

Note #2: Four Eras of Cybercash Innovation

1 Introduction

Figure 1 is a plot of the number of cybercash patents¹ issued each year from 1976 to 2019. If we take an innovation era to be marked by a marked increase in the number of patents issued in a domain followed by a decline, then we can discern four eras of cybercash innovation in this plot: 1976 to 1996, 1997 to 2005, 2006 to 2015, and finally 2016 to the present.

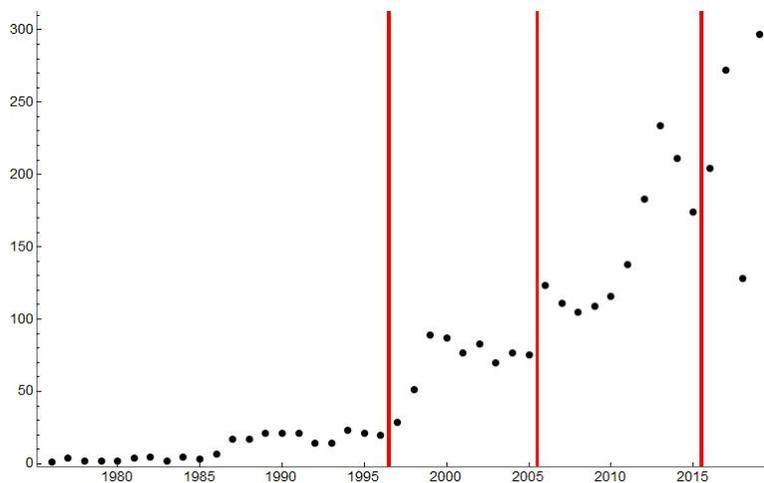


Figure 1: Four Eras of Cybercash Innovation

This note endeavors to characterize the innovation in each of these era by analyzing the text of the patents of each era.

2 Statistics of Cybercash Patents

The abstracts and brief summaries of U.S. patents from 1976 to 2019 were scanned for the search terms pertaining to cybercash listed in Appendix A below. The scan yielded 3,269 patents awarded 4,489 inventors and assigned to 878 organizations. The organizations and inventors with thirty or more cybercash patents in the collection are listed in Table 1 and the inventors with twenty or more cybercash patents are listed in 2. There were 392 patents that were unassigned.

Keywords: cybercash patents, patent analysis, cybercash innovation

¹... as defined by the search terms in Appendix A below.

Organization	Patents
Zynga Inc.	106
Sony Corporation	92
Kabam, Inc.	89
International Business Machines Corporation	67
Hitachi, Ltd.	55
Samsung Electronics Co., Ltd.	41
American Express Travel Related Services Company, Inc.	41
Ganz	35
Fujitsu Limited	35
Game Play Network, Inc.	34
Intertrust Technologies Corporation	31
Citibank, N.A.	30
Semiconductor Energy Laboratory Co., Ltd.	29
Microsoft Corporation	26
Mastercard International Incorporated	24
Verifone, Inc.	23
Kabushiki Kaisha Toshiba	23
Electronic Arts Inc.	22
Bally Gaming, Inc.	21
Nisca Corporation	20
Ricoh Company, Ltd.	20
Aftershock Services, Inc.	20
Visa International Service Association	20

Table 1: Top Assignees of Cybercash Patents

Inventor	Patents
Howard Ganz	35
Russell M. Fine	34
Matthew Adam Ocko	34
David M. Van Wie	31
Francis J. Spahn	31
Victor H. Shear	31
Karl L. Ginter	31
Sholom S. Rosen	28
Kellen Christopher Smalley	27
Michael C. Caldarone	26
Fred Bishop	24
John Kim	24
Steven M. Hoffberg	24
Luc Pieron	24
Stephanie K. Schultz	23
Matthew C. Curtis	22
James Koh	22
Kevin Chanthasiriphan	20

Table 2: Top Inventors of Cybercash Patents

3 Characterizing the Eras

As noted in the introduction, based on the number of cybercash patents granted each year one can perceive four eras of cybercash innovation. These along with the number of patents within each era are described in Table 3.

Era	Years	Cybercash Patents
I	1976–1996	451
II	1997–2005	1,276
III	2006–2015	3,008
IV	2016–2019	1,770

Table 3: Cybercash Patents in Each Era

One way to characterize the four eras is to compute the percentage of patents within each era that contain each of the cybercash search words. This computation is summarized in Table 4.

	I	II	III	IV
Patents	451	1,276	3,008	1,770
cash card	38	20	15	4
money card	5	5	4	2
blind dig. sig.	1	0	0	0
micromint	1	0	1	0
elec. mon. sys.	1	3	1	0
money module	1	2	1	0
millicent	0	1	1	0
cybercash	0	4	1	0
digicash	0	2	1	0
e-cash/ecash	0	3	5	0
digital coin	0	1	0	1
digital cash	0	6	4	1
mondex	0	3	1	1
micropayment	0	2	5	3
e-money	0	1	1	1
double-spending	0	1	1	1
virtual wallet	0	1	1	2
virtual bank	0	1	1	1
virtual currency	0	0	7	16
virtual cash	0	0	4	3
virtual account	0	0	2	2
virtual money	0	0	2	2
e-wallet	0	0	2	3
bitcoin	0	0	0	7
cryptocurrency	0	0	0	5
ethereum	0	0	0	1

Table 4: Percent of Patents Within Each Era Containing Each Search Term

Another way to characterize the eras is to find words in the patents of each era that are not found in the patents in the other eras. Table 5 displays unique words for each era that appeared in the most patents within the era.

I	II	III	IV
plated	SEPP	re-usability	blockchain
ironed	iKP	derail	cryptocurrency
one-bit	non-ergonomic	escalate	game plays
flimsy	SHTTP	misrepresented	Ethereum
reembossed	direct-connect	hesitancy	miners
non-counterfeitable	two-computer	moratorium	crypto-currency
imprinters	internet-draft	sixteen-digit	Nakamoto
electroless	SSP	MBPS	Satoshi

Table 5: Top Unique Words in Each Era

4 Summary

Based on Tables 4 and 5, the four eras of cybercash innovation might be characterized as follows:

1976–1998 Physical aspects of cash-bearing smart cards

1999–2010 Micropayment protocols for the Internet

2011–2016 Vaguely commercialization of cybercash

2011–2016 Bitcoin and blockchain

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Appendix A: Search Terms for Cybercash Patents

The search terms in the following two tables were applied to patent abstracts and brief summaries to identify the 6,234 patents used in this study. While the

Generic	Brand Name	Technical
digital cash	bitcoin	electronic monetary system
digital coin	digicash	micropayment
crypto currency	ecash	monetary stored value
cryptocurrency	mondex	blind digital signature
	micromint	double spending
	millicent	anonymous cash
	ethereum	bankless cash
	cybercash	money module
		blind coin
		divisible coin
		double spending
		bread pudding protocol
		pseudonym authentication

Table 6: Individual Query Terms

Combiner queries are created by concatenating each of the modified terms with the base term. For example, the fourth row in the following table generates the query "cash card" OR "money card".

Base Term	Modified/er Terms	Base Term
cyber	account bank cash coin currency money purse wallet	
virtual	account bank cash coin currency money purse wallet	
e-	cash coin money wallet	
	cash money	card
	hot encrypted	wallet

Table 7: Combiner Query Terms

Appendix B: Patents of David Chaum

Number	Title
10,536,670	Video copy prevention systems with interaction and compression
10,375,042	Precomputed and transactional mixing
10,050,786	Random sample elections
8,162,215	Scan-integrity election systems
8,123,114	Hidden-code voting and marking systems
7,516,891	Ballot integrity systems
7,210,617	Secret-ballot systems with voter-verifiable integrity
6,718,314	Multi-purpose transaction card system
6,434,238	Multi-purpose transaction card system
6,318,137	Electronic lock that can learn to recognize any ordinary key
6,035,380	Integrated circuit
5,956,400	Partitioned information storage systems with controlled retrieval
5,878,140	Limited-traceability systems
5,781,631	Limited-traceability systems
5,712,913	Limited-traceability systems
5,493,614	Private signature and proof systems
5,485,520	Automatic real-time highway toll collection from moving vehicles
5,434,919	Compact endorsement signature systems
5,373,558	Designated-confirmer signature systems
5,276,736	Optionally moderated transaction systems
5,131,039	Optionally moderated transaction systems
4,996,711	Selected-exponent signature systems
4,991,210	Unpredictable blind signature systems
4,987,593	One-show blind signature systems
4,949,380	Returned-value blind signature systems
4,947,430	Undeniable signature systems
4,926,480	Card-computer moderated systems
4,914,698	One-show blind signature systems
4,759,064	Blind unanticipated signature systems
4,759,063	Blind signature systems
4,529,870	Cryptographic identification, financial transaction, and credential device

Table 8: Patents of David Chaum

Appendix C: History of DigiCash

Many are the start-ups that starved waiting for a better offer. Digital Research, Floating Point Systems, and Thinking Machines come to mind in the world of information technology. A less well-known story is the first cybercash company, DigiCash. In 1999 Ian Grigg posted a translation of a story about the history of DigiCash that appeared in the now-defunct Dutch periodical, *Next*. The footnotes in the following note are translator's notes. Thanks to Ian for permission to reprint his e-mail.

10 February 1999. Thanks to RH, IG, The Dutch Natives and Unknown Author.

Date: Wed, 10 Feb 1999 15:41:05 -0400 (AST)
From: Ian Grigg <iang@systemics.com>
To: dbs@philodox.com
Subject: How DigiCash Blew Everything

Editor's note. This was translated by some Dutch natives, and then edited by myself for style. Tricky job really as translation should be done into one's native language. No promises as to accuracy!

iang

The author is unknown. Next! Magazine published it, and the original Dutch is at <http://v>

NEXT, January 1999

How DigiCash Blew Everything

In September 1998 the high-tech company DigiCash finally went bankrupt. The office in Palo Alto, California remained open for a while but it was merely a stay of execution. Two months ago the company filed for Chapter 11.

Nobody realises, but with the "pending failure" of DigiCash, a bit of Dutch Glory died. The company made a brilliant product. Even Silicon Valley was jealous of the avant garde technology invented in the Amsterdam Science Park. Internet "guru" Nicholas Negroponte went so far as to call the electronic payment system, eCash,² "the most exciting product I have seen in the past 20 years." The rise and fall of DigiCash: a story of paranoia, idealism, amateurism and greed.

David Chaum

The name of one man stands out way above anyone else in the history of DigiCash: David Chaum, US citizen, born into a wealthy family, brilliant mathematician and one who had to always have things his own way.³ After travelling around the world he ended up in Amsterdam in the late 80's. Here, he became head of the cryptography department of the CWI (Centre of Mathematics and Information Science). Cryptography is the science of encoding and decoding of data, in order to maintain privacy. Chaum had built a big reputation in

²In the original article, the two words "e cash" were used.

³"Tot op het bot."

this field in the previous few years.

Insiders estimated he was in the top 5 of the world at the time.

And at the CWI, they also worked on electronic payment systems. In the early 90s, Rijkswaterstaat became interested as they were thinking about introducing automatic toll-collection roads. Chaum got together a few researchers, mainly from earlier contacts with the university of Eindhoven. All guys who knew each other through a "young researchers" programme sponsored by Philips. They had all spent their youth programming behind a computer. Enthusiastically they started, and within little over a week the job was done.

DigiCash

Rijkswaterstaat was satisfied and the team got another assignment. That was the moment when Chaum smelt money. Why couldn't he turn the patents he claimed in the 80s into money? On the 21st of April, 1990, the company DigiCash first saw light of day. Unfortunately Rijkswaterstaat decided to put the advanced system on the shelf and to continue with the old standby, number plate recognition. Chaum could have divested himself of the company and continued his work at the CWI, but he had apparently tasted the forbidden fruit of business. He decided to market his research other ways: smart cards, point-of-sale applications, cash registers and tele-banking. Of course, he had to quit his job at the CWI because of the risk of conflict of interest.

Financing of the company was done privately by the American. Former DigiCash employees agree that Chaum and his wealthy family had at least contributed a few million.

It all started out quite nicely. The brand new company sold a smart card for closed systems which was a cash-cow for years. It was at this time that the first irritants appeared. Even if you are a brilliant scientist, that doesn't mean you are a good manager. David Chaum was a control freak, someone who couldn't delegate anything to anyone else, and insisted upon watching over everybody's shoulders. "That resulted in slowing down research," explained an ex-DigiCash employee who wished to remain anonymous. "We had a lot of half-finished product. He continuously changed his mind about where things were headed."

This drove a few people crazy and it didn't take long before the first few turned their back and started their own company. In 1992 Boudewijn de Kerf and Eduard de Jong quit the company and went to Silicon Valley where they invented and sold an operating system to Sun Microsystems for a substantial sum.

Ecash

Annoying as he was, David Chaum had brilliant ideas. In 1993 he invented the digital payment system ecash. According to insiders, it was a technically perfect product which made it possible to safely and anonymously pay over the Internet. This was a field in which a lot of work needed to be done, according to the ever-paranoid cryptographers. They considered that to pay with your credit card was extremely insecure. Someone only had to intercept the number to be able to spend someone else's money. Credit cards are also very cumbersome for small payments. The transaction fees are simply too high. Ecash however was perfectly suited to sending electronic pennies, nickels and dimes over the Internet.

⁴Dutch Department of Public Works. Responsible for waterways and roadways.

It was especially this idealism that prevented people from leaving the stubborn Chaum. Enthusiasm waxed for the elegance of his perfect inspirations. There were even people flying in from the US to witness the birth of something this beautiful, which was unusual, as this is usually only associated with big pay checks plus leased Mercedes in the parking lot.⁵ An ex-employee: "And no nonsense like 'We are going to make this company as big as possible, as soon as possible, and cash out'. No, we really wanted to make this product as big as possible." People who visited and walked around the Matrix building of the Amsterdam Science Park acknowledged that there was a young and dynamic atmosphere. No fast suits, but more like a school-yard gang. Real whiz kids who got coffee from the machine with their own electronic gadgets.

Legendary Suspicion

But even this enthusiasm was unable to withstand the bad feelings generated out of decisions made by CEO David Chaum. Almost every ex-DigiCash employee who you ask is able to tell you a story of his legendary suspicion. "Paranoid" is a word frequently heard. Raymond Stofberg, nowadays owner of the Internet company EURO RSSG Interactive, was responsible for DigiCash financial affairs until August 1996. He explains the story from the beginning. A few years ago Stofberg came to an agreement with Henderson Investment Management. They would invest two tranches for a total of 10 million dollars. When Chaum saw the agreement, he immediately faxed it to all the other venture capitalists which he was negotiating with. Via message drums, word leaked out to Henderson, and the agreement was cancelled.

A little later ING Investment Management was interested. This deal was about twenty million guilders.⁶ The plans were all laid out. ING Barings together with Goldman Sachs would also bring DigiCash to the stockmarket within two years. "The day we were all set to sign David didn't want to", tells Stofberg. "He was so paranoid, that he always thought something was wrong. There were 8 people from ING, including the CEO, and David simply refused to sign!"

Earlier Chaum was contacted by the unavoidable Bill Gates of Microsoft. He would integrate ecash in every copy of Windows 95. Rumor had it, the giant from Seattle offered something like 100 million dollars. David Chaum refused to sell it for less than 1 or 2 dollars per sold copy and that stubborn attitude killed another agreement. "A really sad story," reflects Stofberg. Chaum killed an agreement with another American company, Netscape, in the same way, by insisting straight away that everybody sign non-disclosure agreements, even before negotiations had started. Exit Netscape.

DigiCash was also involved in the first version of I-Pay.⁷ The contracts were there, just the signatures were missing. But a week before the deal was made Chaum decided to tell a large Dutch newspaper that the Chipper and Chipknip systems⁸ were absolutely insecure. "The smartcard is broken," he said. The banks had just invested 250 million guilders in the system, so it wasn't surprising that ABN-Amro executive De Ribourdouille personally killed the DigiCash deal.

⁵"Lease-bak" is a derogative term in Dutch

⁶About 10 million dollars. The guilder trades at 1.8 to 2 per dollar.

⁷A Dutch payment system operated by a cartel of all major Dutch banks.

⁸Smartcard systems operating competitively in the Dutch market.

David Chaum always bailed out at the last moment. Early 1996 there were negotiations with credit card company Visa. The Americans wanted to invest forty million dollars in the company. "But David suddenly demanded 75 million," Raymond Stofberg recalled. "Get lost," was Visa's reply. Retrospectively, a lot of ex-DigiCash employees understand why Chaum was so paranoid. As a cryptographer you have to assume the whole world is trying to rip you off. A certain amount of paranoia is part of the job. Chaum had also worked for intelligence agencies, and that didn't fortify his faith in the good intentions of humankind. His vision of the privacy of the individual was almost an obsession. In 1996 he said, in the relation magazine of Honeywell-Bull: "The difference between a bad electronic cash system and well-designed digital cash will determine whether we will have a dictatorship or a real democracy."

Whilst David might have had little faith in humankind, the employees were getting annoyed with their director. In the beginning they forgave him if another promising deal didn't go through, because David always said there were bigger fish to catch. The world was at their feet. It had to be, because in the whole world there was no product that could even come close to DigiCash. It was this feeling of technological superiority and arrogance that would kill DigiCash. The employees weren't only annoyed with the deals that were cancelled a few days before being closed, but also about the work environment. "David is a real nice guy and you can have a lot of fun with him, but at the same time he abused this employees," tells an ex-employee who wants to stay anonymous. "He always expected an enormous commitment;⁹ once every few weeks you had to work for nights on end." "And there was nothing to compensate for that. Once you were lured inside, you never received pay rises, no extras, nothing. That was very frustrating, but they kept the carrot in front of the donkey¹⁰ with the promise that 'once we make that big deal, we'll all be rich.'" "But we never got any shares. It was a hollow promise."

The Coup

In March 1996, tensions had reached a critical level. The irritation over a series of blunders led to a meeting of eleven important employees. They decided to give David a simple choice: "You're out or we're out." "That was the only way David could no longer fuck up the company," said one of them. The plan was to set up their own company, it had been done before, ex-DigiCash people had set up their own company with success. Accepted tradition¹¹ has it that two out of the eleven members - Jelte van der Hoek and Wouter Habra - went to David who panicked and immediately made them interim-managers. He then disappeared into the background, and eventually returned to the US a year later.

The remaining nine co-conspirators were not happy, but they accepted it for the moment. They had achieved their objective of getting rid of Chaum. But this acceptance was soon replaced with anger at the two new managers. "Jelte was a technical guy, who had been programming since he was seven, he couldn't manage at all. And Habra wasn't suited either. He was too much a deal-maker, not a manager," according to an ex-employee.

Wouter Habra wasn't impressed with the criticism. From Australia he emailed: "DigiCash was founded by crypto-people, and good crypto-people are a bit paranoid. That's why it's not surprising there are different views on the Jelte's and my reasons. That's a pity,

⁹ "Inzet."

¹⁰ "Hielden aan het lijntje."

¹¹ "Volgens de overlevering."

but our objective was to get investment and find a new manager. And that's what we did." Nonetheless frustrations grew. "Three weeks later, I found out they wanted to bypass me and get rid of me," said Raymond Stofberg. "From that time on I knew for sure that Chaum had trusted the wrong people." Other employees shared that belief and hardly 3 months after things had settled down there was a exodus of employees. Since then there is an in-joke that goes: "If you can survive DigiCash, you can handle anything that life throws at you." Amazingly enough DigiCash was still a very sexy company for the rest of the world. A rising star in a world where Internet companies like Netscape and Yahoo showed there were enormous risks, but also enormous benefits. DigiCash was hot and venture capitalists were stampeding to invest in it. Early in 1997 it received an investment of a total of sixteen million guilders from Gilde Investment, a daughter company of the Rabobank, and also Nicholas Negroponte, director of the Media Lab of MIT and writer of visionary books about the Internet. Also included was the well-known venture capitalist, David Marquardt, general partner at August Capital.

A new CEO

The new investors immediately appointed a new Chief Executive Officer: Michael Nash, an American from the credit card company Visa. Most employees didn't really like Nash. "Fast guy, smooth talker, but no content," said one. Nash came from a big bureaucratic company and had no clue on how to run a small company that had to fight in the front line. There were also angered at the fact that Nash immediately opened an office in Palo Alto. You could justify the decision from a marketing point of view, but the result was that the development was split. The costs sky-rocketed to a completely new heights, because the communications between the two departments was slow and cumbersome. The salaries in Silicon Valley were of course much higher than in the Amsterdam Watergraafsmeer.¹² And the American programmers absolutely didn't do a better job than their Dutch colleagues. According to an ex-employee, Nash had his head in the clouds.¹³ Everyone had to work on avant garde products like ecash, for which there was only a very slowly growing market. Real products, with which good money could be made, like smart cards and road-toll systems, were left to slowly die. "Mike would rather talk to Swatch, because he wanted ecash in watches. That didn't help us at all, because ecash is made for a PC. You are allowed to shout about futuristic things, but you should not believe in the hype you have yourself created." DigiCash did have a very impressive board with, for example, David Chaum - who had disappeared into the background - and the influential Nicholas Negroponte. But what good did those names do for the company? "A guy like Negroponte is only there for his image," says yet another ex-employee. "For relatively little money he had a share in a high profile company. But that doesn't help with the management of the company itself. Negroponte is just like any ordinary rock star, he gets out of the plane and when he walks down the stairs he still doesn't know which country he is in. That has been very destructive."

The Credit Card Triumphs

Meanwhile the management tried very hard to sell the ecash system to banks and was more or less successful in it. The Mark Twain Bank, in America, was the first to experiment with ecash. Later, another 7 banks followed, banks like Deutsche Bank and Credit Suisse. Banks are very conservative, they did business with DigiCash to prevent them from falling

¹²Suburb in Amsterdam where the Science Park was located.

¹³"Met zijn hoofd in de wolken."

behind, not to storm ahead and be the first. DigiCash never dealt with the "normal" department but always with a "special product" department. And why would the banks be in any hurry to implement the revolutionary new systems of DigiCash? The electronic payment market was dominated by credit cards, and plenty of money was made off them.

Neither were consumers so unhappy with the current situation. They weren't too convinced about the possibilities of fraud; even if something did go wrong, they weren't the ones to pay, the credit companies were. No worries there. They didn't really care about anonymity either, and certainly with the delivery of physical products this was completely irrelevant.

Everything was in stalemate. The banks were not in a hurry, the consumers didn't see any advantages. Although providers were the ones who would profit mostly from micropayment systems like ecash, they couldn't do anything but wait and be patient. Imagine: CNN receives millions of hits on their website every day. If you could ask one cent every time someone requests a page, that would make millions every year.

Halfway through 1998 everything seemed lost. The high salaries - estimates were that they were shelling out a million a month - quickly ate away reserves and there were no revenues to compensate for that. The company never had a clear marketing strategy. It wasn't till June 1998 that the sales manager at the time, Jan Kees Dunning, chose to change tactics. The dogma of Chaum, that DigiCash should aim for the virtual world, was abandoned. It was no use trying to compete against the credit card companies; they would squash you if you upset them.

Citibank

Jan Kees Dunning explains that from now on, ecash should be offered as a part of a complete range of payment methods. "No longer as the money maker for banks, because it was never that. All banks suffer losses on the traditional payment systems, and with a much cheaper system you could only minimize those losses." "Nowadays, a consumer isn't that loyal anymore. He demands from his bank that it offers all services, if they don't he'll just switch to another bank. Ecash has to be one of those services."

At least that was a clear strategy. But once again things were ruined, this time because of never-ending negotiations with the big American CitiBank. Citibank was a very attractive partner for DigiCash. In the first place, there was a large amount of clients: seventy million. Just as important, the backing of Citibank might convince the other, more skeptical banks. Citibank is known as very aggressive. In the 70s they introduced a universal payment system which enabled them to have very competitive fares and services. If they had started with ecash, none of the other banks could have afforded to lag behind.

But at the crucial moment Citibank decided to merge with the Traveler Group, which focused attention away from DigiCash. At the same time, the stock market valuation of CitiBank dropped to about half of recent values and at times like that, knee-jerk management rules in the US. So much for DigiCash.

Jan Kees Dunning is convinced that the business could have turned out differently to the fatal chain of events that seems to have happened. He estimates that DigiCash needed only another six months to secure a breakthrough. But the American venture capitalists had had enough at this point. They first pulled the plug on the Amsterdam team, and the Palo

Alto team is currently floating between life and death.¹⁴ Only six people remain with the company, and the one thing the new CEO Scott Loftesdale [sic]¹⁵ - Mike Nash was fired in August of 1998 - has left to do is announce the firesale of the DigiCash patents. Which are getting cheaper every minute, because the people who developed the product have all found work elsewhere. The ecash project now conjures up a feeling of history, dead and buried.¹⁶ There has not been any product maintenance, and that's fatal in an environment where everything is changing this rapidly. The future of especially ecash is very uncertain. Either it is sold for a maximum of five million guilders to a company like IBM, who has lagged two years behind with a similar product, according to Dunning, or it disappears. A sad fate for a path-breaker in a digital technique which will have completely eliminated regular cash in, say, twenty years. Everybody is convinced of that; the days of cash are numbered. It's too expensive, too cumbersome and too old-fashioned. David Chaum has since been seen around Berkeley, walking with his soul under his arm¹⁷ He was far ahead of his time. Too far.

¹⁴ "Zweven tussen leven en dood."

¹⁵ Scott Loftesness.

¹⁶ (German) "Das war einmal."

¹⁷ "Lopen met zijn ziel onder de arm."