
CWI
Research institute for mathematics &
computer science in the Netherlands
CWI Lectures on Data Systems Architectures
& Dijkstra Fellowship Award 2024

The winner of 2024

Marcin Żukowski, co-founder of VectorWise and Snowflake, is renowned for his pioneering work in query processing and data storage. After studying Computer Science at the Warsaw University and the Vrije University in Amsterdam, Żukowski began his scientific career at the Centrum Wiskunde & Informatica (CWI) in Amsterdam. There he developed key technologies that have fundamentally transformed how data is stored and accessed. During his PhD, he co-created vectorized execution and lightweight compression for database systems. These advancements reshaped the field, improving database efficiency by an order of magnitude and became the foundation for a new generation of data processing systems.

In 2008, Żukowski co-founded VectorWise, a company that built on these innovations to commercialize highly efficient database engines. Through VectorWise, he showcased the power of column-based data storage and vectorized processing to improve analytics performance on large datasets. As its CEO, he led to the acquisition of VectorWise in 2010.

This success caught the attention of Thierry Cruanes and Benoit Dageville, who invited Żukowski to Silicon Valley in 2012 to become Snowflake's third co-founder. Żukowski work was instrumental in building Snowflake's state-of-the-art processing engine. He also led Snowflake's engineering team in the formational years of the company. Snowflake's launch on the New York Stock Exchange in 2020 raised more money than any other software firm had during its public debut.

Snowflake's approach to data warehousing was groundbreaking, fostering rapid growth and making it a cornerstone

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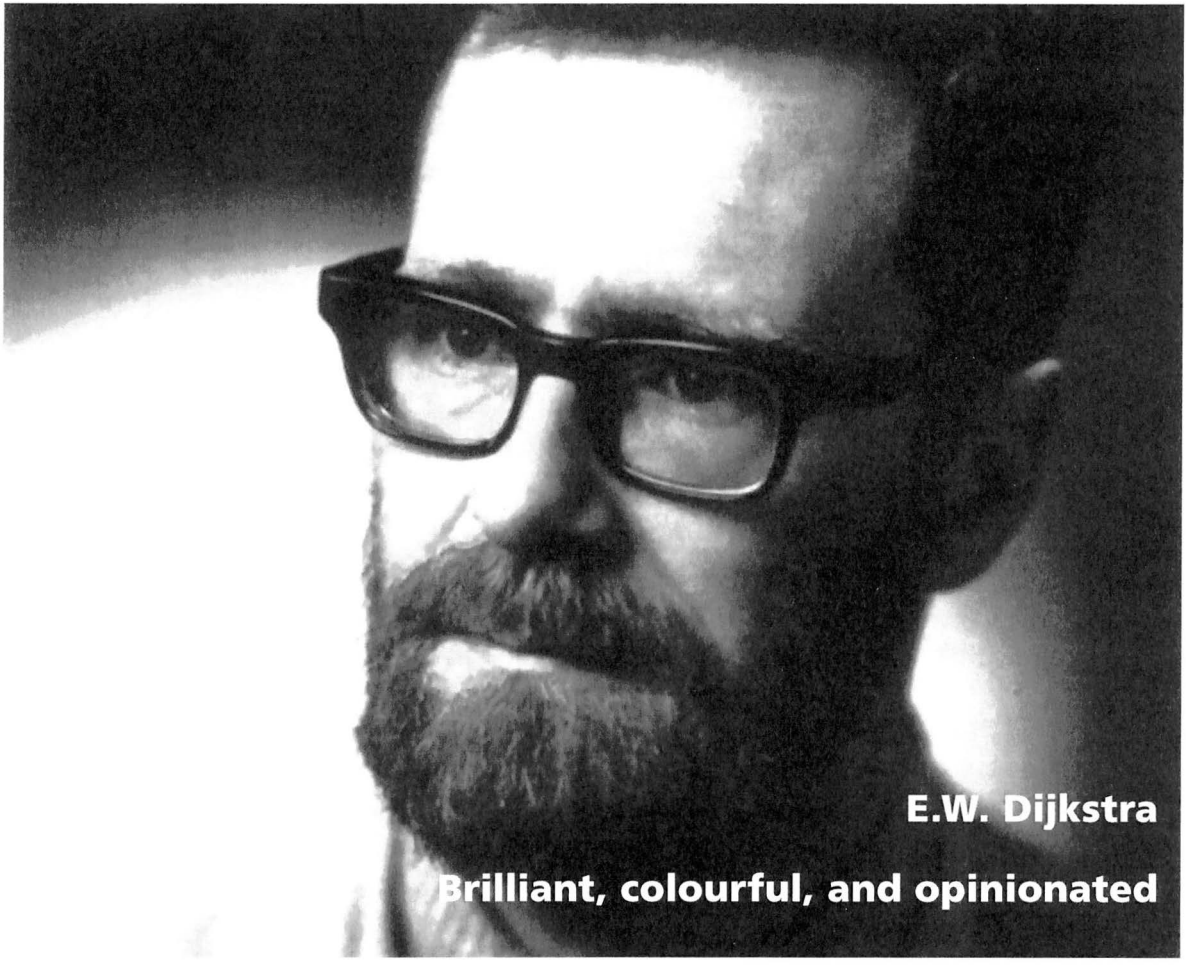

E.W. Dijkstra

Brilliant, colourful, and opinionated

Edsger Wybe Dijkstra was born on 11 May 1930 in Rotterdam, the Netherlands. Trained in theoretical physics, he worked as a computer programmer at the Mathematisch Centrum in Amsterdam from 1952 to 1962. Twenty years later, due to the growing importance of computer science and the pioneering contributions of scientists such as Dijkstra, the centre changed its name to Centrum voor Wiskunde en Informatica (or Centre for Mathematics and Computer Science).

No other scientist has shaped the field of computer science like Dijkstra. His ground-breaking contributions ranged from the engineering to the theoretical side of computer science. They covered areas such as compiler construction, operating systems, distributed systems, sequential and concurrent programming, software engineering, and graph algorithms. Many of Dijkstra's papers, often only a few pages long, are the source of whole new research areas.. In fact, a number of concepts that are now standard in computer science were first identified by Dijkstra and bear names coined by him.

It was thanks to a discussion with Adriaan van Wijngaarden, at that time director of the Computation Department of Mathematisch Centrum, that Dijkstra did not end up becoming

a theoretical physicist. After working as a programmer at the centre for three years, he knocked on Van Wijngaarden's door, full of doubts because he was finding it difficult to combine his role as a programmer with his studies in theoretical physics at Leiden University. 'When I left his office a few hours later,' Dijkstra said in his 1972 ACM Turing Lecture, 'I was a different person.' Indeed, although programming was not yet an established discipline, Van Wijngaarden managed to convince Dijkstra that 'it was here to stay' and that he could play a part in putting the discipline on the map.

Cornerstone of fame: Dijkstra's algorithm

And he did put it on the map. Dijkstra worked at the Mathematisch Centrum from 1952 to 1962, where he came up with what has become, in his words, 'one of the cornerstones of my fame'. That cornerstone is the algorithm for the shortest path, also known as Dijkstra's algorithm. According to Dijkstra, 'it was a twenty-minute invention' that he conceived while having a cup of coffee on the terrace of a café with his fiancée Ria, whom he had met at Mathematisch Centrum. He initially used the algorithm in 1956 to demonstrate the potential of a new computer called ARMAC. But he understood only too well that a demonstration for laypeople had to have a problem and an answer that they could understand.

His solution was to design an algorithm that would find the shortest route between two cities in the Netherlands using a simplified map. 'What's the shortest route from Rotterdam to Groningen?' Dijkstra asked rhetorically in an interview with *Communications of the ACM*. 'It is the algorithm for the shortest path.' Although he used the algorithm for the official presentation of the ARMAC in 1956, it wasn't published until 1959 in his three-page article *A Note on Two Problems in Connexion with Graphs*. Its impact is best

summarized by the Danish computer scientist Mikkel Thorup in 1999: 'Since 1959, all theoretical developments in SSSP [Single-Source Shortest Paths] for general directed and undirected graphs have been based on Dijkstra's algorithm.' Very recently, five researchers showed in an important paper that Dijkstra's algorithm is in a certain natural sense 'optimal', which informally means that it yields the best approach for every possible graph (*www.quantamagazine.org/computer-scientists-establish-the-best-way-to-traverse-a-graph-20241025*).

ALGOL 60 programming

Another key achievement during Dijkstra's time at Mathematisch Centrum was his contribution to the development and popularisation of the ALGOL 60 programming language. In 1958-1959 Dijkstra was involved in a series of meetings which culminated in the publication of the report defining the ALGOL 60 language. Ironically, Dijkstra's name does not appear in the list of 13 authors of the final report: it seems that he left the committee prematurely because he could not agree with the majority opinion. But it was during his tenure as a programmer at Mathematisch Centrum that he and his colleague Jaap Zonneveld wrote the first ALGOL 60 compiler, which among other things used a new method for implementing recursion. His short book *A Primer of Algol 60 Programming*, originally published in 1962, was the standard reference for the programming language for several years.

Tuesday Afternoon Club

In 1962, Dijkstra started working as a professor in the mathematics department at the Technical University of Eindhoven. Two years later, he and his wife Ria moved into a newly

built house in Nuenen, a small village on the outskirts of Eindhoven. Nuenen was put on the world map of computer science in 1973, when Dijkstra started to circulate his reports signed 'Burroughs Research Fellow' with his home address. Many thought that Burroughs, a company known at the time for producing computers based on an innovative hardware architecture, was based in Nuenen.

In fact, Dijkstra was the only research fellow of the Burroughs Corporation and worked for them from home, occasionally travelling to its branches in the USA. As a result, he reduced his appointment at the university to one day a week. That day, Tuesday, soon became known as the day of the famous 'Tuesday Afternoon Club', a seminar in which he and his colleagues discussed scientific articles, scrutinising every aspect - notation, organisation, presentation, language and content. When he moved to the University of Texas at Austin in 1984, it did not take long before a new branch of the Tuesday Afternoon Club opened.

The birth of concurrent programming

In 1968, Dijkstra published his famous paper, *Cooperating Sequential Processes*, which provided the foundation for all subsequent designs of the operating systems and also gave birth to the field of concurrent programming. Many of Dijkstra's ideas from this period had been germinating for some time. Indeed, *Cooperating Sequential Processes* had been completed in 1965 as manuscript, denoted by hem as EWD 123. Dijkstra consecutively numbered his largely handwritten manuscripts, using his Mont Blanc fountain pen, which are known in the world of computer science as EWDs. This paper proposes the first synchronisation mechanism for concurrent processes, the semaphore with its two operations, commonly known as P and V.

Deadlock problem and proofs

In a 1971 paper, Dijkstra illustrated the so-called deadlock problem by means of the 'dining philosophers problem': five philosophers seated around a table are supposed to eat spaghetti sharing only five forks. The problem, however, is that each of them uses two forks to eat. This example became a classic benchmark for explaining new synchronisation primitives. The paper also led to an intense search for high-level synchronisation mechanisms, leading eventually to the concept of a monitor, pioneered by computer scientists Per Brinch Hansen and Tony Hoare.

In the late 1970s, Dijkstra became interested in the development and presentation of proofs. Some of these proofs were surprising applications of his programming methodology to geometry or algebra. He criticised the use of implication and instead favoured proofs presented as chains of equivalences with each step justified as an interlaced comment, and he liked to stress the fact that the equivalence is associative, a fact that logicians knew but apparently never used.

Move to Austin

Dijkstra accepted a position at the University of Texas at Austin in 1984. Austin was like a second home to Dijkstra, and he spent his vacations discovering America's national parks together with his wife in their Volkswagen bus, dubbed the Touring Machine. The classes he taught in Austin actually had little to do with computer science. Instead they dealt with his interest in the presentation of mathematical proofs. He would ask students to write up proofs of the elementary mathematical problems he discussed in class, which he would return with incisive but humorous comments such as 'Many sins of omissions'.

His lectures were highly entertaining because of his sharp comments, striking turns of phrase and curious quotations that he used to put on the blackboard before starting his lecture. He never asked his students to quiet down in the classroom. Instead, he would lower his own voice to the point of being hardly audible. This trick was amazingly effective.

Colourful and opinionated

Dijkstra was a colourful – if sometimes difficult and opinionated – and well-respected man. Many researchers were captivated by his strong personality combined with remarkable working habits, forthright honesty and definite opinions on how to conduct research. Dijkstra seemed to believe that everyone should think, and even behave, the way he did. This made him a natural prophet and accounted for many of his idiosyncrasies.

When asked once how many PhD students he had, Dijkstra replied with a smile: 'Two. Einstein had none'. He attracted a relatively small but stable group of disciples, which included both PhD students and highly renowned computer scientists. They adopted his writing style and notation, his manners, use of a fountain pen, and occasionally even his type of sandals.

Plain prose

The elegance of his writing was unmatched. He could write about formal issues in essay format containing barely any formulas. His paper *Cooperating Sequential Processes* is perhaps the best example. Similarly, he was able to discuss intricate algorithms in distributed computing in a seemingly informal way, in plain prose, with just a few simple formulas. He wrote his articles in a unique style characterised by conciseness, economy of argument, and

clarity of exposition. Each sentence was carefully chiselled. Each paragraph was striking.

The elegance of his writing was matched by his handwriting. In fact, it was so distinct and perfect that in the late 1980s Luca Cardelli, then from the DEC Systems Research Center in California, designed a 'Dijkstra' font for Macintosh computers. Soon after, Dijkstra received a letter typeset in this font and thought it was handwritten, until news of its creation reached him. Some of Dijkstra's colleagues occasionally used this font in their slide presentations during departmental meetings in Austin.

Light in the darkness

Dijkstra's key achievements were recognised early in his career. In 1972, he was presented with computing science's highest honour, the ACM Turing Award. He was a foreign honorary member of the American Academy of Arts and Sciences, a member of the Royal Netherlands Academy of Arts and Sciences (KNAW), and held honorary doctorate degrees from Queen's University Belfast in Northern Ireland and the Athens University of Economics & Business in Greece. In addition, he received numerous other awards and distinctions over a period of 30 years, some just weeks before his death on 6 August 2002.

Not surprisingly, his obituary appeared in a number of newspapers, including *The New York Times*, *The Washington Post*, and *The Guardian*. As J Strother Moore, the chairman of the Computing Science Department at Austin, said during Dijkstra's funeral: 'He was like a man with a light in the darkness. He illuminated virtually every issue he discussed.'

In 2022 an extensive book summarizing Dijkstra's life and works appeared, titled 'Edsger Wybe Dijkstra: His Life, Work, and Legacy'. It was edited by CWI Fellow Krzysztof Apt and Tony Hoare.

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for data-driven businesses worldwide. Žukowski's work has empowered industries from finance to healthcare by making data management faster, more accessible, and cost-effective.

Today, Žukowski contributions continue to impact the database field as he balances his roles as a technology innovator and an advocate for bridging academic research with industry solutions. Since leaving Snowflake, Žukowski transitioned to a role of an investor and advisor, supporting technology development and innovation in his home country, Poland.

About the Dijkstra Fellowships

Once every five years, Centrum Wiskunde & Informatica (CWI) in Amsterdam celebrates the granting of the Dijkstra Fellowships. These fellowships are introduced by CWI to honor scientists for groundbreaking work related to CWI's research themes. The Fellowships are named after the eminent mathematician and computer scientist **Edsger Dijkstra**, who developed groundbreaking work at CWI, such as his shortest path algorithm.

text booklet Mark Speer
photo booklet Edsger Dijkstra in 1963

www.cwi.nl

Programme 21 November 2024

9.30 Walk-in and registration

10.15 Welcome

10.30 **Andy Pavlo**
What Goes Around Comes Around... And Around...

11.15 **Hannes Mühleisen**
Leaving The Two Tier Architecture Behind

12.00 Lunch

13.00 **Allison Lee**
Architecting the Snowflake Data Cloud

13.45 **Viktor Leis**
The Future Of Cloud Database Systems

14.30 Coffee break

15.00 **Madelon Hulsebos**
What Table Representation Learning Brings to Data Systems

15.45 Laudatio by **Peter Boncz** & Dijkstra fellow **Marcin Żukowski**
The Importance of Product

16.30 Drinks