Decrease-radix design principle for multi-valued logic units and its application

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A new theory referred to as the Decrease-Radix Design is proposed. And based on this theory, the regulations of making multi-valued logic operation units are presented. The theory has laid down a solid foundation for the design of re-constructible logic units in ternary optical computers as well as any other multi-valued computers.

The DRD theory, proposed by Prof. Yi Jin, Dr. Jun-Yong Yan and Dr.Kai-zhong Zuo, presents a theoretical and technological guide for the design of multi-valued computers.

The study of the DRD is reported in Issue 10 (October, 2008) of the *Science in China Series F-Information Sciences*.

Early in 2000, Prof. Jin put forward the fundamental principles and architecture of the TOC, and begun to study the experimental system of processing hundreds of bits with his research team. In 2006, Dr. Yan found the basic rule of designing ternary logic optical units when he worked in the team. Based on the rule Prof. Jin advanced the DRD theory which has later become one of the basic theories in the implementation of TOC.

"DRD theory provides a feasible technical method for the design of multi-valued computer systems" Prof. Jin , the head of the research team in Shanghai University, pointed out. "In such a computer all kinds of LUs can be reconfigured according to the requirements and the complexity of program is greatly simplified."

The key of the theory is that if the physical states to represent information include a special state "D", then any of the n(n×n) n-valued LUs can be realized through the combination of the n×n×(n-1) operation-basic-units (OBU) according to the DRD theory, where "D" is a special physical state named by the authors. It will result in A when the state D operates with any state A. For example, in an electronic circuit, zero voltage is the state "D" that will not change the voltage of other states when added by them.

The contributions of the theory include the following aspects:

1. In n-valued computer systems, one only needs to realize n×n×(n-1) OBUs, then all the n-valued LUs can be implemented through combining some of OBUs according to the DRD theory. The combined LUs can be decomposed into OBUs that can be used repeatedly to construct any other units at any time.

2. The theory brings out an original idea for the design of software algorithm, because any LU can be constructed on hardware according to the truth table. The theory has laid down a solid basis for producing new types of computer. For example, although there are 39=19683 ternary logic operations, it is enough to prepare 3×3×2=18 OBUs in hardware of TOC. When operating the system, the right LU will be established automatically according to DRD, and it will be decomposed into OBUs when its task finishes.

For the software programmer , it suffices to extract the truth table from the actual problem and to send it into the computer without making deduction and transformation any more. This process significantly reduces the complexity of software and accelerates the solution of problem.

In 2006, when working with the TOC group in Shanghai University, Dr.

Yan proposed the following idea: using some necessary basic optical units, one can complete all kinds of calculators according to some regular steps. On September 19, 2006 he listed 10 BOUs and based on these BOUs constructed 17 ternary logical units. Through a deep-going study of the basic idea, Prof. Jin found that 'physics state D' is the precondition and the basis of DRD theory.

Paper: YAN JunYong, JIN Yi & ZUO KaiZhong, Decrease-radix design principle for carrying/borrowing free multi-valued and application in ternary optical computer, *Science in China Series F: Information Sciences*, VOL.51, No.10, October 2008, PP1415-1426.

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