Reviewer Response

July 4, 2013

Dear Editors,

Please find enclosed the camera ready version of the book chapter. We have addressed these comments to the best of our ability within the time available, and have in general tried to improve the chapter in a number of ways. Perhaps most obvious is through inclusion of an example, used to illustrate some parts that reviewers found poorly explained.

We include here as well our response to the the specific reviewer comments below in blue.

Yours sincerely,

Walter Willinger and Matthew Roughan

Reviewer A

I like the message of chapter 1, and the way the authors structure it.

Page 6, at "multigraph" bullet: "it is" instead of "its".
Fixed.

Page 7: "ill-defined" or "ill defined" (check as both as valid but i like the first).
Dictionary suggests that ill-defined is best.

Page 7: When you mention the many topological metrics that have been used in the literature, maybe cite some papers that have looked at the relationship between these numerous metrics.
Added A. Jamakovic and S. Uhlig, "On the relationships between topological metrics in real-world networks". Networks and Heterogeneous Media, 3(2):345-359, June 2008 and Haddadi et al. "Network topologies: inference, modeling and generation", IEEE Communications Surveys 2008

Page 8: You may want to cite and refer to the iGen topology generator that tries to provide a set of network design heuristics to be played with. Also on page 44. (http://informatique.umons.ac.be/networks/igen/)
Reference added in the list of tools, and in Section 5.1 with some discussion.

Page 8, Adversarial bullet: "is not well known".
Fixed.

Page 8, Adversarial bullet: It is not as bad as stated. ISPs simply have no incentives to share or publish this information.
We have refocussed this text to concentrate on the attacker, rather than the question of what an ISP is willing to reveal.

Page 9, Informational bullet: Do you have any reference in this area? This sounds like an opinion without much behind to back it up.
This category is really a catch all of motivations that don't fit into the previous classes, but calling it "other" seems a little lame. Certainly, there are non-adversaries, from outside a network that have used traceroute to inform themselves of a networks topology, without any scientific goal in mind. We'd be happy to call it something else if that was a concern.

Page 9, in figure 1: Comparative instead of comparitive.
Fixed.

Page 10, check 2nd sentence after figure 2, seems broken.
Fixed.

Page 10, second half: These bullet points are not well structured, please have a check on the flow.
Rewritten.

Page 12: "a links lower layer properties" (link's)
Fixed.

Page 17: I think providing some references to current hardware switching fabrics capabilities would add weight to your claims. Unless one knows high-router hardware, what you say is hard to be convinced of.
Have added three references to recent hardware descriptions.

Page 22, fact 4: Not sure you want to argue about how wrong there are since the evidence is too weak anyway. There is no substance, period

We have reworded the statement with respect to "current traceroutes", but this is a very well justified point, supported both within the text, and in the many citations provided.

Page 26, last paragraph just after reference to Figure 10, remove a space. Also 2 consecutive instances of "are".

Fixed.

Page 30, first sentence of 3.4: is "90ies" correct?

Changed to be less informal.

Page 35: given that you refer quite often to what might be realistic routing policies (on page 35, 37 and 40) as well as the granularity at which ASes make decisions, you should probably cite the following work as well: - Wolfgang Mhlbauer, Steve Uhlig, Bingjie Fu, Mickael Meulle, Olaf Maennel: In search for an appropriate granularity to model routing policies. SIGCOMM 2007.

Reference added.

Page 46: Related to the pancake view is the locations of PoPs and how these relate to the AS topology. Maybe mention IP geolocation and its inaccuracy here although it does not help. At least that would point to the challenges of building a geographic map of the Internet.

IP geolocation opens another can of worms, and a clear, and competant discussion of this would extend the work considerably. We have simply added a side note, and a reference to Poese et al, "IP geolocation databases: unreliable?", which considers some of these issues.

Reviewer B

I really enjoyed reading this chapter. It's a nice glance back to (nearly) 15 years of researches (and errors) in network topology discovery. In particular, Sec. 3 is a (perfect) example of how measurements (and limits associated to measurement tools) can lead to wrong conclusions (and how those wrong conclusions can lead to 10 years of intense researches).

Although this chapter does not aim at being an exhaustive survey on techniques/properties of Internet topologies, I would suggest authors to add a few references. In particular, in Sec. 1 where I would appreciate a "Notes" section (as in the fashion of Sec. 3.5, for instance) in which authors would list a bunch of additional references. This is particularly interesting for those who would like to investigate other levels of Internet topology (physical, applicative,). Such a "Notes" section would also be interesting at the end of Sec. 2. Even though this chapter is not purely a survey, it has the potential to redirect (interested) readers towards additional papers.

Notes subsections in Sections 1 and 2 didn't work well when we tried it, as much of the material is either introduction, or "primer" type material of the sort found in any graph theory text, but included here to make the chapter self-contained and ensure that notation is consistently defined. Moreover, the obvious way to "read more" is to continue with the chapter, which deals with many of the issues in more detail.

References added, specifically those mentioned below and Aman Shaikh and Albert Greenberg, "Experience in Black-box OSPF Measurement", and Anja Feldmann and Albert Greenberg and Carsten Lund and Nick Reingold and Jennifer Rexford "NetScope: Traffic engineering for IP networks".

In Sec. 2.3. (Types of Networks), authors give a (brief) explanations of various Internet topology levels. I'm not really convinced by the way authors describe the router-level. Authors write that router-level is also known as "IP-level". For me, this statement is a (perfect) example of the vocabulary complexity of this research field. To me, the IP-level refers to the topology directly collected through traceroute probes (i.e., IP interfaces of routers). I believe that considering IP interfaces is a useful measure. "Interfaces are individual devices, with their own individual processors, memory, buses, and failure modes. It is reasonable to view them as nodes with their own connections." (in. "Internet Topology: Connectivity of IP Graphs", by Broido and Claffy, Proc. Internet Symposium on Convergence of IT and Communication, 2001). Rather, the router-level clearly refers to the level obtained when data obtained through traceroutes has been post processed through alias resolution. These are (to me) two separate levels. Note also that router-level information may also be collected through other ways than traceroute + alias resolution: IGMP Probing (cfr. "Quantifying ASes Multi-connectivity using Multicast Information", by Mrindol et al. IMC 2009). IGMP probing here has the advantage that a single probe allows one to collect all interfaces of routers and how those interfaces are connected through routers. However, this is not as perfect as my definition suggest: this is mostly limited to multicast (although you may discover purely unicast interfaces) and subject to filterin g (Marchetta et al. "Quantifying and Mitigating IGMP Filtering in Topology Discovery". In Proc. IEEE GLOBECOM 2012.)

Clarified the terminology WRT to IP- or router-level in Section 2.3.

Have also added a comment about IGMP measurement at the end of Section 3.2.

Again in Sec. 2.3. (Types of Networks), regarding the Switch-Level, I would add that L2 devices allows one to provide redundancies in the network at a reasonable cost (usually, L2 devices are cheaper than routers). I would also add that L2 devices and upper layers interact in such a way that it can lead to misunderstanding. The node degree distribution (as a power-law) is an example of that. Logical links discover through traceroutes may, actually, hide a (or more) L2 device connecting L3 devices (see Mrindol et al. "On the Impact of Layer-2 on Node Degree Distribution" Proc. IMC 2010).

Added comment about adding L2 devices, a reference to the paper, and a forward pointer to some of the layer-2 confusion in the following section.

Last for Sec. 2.3. (Types of Networks), I know the listing of types of networks is not exhaustive but I would also mention the "Subnet level". See "TraceNET: an Internet Topology Data Collecter" (IMC 2010), "Estimating Network Layer Subnet Characteristics via Statistical Sampling" (Networking 2012), and "Inferring Subnets in Router-Level Topology Collection Studies" (IMC 2007).

Subnet level included in router-level description as part of disambiguating IP-level as a term. References included.

In Sec. 3.2.3. (An in-depth look @ Traceroute), authors mention "Opaque L2 clouds". I would be careful with the word "Opaque" regarding MPLS. As authors mentioned, there is a recent in-depth study (IMC 2011) that discusses MPLS. Since RFC4950, it becomes easy to identify MPLS tunnels. Another paper (CCR 2012) clearly shows that opaque tunnels are not really frequent (according to CCR 2012, they are more the exception than the rule).

Included more detailed discussion, including references. However, the question of opacity is not really about how common the issue is, so much as understanding that is (and many other problems can occur), and how the data is and has been delt with when it occurs.

Sec. 3.2.3 (an in-depth look @ traceroute), Lesson 2. I would also put in perspective this lesson with the (already mentioned in this review) IMC 2010 paper that looks at node degree distribution and L2 devices (and, in particular, how high-degree nodes may be due to L2 devices linking several routers together). I would did the same for Fact 2 in Sec. 3.2.4 (just the facts). However, I agree with authors when saying that high-degree nodes may be (also) due to MPLS (but be careful with the word "opaque" – cfr. CCR 2012).

Lesson 2 has been briefly expanded to bring in the issue of L2 devices as well, and to include the citation.

In Sec. 4, authors mention the fact that, regarding AS level topology, it is not easy to determine, for a given router, which interface belongs to which AS (for border routers) and, therefore, to which AS belongs the router. It may be worth mentioning efforts done towards assigning a (border) router to an AS. See PAM 2010 (two papers: "Extracting Intra-Domain Topology from mrinfo Probing" and "Towards Topology Dualism: Improving the Accuracy of AS Annotations for Routers").

References added with a brief explanation in 4.2.1.

Here are a few typos/English mistakes I found:

- page 6: "However, a exemplary" => "However, an exemplary"
- page 6: "e.g. it's easy" => "e.g., it's easy"
- page 7: "clustering coefficient, centrality and so on." => "clustering coefficient, centrality, and so on".
- page 10: "other networks (e.g. the SS7 network)" => "other networks (e.g., the SS7 network)"
- page 11: "requires an understanding the IP (router) " => "requires an understanding of the IP (router) "
- page 13: "the physical connectivity among the those nodes." => "the physical connectivity among those nodes."
- page 40: "this graph should really a hypergraph." => "this graphs should be really a hypergraph."
- page 43: "the PoP level is the more interesting level" => "the PoP level is the most interesting level" (maybe, authors sentence here is correct – if so, please, forgive my lack of English grammar knowledge).

- page 44: "such errors are much lees frequent" => "such errors are much less frequent"

  All fixed.

Additional minor comments:

- page 20: "traceroute to map a network that uses MPLS is depicted in Figure 3b" => bad figure reference (I think this should be Fig. 8b).

  Fixed.

- page 20, in the caption of Fig. 8: "deployment of MPLS (reproduced from ???)" => the reference is missing.

  Fixed.

- try to be consistent in the way you write your bibliography. For the same kind of item (let say conference proceedings, you have different types of entries in your chapter). I would suggest the following: * for proceedings: authors. title. In Proc. conference name (conference acronym). Month Year. It is not required (at least to me) to have the country + city * for journal/magazine: authors. title. In journal name. (volume)issue, pp. pages. Month Year. Anyway, the most important is to be as consistent as possible throughout your references Section.

  The format of the references is determined by the style file, which can be changed by Sigcomm when finalising the chapters to be consistent. However, we have attempted to make sure that the names of conferences and journals are consistent across all references.