

10 Networking Papers: A Blast from the Past

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So it is my turn to recommend a reading list of 10 networking papers. I decided to take this opportunity to recommend papers from the networking area's past. I have several reasons for focusing on such a list. First, as a relatively young discipline that has seen tremendous growth in recent activities and contributions, our present tends to overwhelm our past in sheer volume. So our past can fade away unceremoniously sometimes. To be sure we are all very familiar of certain milestone papers. By definition, however, significant milestones do not occur frequently enough for them to provide an accurate sampling of our past. Second, reading older papers can be quite fascinating. One is often left in awe of the amount of insight and ideas generated by researchers arriving early into an open field of research. Also the research style and context has a strange look and feel to it, reflecting a marked evolution in community research expectations. Finally, I find that reading older papers can give an important fresh perspective on how we read and evaluate more modern literature; especially when trying to judge longevity of contributions.

My list consists of papers primarily from the period between 1975 and 1984; mostly because this is the period during which I personally arrived into the networking scene. I could not resist including one paper from 1962, simply to make the point that my "past" has its own past. Papers were included in the list for many reasons. Some papers are on the list because they describe what I consider to be a milestone contribution, others are on the list to make a point about how sophisticated networking research was at that point in time. Still others were included because they are good representatives of research styles or periods. Some papers possess many of these elements simultaneously.

In the tradition of this column, this is a highly personal list and I made no attempt to be complete in any way. In many instances, the full effect can only be had by reading "around" my list – looking up references or related material in prior or subsequent writings.

So here is my list in chronological order:

- "*Routing Procedures in Communications Networks-Part I: Random Procedures and Part II: Directory Procedures*" [12, 13]. This body of work¹ by Prosser written over 45 years ago (!) is quite fascinating. The papers ask the now classic question of how to best route messages in a communication network, except that in 1962 it was not a classic question yet. Prosser poses the question for military communication networks. This was clearly his motivation. What is interesting though is what distinguished military networks from civilian networks in his mind was that in a civilian network "each station has access to complete and correct information about the system and routes messages on the basis of this information". It is interesting to see how our view of such networks has changed dramatically over the years. As with any work that manages to ask an important and deep question early, the paper contains a wealth of ideas about how to do routing which we continue to investigate today. For example, a quick search on "Random Routing" shows proposals for its use in settings including Mobile Ad-Hoc Networks, Optical WDM networks, and processor interconnection networks.
- "*Packet Switching in a Multiaccess Broadcast Channel: Performance Evaluation*" [8]. I remember falling in love with this paper when I read it. I had always heard and read handwaving arguments about the instability of ALOHA but I could never get an exact answer about why that was the case. Reading this paper was like a revelation. While the math is rather straightforward (at least by today's standards), the analysis produces tremendous insight. In the best tradition of the day, the authors published a follow up paper describing control procedures to deal with ALOHA's instability [10].
- "*The Organization of Computer Resources into a Packet Radio Network*" [7]. My students are often surprised to know that research into mobile and wireless data networking is almost as old as work on the ARPAnet

¹The paper was submitted in September 1962 and published in December 1962 – those were the days!

itself. This paper overviews the motivation and architecture of Packet Radio Networks (really MANETs by another name). I include it here as a representative of this body of work that pre-dates the current interest in such networks and as a pointer to a wealth of early work in this area. The sophistication and ambition of this effort are readily illustrated by the stated goals enumerated in the introduction.

- “*An Optimal Adaptive Scheme for Multiple Access Broadcast Communication*” [9]. This paper, which won the best paper award at the IEEE ICC in 1978, describes the Urn multiple access protocol. The protocol manages to optimally adapt to the network load over a range from TDMA to slotted Aloha. I have always found the idea behind this protocol and its analogy to pulling balls out of an urn to be quite interesting. The paper is an excellent representative of the significant energy that was devoted to designing and understanding Multiple Access Protocols at the time.
- “*Reverse Path Forwarding of Broadcast Packets*” [5]. This is perhaps the most well-known paper out of my list, certainly to anyone that has worked on multicasting. The paper’s intended purpose is to introduce the reverse path forwarding (RPF) technique, an ingenious compromise between highly inefficient but easy to implement flooding and optimally-efficient but cumbersome spanning tree routing. RPF would go on to form the basis of subsequent Internet multicast routing proposals (see e.g. [6]). I am recommending this paper, however, because in the process of describing benchmarks against which one should compare the RPF technique, it manages to pretty much cover the entire spectrum of multicast routing ideas that would then occupy researchers for the next 20 years.
- “*On the Statistical Analysis of Queue Lengths and Waiting Times for Statistical Multiplexers with ARQ Retransmission Schemes*”[15]. I chose this paper because to me it is the quintessential paper of a genre that was very popular in the late 70s but is increasingly rare nowadays. The paper presents a careful model and a highly accessible analysis of ARQ schemes. The results provide interesting insights and the technique is artful. You will have to read it yourself to find out what a “slacket” is. A close contender for this paper slot was another extremely well-done piece of work analyzing the HDLC protocol[4].
- “*Internetwork Protocol Approaches*”[11]. I include this paper in my list for two reasons. First, I wanted to include one paper from the classic April 1980 IEEE Transactions on Communications special issue on Computer Network Architectures and Protocols edited by Paul Green. The 23 articles in this special issue provide an almost complete snapshot of the state of networking at the time. Second, it is interesting to read this paper as it presents a balanced exposition of two predominant interconnection strategies – complete with hand-drawn pictures, presumably by Jon Postel himself. With increased interest in clean-slate approaches to networking it is important to be reminded of the X.25/X.75 interconnection approach. It is also quite interesting from a historical perspective to see how the two approaches were never discussed in the paper as competing and there is never any attempt to show the X.25/X.75 approach in an inferior light.
- “*Videotex Networks*”[2]. We often associate the success of the services provided by the Internet with the success of the Internet itself. But what kind of digital services would we have had without the Internet. This is an impossible question to answer but this paper gives us a clue. It documents the world of Videotex Networks which are envisioned as “utilities [that] will offer a variety of information services and transactions, such as retrieval from multiple independent data bases, messaging, electronic mail, conferencing, banking, teleshopping, and interest matching.” All of this in 1980! The paper describes system architectures, trials of systems and services, all in the context of data networking technology existing at the time. The videotex bubble would burst almost a decade later (but before the invention of the web) for business and economic reasons. It would leave its mark in some systems such as France’s minitel.
- “*Why a Ring?*”[14]. This paper was written at a time when Local Area Network technology was a hot topic. One of the important debates was whether bus networks (using protocols like Ethernet) or ring networks (using protocols like the token ring protocol) would prevail. This paper provides an exquisite summary of the debate and concludes that “both approaches have arguments in their favor.” We clearly know who the winner was – actually neither. The hubbed and switched Ethernet of today shares little with the broadcast bus networks of 1981. In fact one can argue that the idea of using hubs first came up in central wiring techniques proposed to address ring reliability and maintenance problems as discussed in the first part of this paper.
- “*Datagram Routing for Internet Multicasting*”[1]. As far as I can tell this paper presents the first ever concrete proposal for deploying multicast communication in IP networks. The idea is based on the use of multi-destination addressing²: each packet carried a list of destinations in its options field and unicast routing tables were used to route the packet to its multiple destinations. I have to yet hear a satisfactory answer to why this idea was not picked up and deployed. The standard answer is that the scheme did not scale to beyond 8 or 9 receivers. But the Internet was not that large in 1984 and a scheme that would allow an order of magnitude savings of bandwidth should have been welcome any way. The mystery continues. The multidestination addressing idea would be resurrected some 15 years later in efforts on Small Group (a.k.a. explicit) Multicast [3].

I hope you find this list useful as a guide to exploring those years in the networking research community’s past. I would like to encourage others to contribute their own lists to CCR exploring the same or other periods in the networking community’s short but eventful history.

²You guessed it, also described in the 1978 Dalal and Metcalfe paper listed above.

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