

# The Atlas computer and the Invention of Virtual Memory

## **Proposers' response to a portion of Professor Campbell-Kelly's expert review.**

We appreciate the efforts made by both experts in carefully reviewing our application for this milestone award and we welcome their views, which have helped us to refine our proposal. We appreciate Professor Campbell-Kelly's conclusion that there is a compelling case for the milestone and his statement that the inclusion of Tom Kilburn's name is justified but we take issue with his assertion that virtual memory does not merit the description "invention". Accordingly we take this opportunity to establish that virtual memory was indeed invented by the Manchester team for the Atlas computer. We strongly believe that the achievements of inventors should be fully acknowledged in the historical record and we ask that the wording of the citation fully recognises this.

Professor Campbell-Kelly writes that *"The fact that other developers knew and cited the Atlas does not establish that they would not have arrived at the same end without the precedent of Atlas."* It is a well-established principle of academic writing that the original source of an idea should be cited wherever possible. Taken on its own the fact that Atlas was cited by other authors at the time indicates that there was no prior published work, that the concept was not commonly understood prior to the invention, and that the authors attributed their understanding of the concept to the publications of the Atlas team. In our proposal we discuss the fact that the designers of four commercial computers specifically credit their virtual memory designs to the Atlas (IBM, DEC, CDC and ICL) as well as its use in the Multics operating system in 1965. Professor Campbell-Kelly provides no evidence that there was prior knowledge or understanding of virtual memory before its publication nor any evidence that others would readily have arrived at the same conclusion.

The proposal for the Milestone discusses the patents that were awarded for the Atlas computer at some length and on that basis we assert that we have indeed established that virtual memory was invented by the Atlas team. Three of the patents that were awarded describe the essential components of the memory integration system invented by Kilburn that later became known (c. 1965) as virtual memory. [The UK Patent Office guidelines](#) state:

*To be granted a patent, your invention must be all of the following:*

- *something that can be made or used*
- *new*
- *inventive - not just a simple modification to something that already exists*

Thus it is clear that patents are awarded for inventions, a commonly understood principle of patents. If Professor Campbell-Kelly's assertion that *"virtual memory is a foundation technology for which there is no single inventor."* were correct then a patent would not have been awarded as the application would have failed on bullet points 2 and 3.

The direct relationship between patentability and invention is widely understood, for example [the European Patent Office description of requirements for patentability](#) is:

*There are four basic requirements for patentability:*

Art. 52(1)

- (i) *there must be an "invention", belonging to any field of technology (see G II);*
- (ii) *the invention must be "susceptible of industrial application" (see G III);*
- (iii) *the invention must be "new" (see G IV to VI); and*
- (iv) *the invention must involve an "inventive step" (see G VII).*

All four of the EPO requirements for patentability are founded upon invention. Whilst the EPO was not involved in the granting of patents for virtual memory, this example is provided to demonstrate broader acceptance of the fundamental relationship between patents and invention.

We therefore believe that the award of patents in itself defines the patented concept to be an invention.

As described in the proposal the NRDC took legal action against ICL for breach of patents regarding ICL's use of virtual memory in the ICL2900 series computers. ICL contested the case on the grounds that the specific implementation that they had used was not identical to the specific implementation described in the patent. The University's defence (via NRDC) was that the patent described the general principle and that the detailed description presented in the patent was just an example. ICL conceded this point and paid the University a substantial licence fee (£80k) for their use of virtual memory. If the patents could have been undermined by identifying prior art then ICL would have done so. The resolution of the case in favour of the inventors shows that the patents were sound.

We believe that the patents and their successful defence sufficiently disprove the assertion that virtual memory was not an invention but for completeness we also consider the following:

1. *"The fact that other developers knew and cited the Atlas does not establish that they would not have arrived at the same end without the precedent of Atlas"*

If this approach were taken then any invention could be deemed unworthy of the description "invention" by the same argument and nothing could be said to have been invented. The onus is upon the author to demonstrate via prior art that the invention was obvious and Professor Campbell-Kelly has not done so.

2. Professor Campbell-Kelly asserts that virtual memory cannot be said to have been "invented" by the Manchester team, rather it should be described as a "demonstration". Various dictionary definitions of "invention" are given below:

- a) "Create or design (something that has not existed before); be the originator of.  
*'he invented an improved form of the steam engine'" (OED)*
- b) "to design and/or create something that has never been made before:  
*'The first safety razor was invented by company founder King C. Gillette in 1903'.*" (Cambridge dictionary)
- c) "to create or produce for the first time - Thomas Edison invented the light bulb."  
(Miriam Webster)

We believe that the invention of virtual memory by the Manchester team meets or exceeds all of these definitions and that therefore it is correct to describe it as their invention.

Rod Muttam/Roland Ibbett/Simon Lavington/Jim Miles – 2<sup>nd</sup> March 2021