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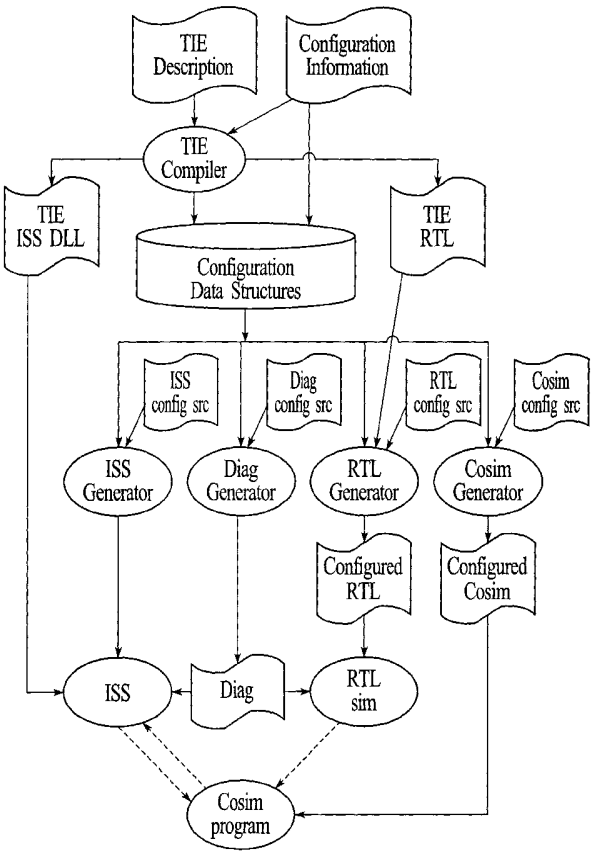
[Continued on next page]

(54) Title: AUTOMATED PROCESSOR GENERATION SYSTEM FOR DESIGNING A CONFIGURABLE PROCESSOR AND METHOD FOR THE SAME



(57) Abstract: A system for generating processor hardware supports a language for significant extensions to the processor instruction set, where the designer specifies only the semantics of the new instructions and the system generates other logic. The extension language provides for the addition of processor state, including register files, and instructions that operate on that state. The language also provides for new data types to be added to the compiler to represent the state added. It allows separate specification of reference semantics and instruction implementation, and uses this to automate design verification. In addition, the system generates formatted instruction set documentation from the language specification.

WO 01/061576 A3

DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW.

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/05051

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06F17/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 896 521 A (SHACKLEFORD J BARRY ET AL) 20 April 1999 (1999-04-20) column 6, line 19 -column 8, line 35 ---	1-5,23
Y	FAUTH A ET AL: "Describing instruction set processors using nML" EUROPEAN DESIGN AND TEST CONFERENCE, 1995. ED&TC 1995, PROCEEDINGS. PARIS, FRANCE 6-9 MARCH 1995, LOS ALAMITOS, CA, USA,IEEE COMPUT. SOC, US, 6 March 1995 (1995-03-06), pages 503-507, XP010147975 ISBN: 0-8186-7039-8 the whole document --- -/--	1-5,23

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 August 2002	14. 11. 02

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hauck, R

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PI US 01/05051

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	HARTOOG M R ET AL: "Generation Of Software Tools From Processor Descriptions For Hardware/software Codesign" PROCEEDINGS OF THE DESIGN AUTOMATION CONFERENCE. ANAHEIM, JUNE 9 - 13, 1997, NEW YORK, ACM, US, vol. CONF. 34, 9 June 1997 (1997-06-09), pages 303-306, XP010227598 ISBN: 0-7803-4093-0 the whole document ---	1-5,23
Y	FAUTH A ET AL: "Generation of hardware machine models from instruction set descriptions" VLSI SIGNAL PROCESSING, VI, 1993., YWORKSHOP ON VELDHOVEN, NETHERLANDS 20-22 OCT. 1993, NEW YORK, NY, USA,IEEE, 20 October 1993 (1993-10-20), pages 242-250, XP010140403 ISBN: 0-7803-0996-0 the whole document ---	1-5,23
Y	EP 0 743 599 A (IMEC INTER UNI MICRO ELECTR) 20 November 1996 (1996-11-20) page 2, line 11 -page 3, line 57 ---	1-5,23
Y	US 5 918 035 A (LANNEER DIRK ET AL) 29 June 1999 (1999-06-29) column 13, line 1 -column 13, line 9 -----	1-5,23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 01/05051

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-5, 23

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-5,23

   A system for designing a configurable processor including means for generating a user-defined register file,

   wherein statements specifying the register file and instructions for accessing the register file are provided.

2. Claims: 6-8,12

   A system for designing a configurable processor including means for generating a user-defined register file,

   wherein read and write ports of the register file are generated and assigned.

3. Claims: 9-11,13-22

   A system for designing a configurable processor including means for generating a user-defined register file,

   wherein a special type of logic for accesing the register file is generated.

4. Claims: 24-27,38

   A system for designing a configurable processor including means for generating a user-defined register file,

   wherein means for verifying correctness of the design are provided.

5. Claims: 28-37

   A system for designing a configurable processor including means for generating a user-defined register file,

   wherein software generation means for generating special types of software are provided.

6. Claims: 39-44

   A system for designing a configurable processor,

   wherein a statement specifying scheduling information of instructions used in the software development tools is included;
   a description of at least one of pipeline logic, pipeline stalling logic and instruction rescheduling logic is generated.

7. Claims: 45-47

A system for designing a configurable processor,

wherein a documentation of a processor instruction set is generated.

8. Claim : 48

A system for designing a configurable processor,

wherein a specification of a processor exception and when a processor instruction raises the exception is included; and hardware supporting that exception as part of the processor hardware implementation is generated.

9. Claim : 49

A processor simulation system comprising:
hardware simulation means for executing a hardware description of an extensible processor;
software simulation means for executing a software reference model of the extensible processor; and
cosimulation means for operating the hardware simulation means and the software simulation means and comparing the results of simulations therefrom to establish correspondence between the hardware description of the extensible processor and the software reference model of the extenisble processor.

1. The only technical relationship between the groups of inventions 1-5 is the subject matter of claim 1 on which all the claims in the above mentioned groups are dependent.

However, document US5896521 discloses:

a) a system for designing a configurable processor (col. 6, lines 34-36), the system comprising:
b) hardware generation means for generating a description of a hardware implementation of the processor (col. 6, line 66 - col. 7, line 8), based on a configuration specification including a predetermined portion (col. 7, lines 64-66: "basic architecture") and a user-defined portion (col. 6, lines 35-40: "primary parameters"); and
c) software generation means for, based on the configuration specification, generating software development tools specific to the hardware implementation (col. 7, lines 15-24);
wherein
d) the hardware generation means is for including a user-defined register file in the description of the hardware implementation of the processor, based on the user-defined portion of the configuration specification (col, 6, 34-39); and
e) the software generation means is for, based on the user-defined portion, including software related to the user-defined processor register file in the software development tools (col. 7, line 57 - col. 8, line 16).

Therefore, the common features between the groups 1-5 of inventions are

not novel.

Consequently, the relationship among the groups 1-5 does not involve "special technical features" as required by Rule 13.2 PCT so that the groups 1-5 are not so linked as to form a single general inventive concept, in violation of Rule 13.1 PCT.

2. Furthermore, the technical relationship between the groups of inventions 6,7,8 and any of the groups of inventions 1-5 is that they all relate to:

a) a system for designing a configurable processor, the system comprising:
b) hardware generation means for, based on a configuration specification including a predetermined portion and a user-defined portion, generating a description of a hardware implementation of the processor; and
c) software generation means for, based on the configuration specification, generating software development toolsspecific to the hardware implementation;

For the same reasoning as under paragraph 1, items a) to c) this is already disclosed by document US5896521. Therefore, the common features between the groups of inventions are not novel.

Consequently, the relationship among the groups 6,7,8 and any of the groups 1-5 does not involve "special technical features" as required by Rule 13.2 PCT so that the above mentioned groups are not so linked as to form a single general inventive concept, in violation of Rule 13.1 PCT.

3. Moreover, the only technical relationship between the group of inventions 9 and any of the groups of inventions 1-8 is that a configurable (or extensible) processor is involved. However, configurable processors are known in the art (see, e.g., US5896521). Therefore, the single common feature between the groups identified above is not novel.

Consequently, the relationship among the group 9 and any of the groups 1-8 does not involve "special technical features" as required by Rule 13.2 PCT so that the above mentioned groups are not so linked as to form a single general inventive concept, in violation of Rule 13.1 PCT.

The application relates to a plurality of inventions, or groups of inventions, in the sense of Rule 13.1 PCT. They have been divided as defined above. If the applicant pays additional fees for one (or more) not yet searched group(s) of invention(s), then the further search(es) may reveal further prior art that gives evidence of a further lack of unity 'a posteriori' within one (or more) of the not yet searched group(s). In such a case only the first invention in this (each of these) group(s) of inventions, which is considered to lack unity of invention, will be the subject of a search.

No further invitation to pay further additional fees will be issued. This is because Article 17(3)(a) PCT stipulates that the ISA shall establish the International Search Report on those parts of the international application which relate to the invention first mentioned

in the claims ('main invention') and for those parts which relate to inventions in respect of which the additional fees were paid. Neither the PCT nor the PCT guidelines provide a legal basis for further invitations to pay further additional search fees (W17/00, point 11 and W1/97, points 11-16).

INTERNATIONAL SEARCH REPORT

nformation on patent family members

Inte---'onal Application No
P US 01/05051

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5896521 A	20-04-1999	JP 2869379 B2	10-03-1999
		JP 9251477 A	22-09-1997
EP 0743599 A	20-11-1996	US 5918035 A	29-06-1999
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US 5918035 A	29-06-1999	EP 0743599 A2	20-11-1996