions/bytemobile-virtual-adaptive-traffic-management-solution.pdf](https://www.citrix.com/content/dam/citrix/en_us/documents/products-solutions/bytemobile-virtual-adaptive-traffic-management-solution.pdf) (Viewed April 14, 2015)

[2] <http://broabandtrafficmanagement.blogspot.com/2015/11/citrix-de-invests-bytemobile-blaming.html> (Viewed April 14, 2015)

# IAB STATEMENT

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*We recommend that encryption be deployed throughout the protocol stack since there is not a single place within the stack where all kinds of communication can be protected.*

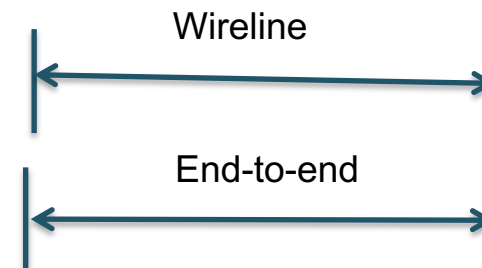
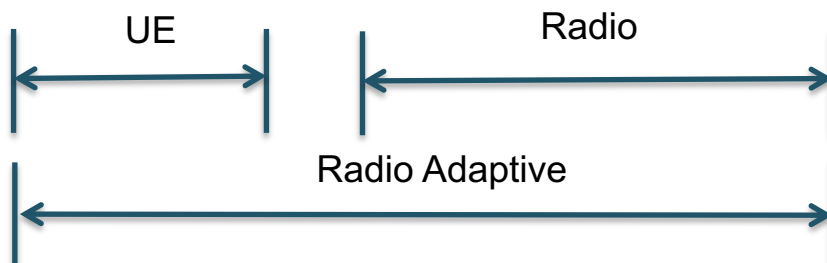
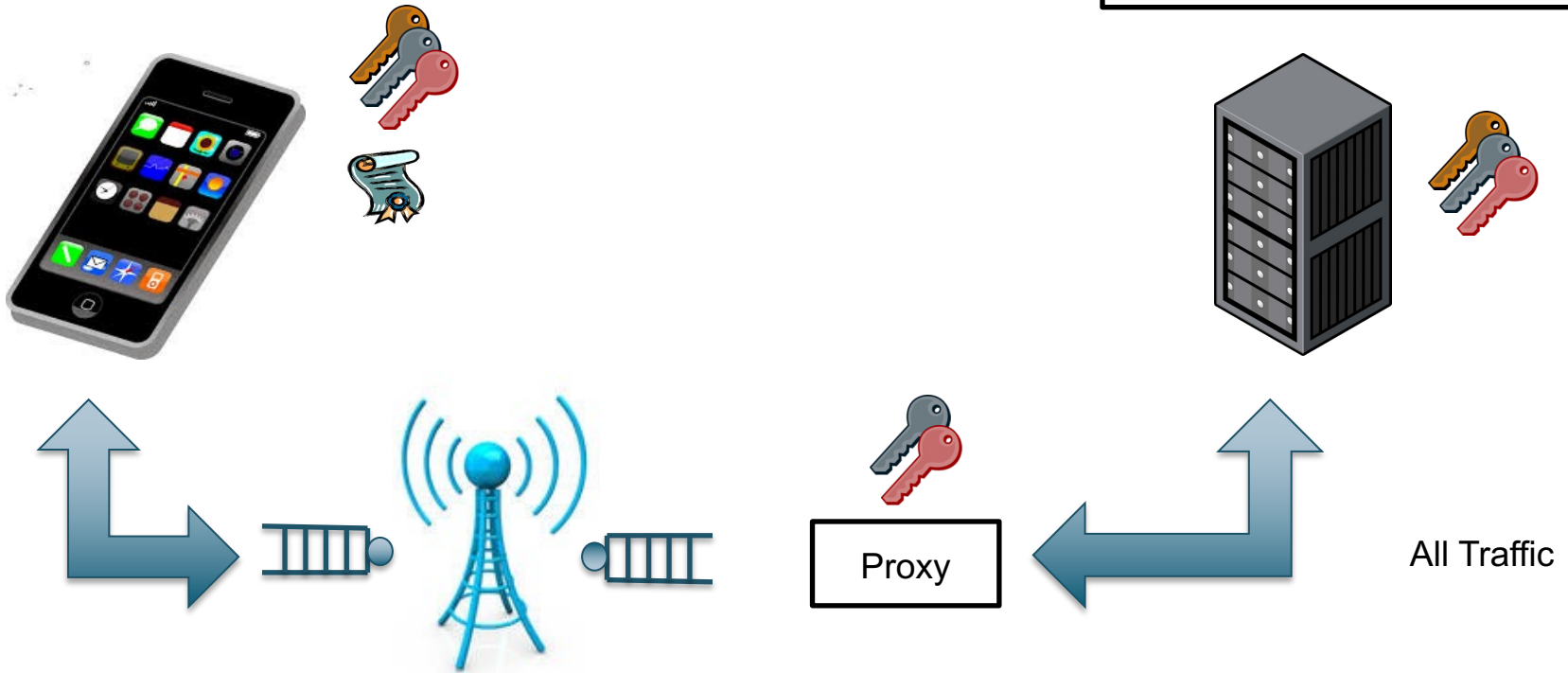
*The IAB urges protocol designers to design for confidential operation by default. We strongly encourage developers to include encryption in their implementations, and to make them encrypted by default. We similarly encourage network and service operators to deploy encryption where it is not yet deployed, and we urge firewall policy administrators to permit encrypted traffic.*

*IAB email, Nov 14, 2014*

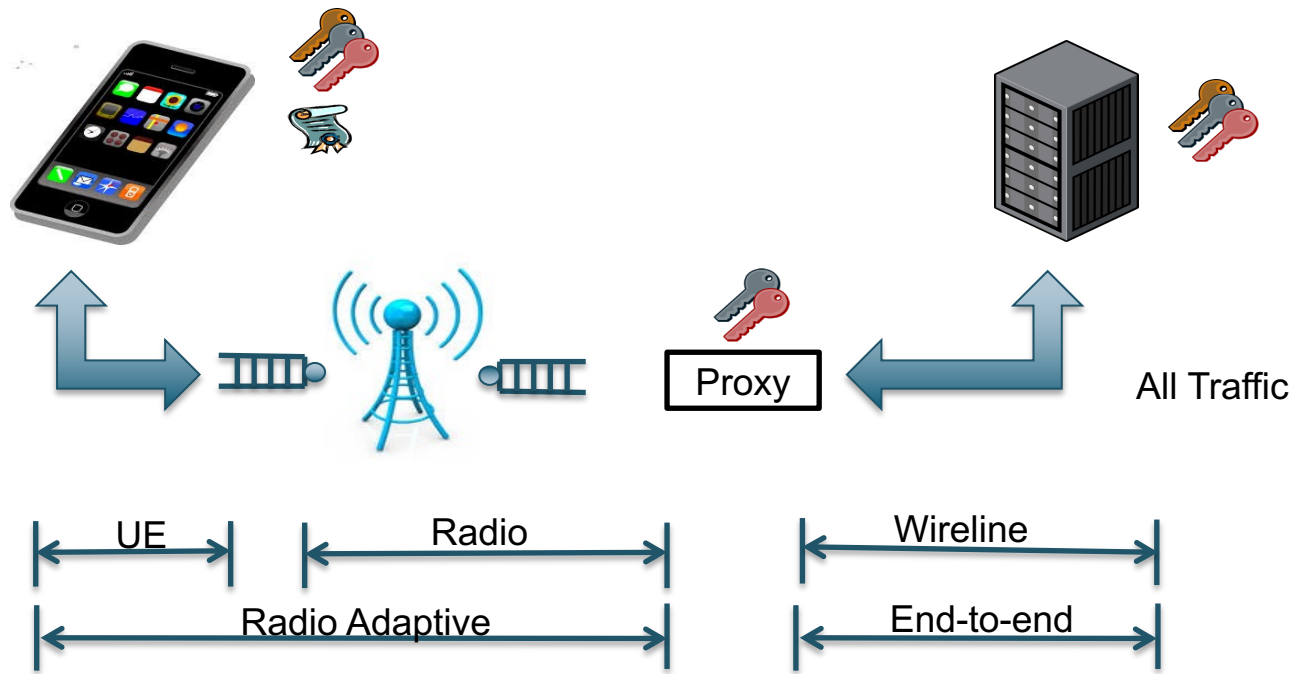
# CCNX SOLUTION



Encryption key  
Authentication key  
Signaling Key  
Data Certificate



# CCNX BENEFITS



- Proxy should give at least same performance benefit for encrypted traffic as today's unencrypted.
- Use of second “radio adaptive” transport protocol may give even better performance for than today's proxies that run TCP on both sides.



# CCNX FEATURES

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- Consumer – Proxy – Replica Key Exchange
  - Consumer-to-Replica secure key exchange.
  - Encryption key, Authentication Key, Signaling Key.
  - Consumer shares Authentication and Signaling key with Proxy (semi-trusted proxy).
  - Proxy can correctly execute encrypted end-to-end transport protocol.
  - Consumer – Proxy can use radio-adaptive transport protocol
  - Proxy only knows limited signaling information. Cannot see anything else about data.
  - Uses HTTP/2-like frame for non-blocking multiplexing.

# NEXT STEPS

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Task	Head Count	Months
Protocol Specification (RFC style)	2	1
Prototypes (one or other or both)		
- NS3 [1] CCNx over LTE	2	4
- OpenAirInterface [2] CCNx over 5G [3]	3	5-7

[1] <https://www.nsnam.org/overview/what-is-ns-3> (Viewed April 14, 2015)

[2] <http://www.openairinterface.org> (Viewed April 14, 2015)

[3] Requires CCNxKE implementation, currently in progress and not included in head count

# SUMMARY

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- TCP has performance problems with wireless
- TCP proxies do not handle encrypted traffic well
- Internet moving to more and pervasive encryption
- CCNx Encryption Proxy
  - Secure, does not need to be fully trusted by consumer.
  - CCNx object protocol ensures end-to-end integrity and authenticity even with shared Proxy keys.
  - Can execute two different transport protocols.
  - Air interface transport protocol can be radio-aware.