Anecdotes

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Developing Telnet's negotiated options

Telnet, for years a key Internet protocol,[1] was developed as part of Arpanet,[2] the precursor of the Internet. Telnet is still in wide use and seems likely to survive indefinitely.[3] Because Telnet is primarily documented by a specification, much of the detail about who authored various bits of Telnet is undocumented. We are writing this description of our involvement in creating Telnet's negotiated options before our memories become so dim we can't remember our involvement at all.

Our situation

In 1972, we were involved with the support and ongoing development of the Arpanet Terminal Interface Message Processor (TIP).[4] The TIP was an Arpanet IMP (the packet switches that made up the Arpanet communications backbone[5]) that also could communicate with numerous local or dial-up terminals. TIPs were scattered throughout the geographical expanse of the Arpanet providing access to either nearby or remote time-sharing systems. Thus, the TIP included an implementation of the Telnet protocol and Network Virtual Terminal (NVT) implementation that let the terminals connected to it (mostly simple, character-at-a-time, ASCII devices) communicate with various time-sharing systems around the network, independent of whatever type of physical terminals those time-sharing systems supported.

Because many people were connected by TIPs to many different kinds of time-sharing systems, we found ourselves highly affected by the ongoing refinement of Telnet's specification and NVT's definition.

Our solution

We had a breakthrough one day, which we called *Telnet negotiated options*. The details of negotiated options were worked out on the plane while we were flying out to the University of California, Los Angeles, for a meeting with other Arpanet developers. The problem we were chatting about was how to make the Telnet protocol uncooperatively extensible—that is, how we could let the protocol change and evolve without requiring dozens of Telnet implementations to change every time some new feature was added. In other words, the issues were how to make the protocol extensible and make it work asynchronously and symmetrically (no master or slave).

One of us (Bernard Cosell) suggested and developed the basic ideas as we talked, while the other of us (Walden) asked about how to deal with various cases and nodded agreement as he began to understand what Cosell was saying.

Cosell remembers the conversation went like this:

> The obvious thing to do was a negotiation.
>
> But there were problems if both sides started negotiating and their requests (and refusals/acceptances) crossed in the pipe. Suppose the computer at which the user is sitting at a terminal and the computer that the user is accessing across the network attempted to agree which computer will echo the characters the user types. Negotiations like the following had to be avoided:
>
> > At about the same time, one system sends "Hey would you please do echoing for me," while the other system sends, "Please do local echoing." The two requests pass like ships in the night.
> >
> > Both systems are flexible, so the first system responds "Okay, I'll echo," while the second also responds, "Okay, I'll echo for you," with the messages again passing each other.
> >
> > And so, still trying to be cooperative, both systems switch their echo modes, "If you insist, I'll shut off echoes and let you echo," passing "If you insist, that's fine by me, I'll let you echo."
>
> And so on.
>
> Also, the right thing would have to happen for an implementation that didn't know anything about the option that appeared so one could implement a computer's protocol handler to understand specific items and safely ignore everything else.
>
> I remember waving my hands, scribbling a few partial examples on a cocktail napkin, and asserting that the protocol I was proposing couldn't possibly "oscillate." The negotiation would always quietly terminate and not go on and on, no matter how confused the two ends got.

At the UCLA meeting, Cosell used a blackboard and his waving hands to describe his idea for negotiated options to the assembled group.

His basic idea started with four commands: DO, DON'T, WILL, and WON'T. However, numerous capabilities exist besides computer echoes that needed to be agreed on between the two computers, depending on what each computer is capable of doing and what is desirable to the user given the computers' capabilities (for instance, whether line-at-a-time or character-at-a-time input is supported). Rather than having a separate set of negotiation commands for each optional Telnet capability, Cosell's solution involved using his four commands as prefixes followed by an option code:[6]

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WILL (option code)
  Indicates the desire to begin
  performing, or confirmation that
  you are now performing, the
  indicated option.
WON'T (option code)
  Indicates the refusal to per-
  form, or continue performing,
  the indicated option.
DO (option code)
  Indicates the request that the
  other party perform, or confirma-
  tion that you are expecting the
  other party to perform, the indi-
  cated option.
DON'T (option code)
  Indicates the demand that the
  other party stop performing, or
  confirmation that you are no
  longer expecting the other party
  to perform, the indicated option.
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Thus, with regard to which computer echoes characters, one or more of the following commands might be used:

```
WILL Echo
WON'T Echo
DO Echo
DON'T Echo
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The purpose of this historical account is not to provide a comprehensive tutorial on how the DO/DON'T/WILL/WON'T prefixes work to negotiate the options specified following the prefixes. Curious readers can read further.[1,7,8]

Diffusing the solution

Walden came out of the meeting at UCLA with the task of writing it all down, and Cosell was to proofread the write-up to make sure that the protocol closed properly. Cosell remembers that even at the meeting the details of DO/DON'T/WILL/WON'T weren't made clear:

> I was content that it was all okay, but it seemed too complicated to bother with trying to explain in detail. The RFC was the first place (other than in the airplane, if you count hand waving) that the whole thing was pinned down.

Upon arrival back at Bolt Beranek and Newman Inc. (BBN), we immediately went to find Jerry Burchfiel and Ray Tomlinson. Burchfiel and Tomlinson had been key members of the BBN team that developed the TENEX time-sharing system,[9] and TENEX systems had been or were being installed at numerous Arpanet sites. (There were probably more TENEXs on the Arpanet at that time than any other single kind of computer system.) Among other things, Tominlson was responsible for Telnet on TENEX, and because he was in effect supporting many instances of the system, he had the same problem we had with the TIP.

Burchfiel and Tominlson could usually be found several times a day having coffee in the BBN cafeteria and discussing their various technical projects. That's where we found them to describe Cosell's idea. They quickly understood and agreed that it looked good.

Over the next little bit of time, Walden drafted a written description of negotiated options, had it reviewed by Cosell (and probably Burchfiel and Tomlinson and possibly others), and published the description in a technical report.[7]

At the time, the Telnet specification was also being drafted (or perhaps an earlier draft was being revised). In any case, Walden also looked at the non-negotiated versions of several existing basic Telnet options and rewrote them in terms of negotiated options. He also added a few Telnet options to the negotiated options list. He remembers doing this writing on one weekend when he and his wife were babysitting for his sister-in-law's children in a suburb outside of Boston. He had taken his SCM portable electric typewriter and plenty of white-out correction tape along to where he was babysitting and drafted this rather major update to the Telnet specification essentially in one sitting. He mailed it to the person editing the Telnet specification (Jon Postel, perhaps) early the next week.[10]

There was immediate general acceptance of the negotiated options concept, and it was implemented relatively soon throughout Arpanet's host computers.

A few years later, the history and status of Telnet until then, including negotiated options, was documented in a multiauthor paper[8] (which Walden initiated and pulled together primarily with the help of Bob Thomas of BBN).

References and notes

1. J. Postel and J. Reynolds, *Telnet Protocol Specication*, RFC 854, Network Working Group, May 1983.
2. L. Roberts and B. Wessler, "Computer Network Development to Achieve Resource Sharing," *AFIPS Conf. Proc.*, vol. 36, AFIPS Press, 1970, pp. 543-549.
3. Historically, computers from different manufacturers, had proprietary operating systems, perhaps used a proprietary character set, and communicated with users at terminals in different ways (for example, line-at-a-time local echo or character-at-a-time remote echo). Before PCs, many computers were time shared, where simultaneous users sat at slow, directly-connected ter-

minals (for example, via 10 characters-a-second phone lines or direct copper wire). Before Arpanet, most computer networks were dedicated to a specific application. In 1969, Arpanet was developed as a "common user network," supporting intercommunication between any user and any application on any computer from any terminal. The Arpanet Telnet protocol included a Network Virtual Terminal (NVT), a hypothetical terminal with a standard set of characteristics (see references 1 and 8). Every computer and operating system was to translate between its native terminal type and the NVT, enabling every computer and operating system to communicate with every kind of user terminal.

4. S.M. Ornstein et al., "Terminal IMP for the ARPA Computer Network," *AFIPS Conf. Proc.*, vol. 40, AFIPS Press, 1972, pp. 243-254.
5. F.E. Heart et al., "The Interface Message Processor for the ARPA Computer Network," *AFIPS Conf. Proc.*, vol. 36, AFIPS Press, 1970, pp. 551-567,
6. In the list of the four prefixes, "you" means the computer executing the WILL or WON'T command regarding the particular option. "Other party" means the other computer is being told to DO or DON'T execute the option. (The wording used in the example comes from reference 1.)
7. B. Cosell and D. Walden, *Telnet Issues*, RFC 435, Network Working Group, 5 Jan. 1973.
8. J. Davidson, W. Hathaway, N. Mimno, J. Postel, R. Thomas, and D. Walden, "The Arpanet Telnet Protocol: Its Purpose, Principles, Implementation, and Impact on Host Operating System Design," *Proc. ACM/IEEE 5th Data Communications Symp.*, 1977, IEEE CS Press, pp. 4-10-4-18.
9. D.G. Bobrow et al., "TENEX: A Paged Time Sharing System for the PDP-10," *Proc. 3rd Symp. Operating System Principles*, 1971, ACM Press, pp. 1-10.
10. Alex McKenzie says Walden also had help with these options from Cosell, Tomlinson, Bob Thomas, Burchfiel, and Dave Crocker (see A. McKenzie, *Telnet Protocol Specication*, tech. report RFC 495, Network Working Group, May 1973). Walden does not remember if he ever lived up to the promise to document more options that McKenzie reported in the RFC.

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