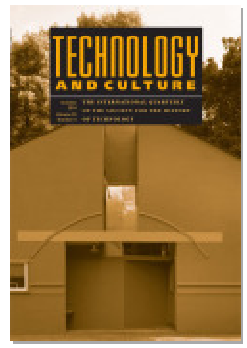
In the Shadow of ARPANET and Internet: Louis Pouzin and the Cyclades Network in the 1970s



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In the Shadow of ARPANET and Internet

Louis Pouzin and the Cyclades Network in the 1970s

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> *Louis Pouzin is best known for his work as the inventor and advocate of "Datagrams," later extended and renamed connectionless communication, as the basic mode for the transmission of packets in a network. . . . Louis was a strong focal point for cooperation between research and industry, between Europe and North America, and between the computer community, the datacom community and the more traditional telecommunications community.*[1]
>
> **—Association for Computing Machinery SIGCOMM Award, 1997**

Introduction

An article in *Le Monde* of 5August 2006, titled "Louis Pouzin, the Man Who Did Not Invent the Internet," described the engineer who led the Cyclades network in the 1970s as a pioneer in packet-switching research. Pouzin's accomplishments had already been recognized in a more institutional way when he was awarded the Association for Computing Machinery's SIGCOMM Award in 1997 and the French Legion of Honor in 2003.[2]

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1. Association for Computing Machinery, "Postel and Pouzin: 1997 SIGCOMM Award Winners."

2. Ibid.; Annales des Mines, "Louis Henri POUZIN."

More recently, Pouzin was one of five men to win the first Queen Elizabeth Prize for Engineering, in 2013, sharing the one-million-pound prize with Vinton Cerf and Robert Kahn (inventors of the Internet's Transmission Control Protocol), Sir Tim Berners-Lee (inventor of the World Wide Web), and Marc Andreessen (author of the Mosaic Web browser).[3]

Each of these accolades was visible only through the filter of the Internet—something that, as *Le Monde* noted correctly, Pouzin did not invent. Thus Pouzin's career presents something of a puzzle: Can it only be judged by his role in the "invention" of the Internet? Or is there a way to appreciate his work on its own terms?

By posing these questions, we build on the argument put forth by Martin Campbell-Kelly and Daniel D. Garcia-Swartz: "Most of the current crop of histories of the Internet can be characterized as 'teleologies' or 'Whig history,'" insofar as they seek simplistic explanations to draw a line from the ARPANET (Advanced Research Projects Agency Network) to the Internet.[4] Indeed, Internet history (or rather networking history, which is a more inclusive term that we prefer) is not a linear success story that starts with the ARPANET and ends with the Internet. Developments in data networking that took place outside the United States or that did not contribute neatly to the narrative of the Internet's success should not remain overlooked and misunderstood.

With these historiographic convictions in mind, this article examines research conducted in France in the Cyclades project, sponsored by IRIA (Institut de recherche en informatique et automatique [Institute for Research in Computer Science and Control]) and led by French computer scientist Louis Pouzin. Our intention is to revive the "horizons of expectation" and "field of experiences" of network architects and engineers, to bring back to life their motivations and hesitations, and to unravel the technical and political complexities of their relationships with other historical actors.[5] In other words, we seek not to judge them teleologically in the shadow of the Internet's "success," but to understand them as products of their own distinctive circumstances.

The first section describes the political and economic forces that led French bureaucrats and computer experts to explore the American ARPANET and to create an indigenous computer networking research project that they named Cyclades. The second section introduces the Cyclades leader, Louis Pouzin, who recruited a cohesive team and nurtured a style of collaborative research that attracted the attention, envy, and criticism of outside observers. The third section shows how Pouzin and his team culti-

3. Queen Elizabeth Prize for Engineering.

4. Martin Campbell-Kelly and Daniel D. Garcia-Swartz, "The History of the Internet: The Missing Narratives," 18–33; Andrew L. Russell, "Histories of Networking vs. the History of the Internet."

5. Reinhart Kosselleck, "Champ d'expérience et horizon d'attente," 307–30.

vated technical and personal links to the ARPANET—a relationship that facilitated the mutual exchange of ideas about packet switching. The final section explores the conflicts between the Cyclades team and the team of engineers who worked for the French monopoly telecommunications administration.

Pouzin eventually won global recognition for his contributions to networking, but his preference for "datagrams" was controversial in France in the 1970s. The problem: Pouzin's datagram design was at odds with the "virtual circuits" design favored by the engineers in the powerful French telecommunications monopoly.[6] The "virtual circuits" prevailed in France, and funding for Pouzin's Cyclades project was cut in 1978—but not before the Americans Cerf and Kahn adopted Pouzin's ideas and made datagrams one of the most important and distinctive characteristics of the Internet.

Toward a French Research Network

THE CONTEXT OF THE PLAN CALCUL

In the middle of the 1960s, French political and technological leaders were aware of the strategic challenges of computing in general, and of the French technological gap with the United States in particular. French anxiety had been heightened by events such as the Bull Affair, which saw the merger of Bull, the French computer manufacturer, with General Electric in 1964. National anxieties were further stoked by the American refusal to supply France with the large computers it needed to develop a nuclear bomb.[7] In this era, computers were no longer seen only as calculators, but also as machines to process and even to communicate information. Therefore the computer was more and more regarded as a political instrument—as a way to achieve particular economic and ideological goals for the Republic.[8]

In 1966, French president Charles de Gaulle launched Plan Calcul to support the French computer industry and computer science research in the face of a fear of American leadership in the field.[9] The motivation was to give France a computer industry worthy of its name with the creation of the CII (Compagnie Internationale pour l'Informatique)—a particularly urgent task after the 1964 Bull Affair. Another aspect of Plan Calcul was an institutional innovation, the creation of the IRIA (which became INRIA in

6. Valérie Schafer, "Datagrammes et circuits virtuels," 29–48.

7. Great Britain shared the same concern at the same time: Harold Wilson created the Ministry of Technology (Mintech) in 1964; it aimed to check and coordinate the efforts of the Ministry of Aviation, the sector of atomic energy, and scientific research more generally. See Jon Agar, *The Government Machine*; and, for similar nation-level studies, Eden Medina, *Cybernetic Revolutionaries*, and Schafer, *La France en réseaux*.

8. Janet Abbate, *Inventing the Internet*, 22; W. Bernard Carlson, "The Telephone as Political Instrument."

9. Pascal Griset, ed., *Informatique, politique industrielle, Europe*.

1979 with the addition of the term "National"). According to its founding documents, IRIA was designed to accomplish four goals: assist the French Computer Science Delegation in its mission; encourage or directly finance fundamental and applied research in computing; educate executives and researchers and coordinate the actions of the administrations, public institutions, and other groups working with computing in France; and build a documentation service.[10]

THE GENESIS OF A COMPUTER NETWORKING PROJECT

Computer networking was not part of IRIA's original mission; rather, its designers were more interested in applied mathematics and automation. IRIA's research on packet switching began with a trip by telecommunications and computer engineers to the United States in 1969, organized by Maurice Allègre, head of the Délégation à l'informatique (Computer Science Delegation). The mission included Alain Profit from the French Center for the Study of Telecommunications, who recalled that the group's preliminary exploration of "teleinformatics in the United States included a visit to Professor [Leonard] Kleinrock's laboratory in Los Angeles," which was "our first contact with packet switching networks."[11]

On their visit to Kleinrock's lab at the University of California (UCLA), the small French mission discovered a pioneering node of research funded by the American Advanced Research Projects Agency (ARPA). The UCLA group was deeply involved with the early design phases of the ARPANET and was the home of several individuals, including Vinton Cerf, Steve Crocker, and Jon Postel, now celebrated as founding fathers of the Internet. These young men were working on an interface between UCLA's Sigma 7 computer and the Interface Message Processor developed by the company Bolt Beranek and Newman (BBN)—a task that culminated when UCLA became the first node of the ARPANET in late September 1969.[12] The French presence persisted in the ARPANET's early days. French engineer Michel Elie (an employee of CII) remembers arriving at UCLA in September 1969 after another Frenchman, Gérard Deloche,[13] and he reported back to the Computer Science Delegation in January 1971 to convince Allègre that networks were an interesting research topic that the French should pursue.[14]

Back in France, it was difficult to generate momentum in support of a vigorous research effort in computer networking, despite the positive ex-

10. Activity Report, 1968, INRIA Archive; Alain Beltran and Pascal Griset, *Histoire d'un pionnier de l'informatique*.

11. Interview with Alain Profit, 4 February 2003.

12. Stephen Levy, "History of Technology Transfer at BBN," 30–38.

13. Gérard Deloche, "Host Software."

14. 88.16.004, CRI/No.1483, Computer Science Delegate, 26 February 1971, INRIA Archive.

periences of Elie, Deloche, and Profit. Other activities during 1971 revealed different facets of French interests in networking, such as the study meetings organized by the Committee for Computer Science Research (hosted by IRIA and linked to the Computer Science Delegation). The immediate objective of these meetings was to promote cooperation and common applications among French database engineers. At first there was no mention of packet switching or precise instructions, only the general goal to connect users of different types of databases by January 1975. Two meetings in 1971 brought together the potential users of government databases and users of documentary and scientific databases.[15] The results were rather disappointing, since the majority of the group expressed skepticism toward the ambitious idea of a network that would interconnect different types of computers and databases. For example, M. Gambach (Center for Technical Studies for the Ministry of Equipment—Aix, France) thought that it would be wiser to start more modestly with a homogenous network—that is, a network between similar types of computers. "Isn't the study of concrete problems more urgent," Gambach cautioned his colleagues, "than that of such a general and large problem?"[16] Subsequent discussion revealed concerns and the limited willingness of the actors to engage in the project.[17]

However, Allègre decided to ignore these critics, launch the networking research project, and implement it at IRIA. The location choice was not obvious at the time, since in the 1970s computer networking was tangential to IRIA's focus on more scientific and targeted projects in the areas of technical computing, applied mathematics, and automation. In the summary of Gérard Le Lann, who joined IRIA in 1972, "At the time, [IRIA] research teams worked on anything but the networks."[18] Nevertheless, networking research found a home in IRIA, perhaps less for scientific reasons than practical ones. Louis Pouzin later suggested a mundane, administrative reason for the choice, a matter of "square meters."[19] In other words, IRIA simply had the office space to accommodate the speculative networking project.

Housed in a building of its own at IRIA, the Cyclades team felt on the margins of an institute very proud of its mathematical traditions. Cyclades researcher Jean-Louis Grangé remembered, "We were not academics, not university professors. We were cowboys."[20] Despite the evident discipli-

15. 88.16.005, Network Meeting, 7 May 1971, CRI/No. 1596, 26 May 1971, INRIA Archive.

16. Ibid.

17. Beltran and Griset, *Histoire d'un pionnier de l'informatique*, 90. There is some symmetry here with the limited willingness of American academic researchers to join the ARPANET project. See Abbate, *Inventing the Internet*, 50; Serres, "Aux sources d'Internet," 411–13; Russell, *Open Standards and the Digital Age*, 229–38.

18. Interview with Gérard Le Lann, 12 November 2002.

19. Interview with Louis Pouzin, 1 December 2003.

20. Interview with Jean-Louis Grangé, 20 August 2007.

nary and cultural mismatch, the Cyclades project eventually would comply with the mission of the young institute. Allègre's proactive attitude allowed him to surmount the initial bureaucratic hurdles for a French project on computer networking. His next step was to hire a team leader.

Pouzin: Programmer and Team Leader

THE ENGINEER WHO "DEVELOPED SYSTEMS"

Louis Pouzin had deep and diverse experience with computing before his arrival at IRIA in 1971. After graduating from the École Polytechnique in 1950, he took a job at La Compagnie industrielle des téléphones (Industrial Phone Company), and then joined the Bull Company in 1957 to manage a small technical department focused on research and commercialization. In 1963 he went on extended leave to spend time in the United States at Fernando Corbató's laboratory at MIT. Pouzin's time at MIT was tremendously creative and productive. There he gained experience with programming, built relationships with colleagues at MIT and elsewhere in the United States, and helped to build two pioneering time-sharing systems, CTSS (Compatible Time-Sharing System) and Multics. As part of this work, Pouzin created a command that executed a list of commands for repetitive tasks—a concept that later inspired the "shell" scripts in the UNIX programming language.[21]

In 1965 Pouzin returned to Bull, which recently had been bought (in part) by General Electric. He led a software development project on a GE 600 for the National Weather Service, but as he started to study the project, General Electric decided not to market the GE 600 in France. Pouzin (and the weather contract) thus left Bull and continued at Sacs (a French IT services company) from 1967 to 1969, where he worked on a Control Data machine. He then moved to work on computing for the French automobile company Simca, but found his tasks "a little bit boring."[22] Happily for Pouzin, French computer scientists Louis Bolliet and François Sallé approached him to join the network project of the Computer Science Delegation within IRIA. Pouzin recalled that once he heard of the opportunity at IRIA, "It did not take me long to decide."[23]

Pouzin's initial employment contract was atypical: he signed first with the Computer Science Delegation, but worked at IRIA, and only became an IRIA employee two or three years later. His technical mission was, in a similar way, provisional. Allègre recalled, "I had a budget available and it

21. 88.16.005, Louis Pouzin Curriculum Vitae, 1st June 1971, INRIA Archive; interviews with Louis Pouzin, 12 November 2002 and 2 April 2012; Louis Pouzin, "The Origin of the Shell"; and David Walden and Tom Van Vleck, eds., *The Compatible Time Sharing System*.

22. Interview with Louis Pouzin, 2 April 2012.

23. Interview with Louis Pouzin, 12 November 2002.

seemed to be interesting research. . . . There were no specific targets because no one was able to plan, especially for computer research."[24]

When Pouzin was asked to supervise the development of a research network at IRIA, he had already earned a "reputation of a guy who developed systems."[25] During his work at MIT, the National Weather Service, and Simca, Pouzin had gained experience with a wide variety of computers and operating systems. Through this, he was able to combine a firm grasp of the fundamentals of programming with a larger sense of the possibilities of computing. He also developed a feeling that would stick with him for the rest of his career: an antagonistic attitude toward powerful institutions in general, and toward IBM—the giant of international computing—in particular. He later recalled with relish his experience at Simca, where "the head of IT [of Simca] in the United States was a fanatic of IBM." With characteristic irreverence, Pouzin decided to start a "fun" project "to replace the IBM discs with compatible ones. . . . Of course people from IBM saw me with much nuisance, and as usual they tried to use their influence." Pouzin smiled as he remembered his project, where he demonstrated that non-IBM parts were "less expensive and much faster."[26]

In the 1970s, Pouzin continued his campaign against IBM. Such an attitude was perfectly aligned with the initial motivation of the Computer Science Delegation, which was to promote the French computer industry and resist the hegemony of IBM.

RESISTING CENTRALIZED CONTROL BY DESIGN

To communicate his design philosophy, Pouzin searched for a project name that would convey his heterogeneous vision for the international computer industry. Eventually Pouzin found inspiration in the Cyclades, the Greek islands that took their name from the circle they formed in the Aegean Sea. The name Cyclades also provided Allègre with a compelling metaphor of the broader strategic function of the project, as he explained to French ministers in 1974:

> One should retain the image [of the Cyclades islands]; the processing centers are still today islands isolated in the middle of an ocean of data, which overwhelms our civilization. Now, thanks to the networks, these islands will be able to connect and thus contribute to a wide circle of information exchanges which will shape the future development of our society.[27]

24. Interview with Maurice Allègre, 16 November 2002.
25. Interview with Louis Pouzin, 12 November 2002.
26. Interview with Louis Pouzin, 12 November 2002 and 2 April 2012.
27. 02.00.013, Maurice Allègre, Presentation of the Cyclades network in front of the Ministers, 8 February 1974, INRIA Archive.

Behind its picturesque name, Cyclades hid a complex reality. In February 1972, Pouzin argued that the nascent Cyclades project should be both "a tool and an experiment."[28] It could be a tool, he explained, that satisfied the initial goal of allowing users to access the various databases of the French administration. In addition, and more ambitiously, Pouzin envisioned Cyclades as an experiment that would have an impact on research in the emerging field of data transmission, known elsewhere as computer communication.[29] To meet the latter (more intellectually compelling) goal, Pouzin proposed to build a packet-switching network that would be heterogeneous, connecting machines of different manufacturers and various operating systems. The work began officially in November 1971, gained momentum in early 1972, and soon exceeded the vague initial objectives assigned by the Computer Science Delegation.

LOOKING FOR RARE GEMS

With his technical and political missions successfully aligned and a budget and some authority conferred, Pouzin began to recruit a team to build Cyclades. He started with an announcement in newspapers in January 1971, attracting about sixty responses including Jean Le Bihan, who was hired. But for the most part, recruitment and hiring occurred by word of mouth: Pouzin himself arrived at IRIA with Jean-Louis Grangé, who had worked with Pouzin both at the National Weather Service and then at Simca.[30]

Grangé's task was to build Cigale, the store-and-forward packet-switching network—similar to the American ARPANET—at the core of the Cyclades project. Cigale's first demonstration, in November 1973, was a four-node network with one packet switch. The network expanded to sixteen computers with a five-node switch in 1974, and thus provided an infrastructure and test bed for the experimental projects of Cyclades such as software, terminals, and protocols. In 1974, Pouzin emphasized the conceptual underpinnings of Cigale: "a distinctive character of CIGALE is not its gadgetry, but its basic simplicity. The result is an unusual flexibility in handling all sorts of protocols and connections"[31] (fig. 1).

Pouzin's next two hires—Gérard Le Lann and Hubert Zimmermann—came to the project by a chain of contacts. Le Lann worked with computers as data-collecting tools at the European Organization for Nuclear Research (CERN) from 1969 to 1972, but he was not content simply to use computers as tools for physicists. Instead, he wanted to focus his research more on

28. 02.00.013, GAL 006, Diffusion: CRI, Identification: The Cyclades Network presentation by Louis Pouzin, 29 February 1972, INRIA Archive.

29. Pouzin, ed., *The Cyclades Computer Network*.

30. 02.00.013, Activity Report, from November 1971 to June 1972, by Louis Pouzin, 12 July 1972, INRIA Archive; interview with Jean-Louis Grangé, 3 April 2012.

31. Pouzin, "Cigale, the Packet Switching Machine," 155.

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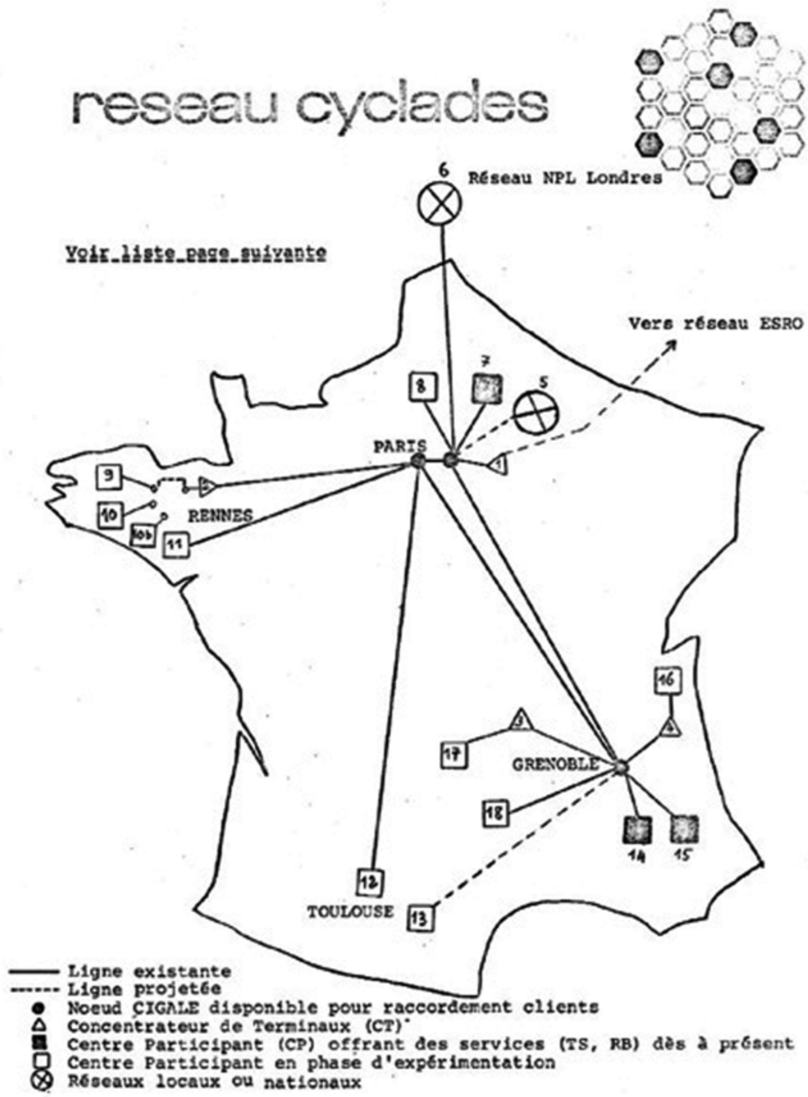

FIG. 1 Cyclades topology in January 1975. (Source: INRIA Archive, ©INRIA.)

computing itself and to interact with his American counterparts. Pouzin was impressed by Le Lann's intelligence and ambition, and brought him to Cyclades in September 1972. Zimmermann came from a different background, but had similar ambitions as Le Lann. After spending five years in the French Army at Seft (Section d'études et de fabrication des transmissions), by 1972 Zimmermann wished to find a new project—perhaps in the United States—where he could develop his knowledge of data processing. Zimmermann met and impressed Pouzin, who was happy when Zimmermann accepted an offer to join the Cyclades project and remain in France.[32] Together they began to write a book about Cyclades after Pouzin received "strong advice" from an official in the Ministry of Finance that "'In France, if you don't have a book on a project, you don't exist.' So we had to write a book." Pouzin continued, "It was a way to spread our ideas without really making an effort to do it—except writing the book in the first place."[33]

With the project established in the technical and bureaucratic realms, Pouzin continued to build his team. Najah Naffah joined IRIA in 1975, after working for three years on the installation of automatic radars in his home country of Lebanon. While at IRIA, Naffah pursued a Ph.D. (with Zimmermann as his advisor) and experimented with terminal attachments to the packet-switched network.[34] Michel Gien, who previously worked as a systems engineer in the Computer Center at IRIA, also joined Cyclades around the same time. Pouzin relied on Gien to be the liaison between Cyclades and the European Informatics Network (EIN), initially because Gien spoke English.[35] The participation of Naffah and Gien indicates Pouzin's growing ambition and the ever-increasing capabilities of Cyclades as it moved into different types of capabilities for computer terminals (Naffah) and developed stronger alliances across Europe (Gien).

The Cyclades researchers, under Pouzin's supervision, were a small but effective team during the mid-1970s. This effectiveness was aided by some engineers employed by CII and by French IT services companies who were working at the interfaces of public research and private production. Like the small groups that created the ARPANET, the Cyclades team worked with a collaborative and optimistic spirit and a keen sense of purpose that typically accompanies groundbreaking research.[36] Former Cyclades members remember their work as a "conquistadores" and "cowboys" adventure, where they "colluded as thick as thieves" and were constantly "on to something."[37] And they all remember that Pouzin was uncompromising: he did not make concessions, and he possessed an "instinctive, probably genetic" revulsion toward monopolies and those who made unwise technical decisions based on political motivations.[38]

Pouzin's combative attitude inspired, but it could also cause problems: Le Bihan recalled fondly that Pouzin was a "gunslinger" who "did not compromise," while Gien noted Pouzin's sometimes aggressive "frontal ap-

32. Interview with Gérard Le Lann, 3 April 2012.

33. Interview with Louis Pouzin, 2 April 2012.

34. Interview with Najah Naffah, 2 March 2007 and 3 April 2012.

35. Schafer, "L'Europe des réseaux dans les années 1970"; interview with Michel Gien, 3 April 2012.

36. On the ARPANET team, see Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late*; and Abbate, *Inventing the Internet*.

37. First two quotes from interview with Jean-Louis Grangé, 20 August 2007; final quote from interview with Jean Le Bihan, 13 December 2006.

38. Interview with Louis Pouzin, 12 November 2002.

proach."[39] At the same time, Pouzin's feistiness could be an asset, particularly in public performances and lectures. Naffah remembers that Pouzin had a gift of communication, and his lectures would leave "bubbling rooms," while Grangé praises Pouzin's humor, his ability to "do the show" in public, and his "phenomenal success in international conferences."[40] These qualities inspired loyalty among those who trusted him, but also provoked his opponents—that is, those who were the targets of his withering, witty, and technically astute critiques.

Inspired by, but Not Linked to, the ARPANET

ARPANET, A REFERENCE

Because it inspired the initial launch of the Cyclades project, the American ARPANET project was a constant reference point for the French during the formative stages of Cyclades. It would have been a natural step, given the experimental and heterogeneous nature of both packet-switching projects, to create a physical link between the two. However, political factors—both outside the research projects and within the leadership of ARPANET and Cyclades—complicated efforts to bring the two networks into a closer collaboration.

As early as 1971, officials in the French embassy in Washington recommended a liaison between Cyclades and ARPANET, thanks to a persuasive conversation with UCLA professor Michel Melkanoff. According to French engineer Michel Montpetit, Melkanoff was an "advocate for the participation of France in the ARPANET" who emphasized several factors in his discussion with French officials. He believed strongly in the "scientific interest and prestige of a participation in a large international network," the opportunity to "discover the problems to operate an international network: standards, procedures, operating," and the potential to "be associated with the developments and know everything that is done in the ARPA community." To protect their independence, French engineers would also need to "be able to cut the connection with ARPANET" and still ensure that "our network segments will continue to operate."[41]

The actual collaboration between ARPANET and Cyclades engineers was productive, even if it did not follow exactly the outlines of Melkanoff's vision. The cost of a direct connection from Cyclades to the ARPANET was valued at 13 million francs over three years, with most of the cost projected to go toward the required transatlantic telecommunications infra-

39. Interview with Jean Le Bihan, 13 December 2006; interview with Michel Gien, 26 December 2006.

40. Interview with Najah Naffah, 2 March 2007; interview with Jean-Louis Grangé, 20 August 2007.

41. 88.16.005, from Michel Monpetit to Louis Pouzin, 23 November 1971, copy of a letter from the French embassy in Washington, INRIA Archive.

structure. Not only would the cost and political subtext make such a connection difficult to "sell to the Computer Science Delegation," as Pouzin later recalled; it would also require the Cyclades engineers to develop a converter to the ARPANET's transmission protocol, the Network Control Program (NCP), which seemed primitive to Pouzin's way of thinking. But the more fundamental problem was an overarching logic that Pouzin recalled in 2012: "everything that could seem to contribute to American hegemony was not correct. The connection seemed to me to be politically dangerous." Eventually, the idea of a direct connection was dropped.[42]

COOPERATION AND KNOWLEDGE TRANSFERS

Despite the absence of a physical connection between Cyclades and the ARPANET, Cyclades engineers maintained constant exchanges with ARPANET engineers, including some especially productive contacts with engineers at BBN such as Alex McKenzie and David Walden.[43] Cooperation was formalized between Cyclades and BBN through contracts, documentation exchanges, and mutual visits, and information flowed both ways across the Atlantic. For example, a BBN consulting engineer spent two days at IRIA in 1972, and in 1975 Pouzin went to BBN, where he met with engineers and studied the maintenance and security problems of the ARPANET.[44]

Another liaison between the French and the Americans was institutionalized when Gérard Le Lann from Cyclades went to Stanford to work in Vinton Cerf's laboratory. Le Lann recalled: "I arrived at Stanford in 1973 and there started an exceptional experience. . . . We had insane evenings of brainstorming. To be in an American university at this time was fantas-

42. Interview with Louis Pouzin, 11 January 2007; interview with Louis Pouzin, 2 April 2012. Thanks in large part to the diplomatic talents of University College London (UCL) computer scientist Peter Kirstein, Great Britain established a connection to the ARPANET at UCL in July 1973. At the same time as they were speaking of collaboration, the French and British researchers sometimes acknowledged the implicit competition between the respective networking research going on in the United States, Great Britain, and other countries in Europe. Writing to Pouzin in July 1974, H. Vigne of the French National Center for Scientific Research complained that "Cyclades is still unknown in Great Britain because little is said of what is happening in Europe, except in the Latin countries. . . . In addition, we are in competition with ARPANET promoted by Peter Kirstein." 88.16.005, from H. Vigne (National Center for Scientific Research) to Louis Pouzin, 26 July 1974, INRIA Archive. See also Kirstein, "Early Experiences with the ARPANET and Internet in the United Kingdom," 38–44; and 84. 22. 004, *The Uses of the Arpa Network via the University College of London*, by P. Kirstein and S. Kenney, September 1975, INRIA Archive.

43. Interview with Jean-Louis Grangé, 3 April 2012.

44. 88.16.013, Louis Pouzin, Activity Report, from July to December 1972, ORG 015, 8 January 1973, INRIA Archive; 88.16.014, Louis Pouzin, Visit Report to BBN, 20 June 1975, LP/CB 75 281, 22 July 1975, INRIA Archive. See also Bibliothèque Cyclades (Cyclades Library) 84.22.003, INRIA Archive.

tic."[45] Le Lann's time at Stanford coincided with new research questions that the ARPANET engineers faced through network experiments that sent packets over radio spectrum (such as Alohanet and PRNET) and satellite connections (SATNET). These experiments prompted Robert Kahn, ARPA's Information Processing Techniques Office director who oversaw the funding and research priorities for the ARPANET, to think not only about the old problem of interconnecting heterogeneous *computers*, but of a new problem: the interconnection of heterogeneous *networks*. A key challenge for network interconnection was to agree on and use a consistent transmission protocol that could operate across different types of networks, and by 1973 it had become clear that the ARPANET's Network Control Program (NCP) simply was not suitable for Internetworking.[46]

With these problems in mind, Kahn pursued a collaboration with Cerf, who recently had graduated from UCLA, started a job on the faculty at Stanford, and continued to organize seminars and discussions on the topic. Cerf and Kahn's partnership famously produced a 1974 article that defined a "Transmission Control Program" (TCP), which then developed into TCP/IP (Transport Control Protocol and Internet Protocol) and replaced NCP as the host protocol on ARPA-funded networks in the 1980s.[47] Although Cerf and Kahn are now celebrated as "fathers of the Internet," Cerf's own recollections suggest that the French were contributing in fundamental ways to Cerf and Kahn's vision of Internetworking. In a 1990 interview, Cerf explained:

> Several people had a lot of influence on how the design [of TCP] went. Bob [Kahn] and I spent a lot of time working through various concepts and we wrote that paper in 1974. But I had also a lot of exposure to Hubert Zimmermann and to Louis Pouzin, both of whom had been doing experiments at INRIA, it was called IRIA at the time, on packet switching. They had developed a system they called Cyclades, and the underlying network was called Cigale. It was a pure datagram network. . . . Anyway, Pouzin's ideas on windowing techniques were very appealing to me, and I incorporated them into the initial TCP design. A guy named Gérard Le Lann was at IRIA working with Pouzin and came to my lab at Stanford for a year and had a lot to do with the early discussions of what the TCP would look like.[48]

The participation of Le Lann—who was in some ways, as Cerf recalled, a proxy for Pouzin and Zimmermann—therefore was essential for the

45. Interview with Gérard Le Lann, 12 November 2002. See also his 3 April 2012 interview.

46. Abbate, *Inventing the Internet*, 122.

47. Amy Slaton and Janet Abbate, "The Hidden Lives of Standards," 95–144.

48. Vinton Cerf, OH 191, oral history interview by Judy O'Neill, 24 April 1990, Reston, VA, CBI.

transition from a *network* protocol (NCP) to an *internetwork* protocol (TCP). As Janet Abbate has summarized, Cerf, Le Lann, and Ethernet co-inventor Robert Metcalfe "collaborated closely on the specifications for TCP . . . and thus the protocol reflected the design philosophies of Cyclades and Ethernet while deviating significantly from the approach that had been taken with the ARPANET."[49]

Such collaboration reminds us that the TCP-based Internet was but one project within the broader realm of research on packet switching that included projects in France, Great Britain, and elsewhere. Beginning in 1972, Cerf and Pouzin led an effort to unite these disparate projects in order to create and adopt a single, standard transmission protocol for digital packet-switched networks. A small committee, the International Network Working Group (INWG) was formed at the International Computer Communication Conference in October 1972, a conference that also hosted the first public demonstration of the American ARPANET. Pouzin, Cerf, and their colleagues organized INWG to function as a pre-standardization venue in which the packet-switching researchers could exchange ideas and develop an internal consensus for a standard transmission protocol for digital packet-switched networks. Once they reached a consensus, they planned to submit the protocol for formal international standardization to two standard-setting committees, one hosted by the International Telegraph and Telephone Consultative Committee (CCITT) and the other hosted by the International Organization for Standardization (ISO).[50]

A FAILED INTERNATIONAL ALLIANCE

If the question of a common transport protocol was merely a technical matter, one that could be sorted out between like-minded researchers looking for an optimal technical solution, then the ARPANET and Cyclades transport protocols would have converged in 1974 and 1975. Within INWG, a small group of engineers worked diligently to reconcile the slight differences in approach of transport protocols being developed in the ARPANET (by Cerf and Kahn, circulated to INWG members in September 1973) and in Cyclades (by Pouzin, Zimmermann, and Elie, circulated to INWG members in October and December 1973).[51] (Pouzin, always sensitive to the importance of titles, began to use the term "catenet" to refer to

49. Abbate, *Inventing the Internet*, 127. See also Urs von Burg, *The Triumph of Ethernet*.

50. Alex McKenzie, "INWG and the Conception of the Internet." See more generally Andrew L. Russell, *Open Standards and the Digital Age*, 171–96.

51. Vint Cerf and Robert Kahn, "HOST and PROCESS Level Protocols for Internetwork Communication," 13 September 1973, INWG 39; Hubert Zimmermann and Michel Elie, "Proposed Standard Host-Host Protocol for Heterogeneous Computer Networks: Transport Protocol," December 1973, INWG 43: both from Alexander McKenzie Collection of Computer Networking Development Records, CBI 123 (hereafter McKenzie Collection), CBI.

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the concatenation of networks that a single transport protocol could create. Ultimately, the term "Internet"—a conceptual synonym for catenet—won that particular terminological battle.[52]) Revisions to the respective proposals circulated among INWG members throughout 1974. Some subtle differences persisted between the designs, despite an attempt by BBN's McKenzie in the fall of 1974 to synthesize the two designs into a single "Internetwork Host-to-Host Protocol."[53]

Technical and political developments during 1975 added urgency to INWG's task of reconciliation and synthesis. The chief external concern was the telecommunications engineers working through the CCITT, who were negotiating the technical features of the protocol that would be published in 1976 as X.25. Researchers in INWG, still hoping that they could create a synthesis of the ARPANET and Cyclades designs, convened a summit of sorts in July 1975, when Cerf, Zimmermann, McKenzie, and British computer scientist Roger Scantlebury met in London. In "less than a week," the four engineers eventually agreed on a consensus protocol, known as INWG 96, and circulated it to INWG members for them to approve as an INWG contribution to the international standards effort in the CCITT.[54]

In December 1975, a large majority of INWG researchers voted in favor of synthesis; it was approved by a vote of 25.8 in favor, 7.5 against, and 8.7 abstentions.[55] With the vote, the leaders of most of the leading network projects, including Cyclades, Britain's NPLnet, and the European Informatics Network, committed to the immediate adoption and implementation of INWG 96. But conspicuous "no" votes came from American ARPA contractors—despite Cerf's personal role in the creation of INWG 96 and vote in favor of it.[56] McKenzie, who published his recollections in a

52. On "catenet," see Louis Pouzin, "Interconnection of Packet Switching Networks," October 1973, INWG 42, McKenzie Collection, CBI; Pouzin, "A Proposal for Interconnecting Packet Switching Networks," March 1974, INWG 60, McKenzie Collection, CBI; and Vint Cerf, "The Catenet Model for Internetworking."

53. Alex McKenzie, "Internetwork Host-Host Protocol," December 1974, INWG 74, McKenzie Collection, CBI; McKenzie, "INWG and the Conception of the Internet," 69–70.

54. Rybczynski, "Commercialization of Packet Switching (1975–1985)," 26–32; Després, "X.25 Virtual Circuits—Transpac in France—Pre-Internet Data Networking," 40–46; McKenzie, "INWG and the Conception of the Internet," 69–70.

55. Vote totals were not whole numbers because voting privileges were extended only to institutions, not individuals. Two institutions—the University of Tokyo and BBN—had multiple individuals active in INWG, with evident disagreements on INWG 96. Two of three from Tokyo abstained, with one in favor; the BBN vote split evenly, with two in favor and two against. "Result of Vote on End-to-End Protocol," March 1976, INWG 109, McKenzie Collection, CBI.

56. Vint Cerf, Alex McKenzie, Roger Scantlebury, and Hubert Zimmermann, "Proposal for an Internetwork End-to-End Protocol," 29 July 1975, INWG 96, McKenzie Collection, CBI; Vinton Cerf, "Result of Vote on End-to-End Protocol," March 1976, INWG 109, McKenzie Collection, CBI.

2011 article, reported that INWG members "were all shocked and amazed when Bob Kahn announced that DARPA researchers were too close to completing implementation of the updated INWG 39 [TCP] protocol to incur the expense of switching to another design." As McKenzie summarized, "DARPA had a bigger research budget than any of the other research organizations, and for this reason, its protocol choice became dominant over time."[57]

McKenzie's emphasis on the American research budget rather than any inherent superiority of TCP's technical characteristics reminds us to return to the key factors in French politics that ultimately doomed Cyclades. Where the leaders of the ARPANET benefited from generous funding and relative insulation from powerful forces in American politics, Pouzin and the Cyclades researchers enjoyed no such autonomy. It simply was not possible for the French, like packet-switching researchers in other European countries, to develop their own protocols in a political vacuum.[58] The Europeans knew they needed to cooperate in order for their proposals to stand any chance of being adopted—hence their high hopes for their collaborative efforts in an international pre-standardization alliance such as INWG. Unfortunately for Pouzin and his team, the mandate to cooperate also forced them to negotiate with, and ultimately confront, telecommunications engineers in the French telephone monopoly.

Pouzin: Agitator and Provocateur

THE DATAGRAMS ADVOCATE

A respect for diversity informed the design of Cyclades, but the design team's experiences with "collaboration" also had the unintended consequence of feeding their more combative tendencies. One such attempt at collaboration occurred between Pouzin's team of "cowboy" computer researchers at IRIA and their peers in telecommunications. At CNET (the Centre National d'Études des Télécommunications, the research arm of the French telecommunications authority) and at CCETT (the Centre commun d'études de télévision et télécommunications, launched in 1972), French telecommunication engineers were developing a network called RCP, also based on packet switching. As we will see, RCP embodied a different set of social values and design choices.[59]

Since French officials did not intend for these two public research projects—Cyclades and RCP—to compete, it seemed natural to bring them closer together. Both teams tried to cooperate in 1972, but by 1973 Pouzin and Rémi Després, the leader of the RCP project, realized the incompatibility of their approaches. Over the next few years, Pouzin failed to attract

57. McKenzie, "INWG and the Conception of the Internet," 68.

58. Interview with André Danthine, 6 April 2012.

59. Schafer, "Datagrammes et circuits virtuels," 29–48.

the necessary political support for Cyclades, despite a promising start. On 29 June 1972, there was an agreement between the head of the Telecommunications Administration, Louis-Joseph Libois, and the Computer Science Delegation delegate Maurice Allègre. They proposed cooperation with regard to the complementary objectives of the two public research centers, CNET and IRIA. The French public administration of postal services and telecommunications (PTT) agreed to provide free lines and modems to Cyclades for three years to implement the network, but the intellectual exchanges and the shared responsibility were more difficult to secure.[60] In July 1972 Pouzin confirmed the assignment of Jean-Louis Grangé from the Cyclades team to CNET, as a technical liaison to work on their joint project to build a packet-switching sub-network called Mitranet. (Mitranet would then be called Cigale in Cyclades, because "some purists in the administration were offended by the Anglo-Saxon sounding."[61])

While cooperation seemed quite committed, discussions in September and October 1972 indicated the difficulties that lay ahead.[62] In mid-October, Pouzin wrote to Pierre Conruyt, assistant director of CCETT, and complained that work was "very slow" because of "a lack of homogeneity in the work team." According to Pouzin, Cyclades team members were helping CNET, but CNET engineers had refused to work on the IRIA computer, a Xerox Sigma 7 that had been modified by engineers at IRIA.[63]

Grangé, the Cyclades computer engineer sent to work with the telecommunications team, remembers his installation with Després and his departure just as quickly, after less than a month of work. There was "a total incompatibility on every level," and the two teams were unable to "agree on anything."[64] Grangé recalled,

> I think the basic reason was that I was a computer and system man, right? And they were much more oriented to telephony, reproducing circuits, etc. And I didn't understand that. It was not my philosophy. And it was not *our* philosophy. So I went to see Louis, and I told him, "I can't do it." And he said, "Okay. Come back home."[65]

From that point, Pouzin saw cooperation with CNET as merely symbolic. Després continued his own project, with no signs of merging it with Pouzin's project. He and his supervisors in the PTT saw the same problem that

60. 19820493, 9, Cyclades-Transpac Relations, 20 December 1974, CAC/88.16.013, "CNET—Cyclades Cooperation," 9 June 1972, INRIA Archive.

61. Email from Louis Pouzin to Valérie Schafer (June 2003).

62. Schafer, *La France en réseaux (années 1960–1980)*, 97–99.

63. The C10070 was a machine for scientific computing, a Xerox Data Systems Sigma 7 equipped with an operating system redesigned by IRIA teams: 88.16.004, "The History of Cigale Development," 20 March 1974, INRIA Archive.

64. Interview with Jean-Louis Grangé, 20 August 2007.

65. Interview with Jean-Louis Grangé, 3 April 2012.

Pouzin saw, but from a different perspective. Després recalled in a 2012 interview:

> The IRIA team, Louis Pouzin, had a view that he knew how to do the network that we wanted to design better than we did. And he convinced the Ministry of Industry and Maurice Allègre . . . that we didn't understand what were the requirements of the market. Instead of letting us develop our network and using it, he tried to replace our design by his own design. At some time, it was agreed that one person of his team would work with us—Jean-Louis Grangé. He came here at CNET for some time, but he was not really interested in participating in the RCP project and he stopped some time after that. . . . Only once I was invited by Louis Pouzin to go to IRIA where, instead of listening to what I was designing and why, he told me all the details of how our network should be done, with lots of mistakes as far as I am concerned. It couldn't fit with our requirements. So this kind of disappeared as a will to cooperate.[66]

Despite the political will to cooperate, expressed repeatedly by the administrators in the PTT and IRIA, the key actors—the engineers on the front lines of experimental data networks—were not inclined to work together.

The problems between "two schools of packet switching" (as Pouzin called them) were simultaneously technical, political, and sociological. At CNET, seated within the powerful state telecommunications agency, French engineers chose to pursue a "virtual circuit" approach. Such an approach broke a message into packets, which would be sent through a network where each connection was identified. Packets could therefore be traced through the network, thus providing predictability for the network operator and for the users at the ends of the network. Virtual circuits created, in effect, a *connection* between two terminals at the edges of the network through which all packets would pass. Complex transmission tasks—such as ensuring that every packet arrived at its destination in the correct sequence—would be managed within the network, not by the computer terminals at the ends of the network. Després, the designer of the RCP network, recalled that his virtual circuit design could "give the guarantee of never losing anything except when there is hardware failure or link failure." Such guarantees were crucial for the business model of the PTT, because they were "key for acceptability of the service we offered."[67] Because virtual circuits offered better control and reliability, they were better adapted to the requirements of a public network.[68]

The virtual circuit design—which would become the basis of the inter-

66. Interview with Rémi Després, 16 May 2012.

67. Ibid.

68. Interview with Philippe Picard, 1 February 2003.

national X.25 standard published in 1976—also fit well with the networking approach of a dominant user, IBM.[69] IBM's Systems Network Architecture (SNA), according to IBM France engineer Marc Levilion, transmitted data between computers first by considering a "map of the routes available," and then by sending "each new communication between applications" along "one particular physical route across a network."[70] Virtual circuits, in other words, provided an incremental transition to packet-switching networking, in an attempt to minimize the disruptive effects of the new technology. CNET selected this style of "virtual circuit" fixed routing, as did other national telecommunication administrations such as the British Post Office for its EPSS network (Experimental Packet-Switching Service).[71]

Pouzin and his team did not share this worldview. They saw virtual circuits as the invention of a monopoly tradition of deterministic, circuit-oriented telecommunications.[72] They were not trained as telecommunications engineers, and had never been socialized into the bureaucratic cultures of IBM or the French telecom monopoly. Rather, their background in computing introduced them to non-deterministic models of communication that promised to be more efficient and robust than deterministic circuits. Pouzin's team saw no need to account for packets at each hop across the network. Instead, he proposed a "datagram" design that departed radically from the connection-oriented network designs used in traditional telephony, in RCP, and in the ARPANET. In short, he proposed to build a simpler network that would depend on the ever-increasing sophistication and processing power of computer terminals. Pouzin's definition of datagrams—and meditation on their merits—deserves extended quotation:

> The essence of datagram is connectionless. That means you have no relationship established between sender and receiver. Just things go separately. One by one. Like photons. . . . Putting together things that are interrelated are the business of the higher-level sender and receiver. . . . But the network ignores those relationships.[73]

Pouzin and his colleagues in Cyclades were aware that their project was part of a national policy which aimed to promote the hardware of the French computer manufacturer CII. Such a policy required that international networking standards could not confer advantages to IBM, which was already threatening to extend its domination of international com-

69. Després recalled that the French telecom monopoly's users were "companies using IBM computers. . . . IBM had at that time more than half the market." See also Rybczynski, "Commercialization of Packet Switching (1975–1985)"; and Després, "X.25 Virtual Circuits."

70. Interview with Marc Levilion, 2 April 2012.

71. Després, "Les origines de l'avis X25 du CCITT et du réseau Transpac."

72. Interview with Maurice Allègre, 16 November 2002.

73. Interview with Louis Pouzin, 2 April 2012.

puter markets. To counter that threat, Pouzin chose to develop what would soon be called an "open" network: a general network that was not created for a single type of computer. He recalled: "Once we had decided that we wished to promote CII, the network had to be heterogeneous, as CII didn't hold a monopoly; we had to be able to integrate into the network not only CII, but also, necessarily, a certain number of machines by IBM, Control Data, Burroughs, and so on. . . . The idea was not only pragmatic but also politically correct."[74]

Pouzin's own account underplays the extent to which his datagram idea was deeply threatening to the entrenched ways of doing things in the international computer industry, where the manufacturers developed proprietary architectures (for example, IBM's SNA and Digital's DECNET) which allowed only their own computers to be linked. Cyclades pioneered and provided a new way to think about who would control network interconnection. Pouzin's approach was threatening precisely because it proposed a conceptual change in the field of networking and aimed to upset the industrial market dominated by IBM and its vision of centralized computing (fig. 2).

THE OPPONENT OF VIRTUAL CIRCUITS

Pouzin's subversion was especially pronounced when he promoted Cyclades at international conferences—venues where he saw opportunities to expose the political forces at work within France and throughout the nascent international data communications industry. A typical example of his rhetoric was his presentation in June 1976 at the National Computer Conference in New York, "Virtual Circuits vs. Datagrams: Technical and Political Issues." He was plainspoken when addressing the technical issues as well as the "political significance of the [datagram versus virtual circuit] controversy," which he saw as "initial ambushes in a power struggle between carriers and the computer industry. Everyone knows in the end, it means IBM vs. Telecommunications, through mercenaries"[75] (fig. 3).

Pouzin continued his defense of datagrams—and attacks on virtual circuits and monopolies—with a presentation in August 1976 at the International Conference on Computer Communication in Toronto. He brazenly declared that the French PTT had signed a "pact" to reject datagrams so that they could impose their own standards and "keep a firm grip" on users.[76]

74. Interview with Louis Pouzin, 12 November 2002.

75. Louis Pouzin, "Virtual Circuits vs. Datagrams: Technical and Political Issues," January 1976, INWG 106, McKenzie Collection, CBI. Subsequently published in the *1976 Proceedings of the National Computer Conference* (New York: AFIPS, 1976), 483–94. Abbate notes, "Perhaps anticipating opposition to their unconventional approach, the members of the Cyclades group were extremely vigorous in advocating their Inter-net-working philosophy." Abbate, *Inventing the Internet*, 125.

76. 86.07.006, LP/cb 76 49, 10 February 1976: "A Hot Potato: Virtual Circuits vs

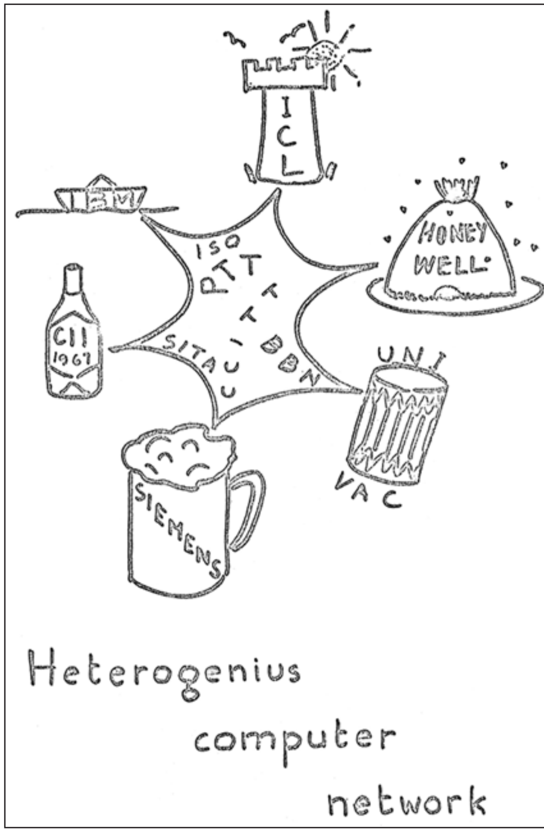

FIG. 2 Pouzin's slide of a "Heterogenius" computer network—a characteristic play on words designed to show how users would not be captured by a specific vendor; thus they would have the freedom to experiment and to share data with users of other computers. (Source: Louis Pouzin, INWG Note #49, August 1973, "Network Architectures and Components," Box 1, Alexander McKenzie Collection of Computer Networking Development Records. Courtesy of the Charles Babbage Institute, University of Minnesota.)

His slides dramatized the point: one slide contained a drawing of a castle provocatively labeled "PTT" with users hanging from the parapets. A young American networking engineer who attended the conference, Michael O'Dell, recalled Pouzin's performance as a transformative moment in his career: "It was a tent revival. . . . I've never seen anything like it at a technical conference. That day some of us got the religion." O'Dell and others

Datagrams," INRIA Archive: "The VC protocol is just the top of the iceberg, as it is not sufficient for the handling of terminals. The carrier will necessarily define much more than that: virtual terminal, command language, editing facilities, modes of operation, etc." See also Pouzin, "The Network Business—Monopolies and Entrepreneurs," 563–67.

FIG. 3 Louis Pouzin and Jean-Louis Grangé at a 1976 conference. (Source: INRIA Archive, ©INRIA.)

report that Pouzin, when told his presentation time was over, turned to the audience and asked if they wanted to hear more. When the audience roared in approval, they empowered Pouzin to extend a perfor-mance that O'Dell recalled as

> somewhere between a deep-south summer-steam-heat sweat-fest Full-Duplex Gospel Tent Revival and The Beatles on Ed Sullivan. . . . You could see it in the eyes of the idolaters—FEAR! I say FEAR of the DATAGRAM was upon them! The MIGHTY POUZIN finally bid the crowd disperse, but the fire lit that day in fact changed lives.[77]

Pouzin's showmanship and technical acuity made him an instant cult hero for young networking engineers like O'Dell, who went on to be chief scientist for UUNET, the first commercial Internet service provider. Such qualities, however, did not endear Pouzin to the technological and political hierarchies in France who hoped to keep such expressions of internal dissent out of public view. André Danzin, director of IRIA, chastised Pouzin in 1977 after another fiery public performance:

> This speech, of political nature, created a polemic between Telecommunications and ourselves, and, consequently, between the Telecommunications people and our ministry. This polemic is harmful for

77. Personal correspondence with Michael O'Dell, 14 November 2012.

the French interests and has a non-constructive impact. Of course, the press was happy to dramatize the debate.[78]

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Danzin's reaction did not dispute the efficacy of Pouzin's datagrams, only the "political" priority of French industrial policy that demanded collaboration among French engineers. It was a demand that contributed to the demise of Cyclades and to the banishment of Pouzin from the field he had inspired and helped to create.

Conclusion: The End of Cyclades

Although Cyclades grew robustly in the 1970s and inspired European and international conceptual extensions (in the European Informatics Network and in the project for Open Systems Interconnection), it died in 1979. On the surface, it died from budgetary problems that arose as it fell between the gaps of a research project and a part of the information infrastructure of post-industrial France.[79]

Such an outcome was anticipated in 1974 by André Danzin in a "personal" note to Hugues de l'Estoile, head of the General Industry Direction (Direction Générale de l'Industrie) that President Valéry Giscard d'Estaing created to replace the old Computer Science Delegation. Danzin wrote, "I'm a little embarrassed by the international Cyclades success [which] raises, in fact, the whole problem of 'What to do with Cyclades?'" Pouzin's accomplishments with Cyclades far exceeded technical expectations, and also far exceeded the political expectations of French industrial policymakers.[80]

The extinction of Cyclades occurred not only because Pouzin's rivals in the PTT were more powerful, but also because of the prevailing forces of French political economy under President Giscard. Pouzin later complained that Giscard "absolutely had no technology vision," was advised by people with "no technical training," and thus dismantled the structures that de Gaulle's policy of independence had established.[81] Consequently, the end of Cyclades occurred alongside the end of the Computer Science Delegation and of the CII. Giscard's new plan for French telecommunications policy depended on the monopoly PTT.[82] Since the merger of the CII with Honeywell Bull in 1976, Cyclades team members found cooperation more difficult as CII-Honeywell Bull tried to lock its products in with homogenous networks. Moreover, the international standardization of virtual circuits in the X.25 standard (1976) and the subsequent launch of the

78. 02.00.013, from André Danzin to Louis Pouzin, No. ADM: LM/197, 25 October 1977, INRIA Archive.

79. From Jean-Louis Grangé to Misters Danzin, Peissik, Nivelet et Zimmermann, "Cyclades Exploitation," Réf: 33/78/CDC-JLG, 3 February 1978, INRIA Archive.

80. 02.00.011, from André Danzin to Hugues de l'Estoile, 14 November 1974, INRIA Archive.

81. Interview with Louis Pouzin, 2 April 2012.

82. Schafer, *La France en réseaux (années 1960–1980)*, 246–55.

X.25-based Transpac network in France (1978) aligned political and industrial forces against Pouzin's datagrams.

History seldom provides such clear examples of a group becoming a victim of its own success. One could read the Cyclades story as a missed opportunity for France: the French could have chosen Cyclades and its technical solution of datagrams, which were then implemented in the Internet. Instead, France chose Transpac and the Minitel.[83] With them in place, French authorities had no need for Pouzin's disruptive datagrams and embarrassing speeches. Computer scientist Christian Huitema, referring to the confrontation of IRIA's Cyclades project and CNET's RCP project (which eventually became Transpac),[84] recalled the internal French dispute:

> The [Cyclades] experience had gone perfectly, but the French Telecommunications administration decided that it had no future and that it was necessary to stake everything on the Transpac network, which was also a great success and connected the Minitel. Transpac, although dedicated to the data exchanges, looked much more than Cyclades or ARPANET like a conventional phone network: it was much easier to collect taxes. Consequently, any research that aimed at developing an alternative technology seemed inappropriate.[85]

We should resist the temptation to view this technical and industrial story with the clarity of hindsight and reduce it to a French strategic error. When French officials under Giscard ensured that Pouzin would become *Le Monde*'s "man who did not invent the Internet," they had other strategic and economic goals in mind. Pouzin's plan for networking was to make the network simple, but what seemed simple and obvious to him—datagrams and a *best effort* model of packet transmission—was not desirable for existing business models and customer demands. The French telecom monopoly's plan—and Després's network designs for Transpac—charted a different course that was wary of outside innovation: they centralized control within the network to ensure that the network provider controlled data traffic and quality of service. Indeed, Transpac was a real success at its time, supporting in the 1990s something like 6 million users. The Minitel persisted until June 2012, and had many users who particularly appreciated its security and robustness—in contrast to the often-unreliable commercial Internet.

France finally starved the Cyclades network in 1979, even though it was operational, efficient, and a source of inspiration for computer network researchers around the world. Pouzin was transferred to CNET in 1980 under new instructions, and "preferred to keep a low profile."[86] Zimmermann and Gien went with him and continued to flourish in their new

83. William Cats-Baril and Tawfik Jelassi, "The French Vidéotex System Minitel," 1–20; Marie Marchand, *La grande aventure du Minitel*.

84. Griset, "Entre logique d'opérateur et système national d'innovation," 9–32.

85. Christian Huitema, *Et Dieu créa l'Internet*, 2.

86. Interview with Louis Pouzin, 2 April 2012.

environment, mostly because the telecommunications monopoly gave them autonomy as part of a plan to "get more of the data processing culture" into its operations.[87] Gien recalled that Pouzin, on the other hand, "had a lot of people that didn't like him for political reasons" because he was "always saying in public things that you don't say in public, and people were very embarrassed."[88] Pouzin paid a price for his iconoclasm, but the team he recruited (Zimmermann, Gien, Naffah, Grangé, Le Bihan, and Le Lann) was chosen to lead pilot projects on operating systems, database systems, office systems, satellite communications, and resilient systems—all with deep strategic significance for French computing.[89]

To be sure, Cyclades had an impact beyond its physical existence. It created a competence in networking within French software companies and at CII, and contributed valuable ideas and experience to international networking projects such as the European Informatics Network and Open Systems Interconnection. These contributions, however, did not bring any significant notice to the Cyclades team or to Pouzin. It was only when the Internet emerged as a global phenomenon in the late 1990s that Pouzin was recognized. By the early 2000s, Vint Cerf defended Pouzin as the "datagram guru" and regularly cited Pouzin's contributions to the design of the "end-to-end" Internet.[90] The Cyclades project exists now only in the Internet's shadow, even though it was conceived with the idea that a place in the sun was possible.

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