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**Frenkel**

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(54) **SYSTEMS AND METHODS FOR DISTRIBUTED RULES PROCESSING**


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***G06F 17/30*** (2006.01)
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CPC ................ ***H04L 67/10*** (2013.01); ***G06F 17/30*** (2013.01); ***H04L 67/14*** (2013.01)

(58) **Field of Classification Search**
CPC . G06F 21/6218; G06F 21/604; G06F 21/577; H04L 63/0281
See application file for complete search history.


(56) **References Cited**


U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 4,047,059 A | 9/1977 | Rosenthal | |
| 4,344,142 A | 8/1982 | Diehr, II et al. | |

(Continued)

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| DE | 19911098 | A1 | 12/1999 |
| EP | 0 549 208 | A2 | 6/1993 |

(Continued)

OTHER PUBLICATIONS

[No Author Listed] About the Integrated Work Manager (IWM). Pegasystems, Inc., Apr. 30, 2009, 3 pages, <http://pdn-dev/DevNet/PRPCv5/KB/TMP9ad01zurnf.asp>.

(Continued)



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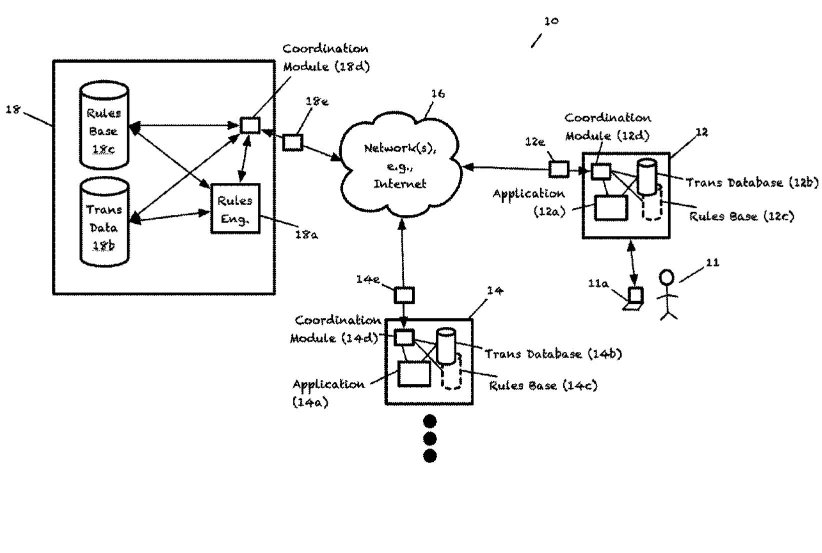
(57) **ABSTRACT**


The invention provides in some aspects a distributed rules processing system that includes a first and second digital data processors that are coupled to one another by one or more networks. A rules base and a transactional data base are each coupled to one of the digital data processors; both may be coupled to the same digital data processor or otherwise. One or more coordination modules (e.g., "proxies"), each of which is associated with a respective one of the digital data processors, makes available to a selected one of those digital data processors from the other of those digital data processors (i) one or more selected rules from the rules base, and/or (ii) one or more data from the transactional database on which those rules are to be executed. The selected digital data processor executes one or more of the selected rules as a rules engine, executes one or more of the selected rules using a rules engine, and/or processes one or more data from the transactional database with rules executing on a rules engine.


**18 Claims, 3 Drawing Sheets**



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,602,168 A 7/1986 Single
4,607,232 A 8/1986 Gill, Jr.
4,659,944 A 4/1987 Miller, Sr. et al.
4,701,130 A 10/1987 Whitney et al.
4,866,634 A 9/1989 Reboh et al.
4,884,217 A 11/1989 Skeirik et al.
4,895,518 A 1/1990 Arnold et al.
4,930,071 A 5/1990 Tou et al.
4,953,106 A 8/1990 Gansner et al.
5,062,060 A 10/1991 Kolnick
5,077,491 A 12/1991 Heck et al.
5,093,794 A 3/1992 Howie et al.
5,119,465 A 6/1992 Jack et al.
5,129,043 A 7/1992 Yue
5,136,184 A 8/1992 Deevy
5,136,523 A 8/1992 Landers
5,140,671 A 8/1992 Hayes et al.
5,193,056 A 3/1993 Boes
5,199,068 A 3/1993 Cox
5,204,939 A 4/1993 Yamazaki et al.
5,228,116 A 7/1993 Harris et al.
5,259,766 A 11/1993 Sack et al.
5,262,941 A 11/1993 Saladin et al.
5,267,175 A 11/1993 Hooper
5,267,865 A 12/1993 Lee et al.
5,270,920 A 12/1993 Pearse et al.
5,276,359 A 1/1994 Chiang
5,276,885 A 1/1994 Milnes et al.
5,291,394 A 3/1994 Chapman
5,291,583 A 3/1994 Bapat
5,295,256 A 3/1994 Bapat
5,297,279 A 3/1994 Bannon et al.
5,301,270 A 4/1994 Steinberg et al.
5,310,349 A 5/1994 Daniels et al.
5,311,422 A 5/1994 Loftin et al.
5,326,270 A 7/1994 Ostby et al.
5,333,254 A 7/1994 Robertson
5,339,390 A 8/1994 Robertson et al.
5,374,932 A 12/1994 Wyschogrod et al.
5,379,366 A 1/1995 Noyes
5,379,387 A 1/1995 Carlstedt et al.
5,381,332 A 1/1995 Wood
5,386,559 A 1/1995 Eisenberg et al.
5,395,243 A 3/1995 Lubin et al.
5,412,756 A 5/1995 Bauman et al.
5,421,011 A 5/1995 Camillone et al.
5,421,730 A 6/1995 Lasker, III et al.
5,446,397 A 8/1995 Yotsuyanagi
5,446,885 A 8/1995 Moore et al.
5,450,480 A 9/1995 Man et al.
5,463,682 A 10/1995 Fisher et al.
5,473,732 A 12/1995 Chang
5,477,170 A 12/1995 Yotsuyanagi
5,481,647 A 1/1996 Brody et al.
5,499,293 A 3/1996 Behram et al.
5,504,879 A 4/1996 Eisenberg et al.
5,512,849 A 4/1996 Wong
5,519,618 A 5/1996 Kastner et al.
5,537,590 A 7/1996 Amado
5,542,024 A 7/1996 Balint et al.
5,542,078 A 7/1996 Martel et al.
5,548,506 A 8/1996 Srinivasan
5,561,740 A 10/1996 Barrett et al.
5,579,223 A 11/1996 Raman
5,579,486 A 11/1996 Oprescu et al.
5,586,311 A 12/1996 Davies et al.
5,596,752 A 1/1997 Knudsen et al.
5,597,312 A 1/1997 Bloom et al.
5,608,789 A 3/1997 Fisher et al.
5,611,076 A 3/1997 Durflinger et al.
5,627,979 A 5/1997 Chang et al.
5,630,127 A 5/1997 Moore et al.
5,649,192 A 7/1997 Stucky
5,655,118 A 8/1997 Heindel et al.
5,664,206 A 9/1997 Murow et al.
5,675,753 A 10/1997 Hansen et al.
5,678,039 A 10/1997 Hinks et al.
5,689,663 A 11/1997 Williams
5,715,450 A 2/1998 Ambrose et al.
5,732,192 A 3/1998 Malin et al.
5,754,740 A 5/1998 Fukuoka et al.
5,761,063 A 6/1998 Jannette et al.
5,761,673 A 6/1998 Bookman et al.
5,765,140 A 6/1998 Knudson et al.
5,768,480 A 6/1998 Crawford, Jr. et al.
5,788,504 A 8/1998 Rice et al.
5,795,155 A 8/1998 Morrel-Samuels
5,809,212 A 9/1998 Shasha
5,815,415 A 9/1998 Bentley et al.
5,819,257 A 10/1998 Monge et al.
5,822,780 A 10/1998 Schutzman
5,825,260 A 10/1998 Ludwig et al.
5,826,077 A 10/1998 Blakeley et al.
5,826,239 A 10/1998 Du et al.
5,826,250 A 10/1998 Trefler
5,826,252 A 10/1998 Wolters, Jr. et al.
5,829,983 A 11/1998 Koyama et al.
5,831,607 A 11/1998 Brooks
5,832,483 A 11/1998 Barker
5,841,435 A 11/1998 Dauerer et al.
5,841,673 A 11/1998 Kobayashi et al.
5,864,865 A 1/1999 Lakis
5,873,096 A 2/1999 Lim et al.
5,875,334 A 2/1999 Chow et al.
5,875,441 A 2/1999 Nakatsuyama et al.
5,880,614 A 3/1999 Zinke et al.
5,880,742 A 3/1999 Rao et al.
5,886,546 A 3/1999 Hwang
5,890,146 A 3/1999 Wavish et al.
5,890,166 A 3/1999 Eisenberg et al.
5,892,512 A 4/1999 Donnelly et al.
5,907,490 A 5/1999 Oliver
5,907,837 A 5/1999 Ferrel et al.
5,910,748 A 6/1999 Reffay et al.
5,911,138 A 6/1999 Li et al.
5,918,222 A 6/1999 Fukui et al.
5,920,717 A 7/1999 Noda
5,930,795 A 7/1999 Chen et al.
5,945,852 A 8/1999 Kosiec
5,974,441 A 10/1999 Rogers et al.
5,974,443 A 10/1999 Jeske
5,978,566 A 11/1999 Plank et al.
5,983,267 A 11/1999 Shklar et al.
5,987,415 A 11/1999 Breese et al.
5,990,742 A 11/1999 Suzuki
5,995,948 A 11/1999 Whitford et al.
5,995,958 A 11/1999 Xu
6,008,673 A 12/1999 Glass et al.
6,008,808 A 12/1999 Almeida et al.
6,012,098 A 1/2000 Bayeh et al.
6,020,768 A 2/2000 Lim
6,023,704 A 2/2000 Gerard et al.
6,023,714 A 2/2000 Hill et al.
6,023,717 A 2/2000 Argyroudis
6,028,457 A 2/2000 Tihanyi
6,037,890 A 3/2000 Glass et al.
6,044,373 A 3/2000 Gladney et al.
6,044,466 A 3/2000 Anand et al.
6,078,982 A 6/2000 Du et al.
6,085,188 A 7/2000 Bachmann et al.
6,085,198 A 7/2000 Skinner et al.
6,091,226 A 7/2000 Amano
6,092,036 A 7/2000 Hamann
6,092,083 A 7/2000 Brodersen et al.
6,094,652 A 7/2000 Faisal
6,098,172 A * 8/2000 Coss et al. ...................... 726/11
6,105,035 A 8/2000 Monge et al.
6,108,004 A 8/2000 Medl
6,122,632 A 9/2000 Botts et al.
6,125,363 A 9/2000 Buzzeo et al.
6,130,679 A 10/2000 Chen et al.
6,137,797 A 10/2000 Bass et al.
6,144,997 A 11/2000 Lamming et al.
6,151,595 A 11/2000 Pirolli et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS


| | | | |
|---|---|---|---|
| 6,151,624 | A | 11/2000 | Teare et al. |
| 6,154,738 | A | 11/2000 | Call |
| 6,167,441 | A | 12/2000 | Himmel |
| 6,177,932 | B1 | 1/2001 | Galdes et al. |
| 6,185,516 | B1 | 2/2001 | Hardin et al. |
| 6,185,534 | B1 | 2/2001 | Breese et al. |
| 6,192,371 | B1 | 2/2001 | Schultz |
| 6,194,919 | B1 | 2/2001 | Park |
| 6,212,502 | B1 | 4/2001 | Ball et al. |
| 6,216,135 | B1 | 4/2001 | Brodersen et al. |
| 6,233,332 | B1 | 5/2001 | Anderson et al. |
| 6,233,617 | B1 | 5/2001 | Rothwein et al. |
| 6,240,417 | B1 | 5/2001 | Eastwick et al. |
| 6,243,713 | B1 | 6/2001 | Nelson et al. |
| 6,246,320 | B1 | 6/2001 | Monroe |
| 6,275,073 | B1 | 8/2001 | Tokuhiro |
| 6,275,790 | B1 | 8/2001 | Yamamoto et al. |
| 6,281,896 | B1 | 8/2001 | Alimpich et al. |
| 6,282,547 | B1 | 8/2001 | Hirsch |
| 6,300,947 | B1 | 10/2001 | Kanevsky |
| 6,304,259 | B1 | 10/2001 | DeStefano |
| 6,308,163 | B1 | 10/2001 | Du et al. |
| 6,313,834 | B1 | 11/2001 | Lau et al. |
| 6,314,415 | B1 | 11/2001 | Mukherjee |
| 6,324,693 | B1 | 11/2001 | Brodersen et al. |
| 6,330,554 | B1 | 12/2001 | Altschuler et al. |
| 6,338,074 | B1 | 1/2002 | Poindexter et al. |
| 6,341,277 | B1 | 1/2002 | Coden et al. |
| 6,341,293 | B1 | 1/2002 | Hennessey |
| 6,344,862 | B1 | 2/2002 | Williams et al. |
| 6,349,238 | B1 | 2/2002 | Gabbita et al. |
| 6,351,734 | B1 | 2/2002 | Lautzenheiser et al. |
| 6,356,286 | B1 | 3/2002 | Lawrence |
| 6,359,633 | B1 | 3/2002 | Balasubramaniam et al. |
| 6,366,299 | B1 | 4/2002 | Lanning et al. |
| 6,369,819 | B1 | 4/2002 | Pitkow et al. |
| 6,370,537 | B1 | 4/2002 | Gilbert et al. |
| 6,380,910 | B1 | 4/2002 | Moustakas et al. |
| 6,380,947 | B1 | 4/2002 | Stead |
| 6,381,738 | B1 | 4/2002 | Choi et al. |
| 6,389,460 | B1 | 5/2002 | Stewart et al. |
| 6,389,510 | B1 | 5/2002 | Chen et al. |
| 6,393,605 | B1 | 5/2002 | Loomans |
| 6,396,885 | B1 | 5/2002 | Ding et al. |
| 6,405,211 | B1 | 6/2002 | Sokol et al. |
| 6,405,251 | B1 | 6/2002 | Bullard et al. |
| 6,415,259 | B1 | 7/2002 | Wolfinger et al. |
| 6,415,283 | B1 | 7/2002 | Conklin |
| 6,418,448 | B1 | 7/2002 | Sarkar |
| 6,421,571 | B1 | 7/2002 | Spriggs et al. |
| 6,426,723 | B1 | 7/2002 | Smith et al. |
| 6,429,870 | B1 | 8/2002 | Chen et al. |
| 6,430,571 | B1 | 8/2002 | Doan et al. |
| 6,430,574 | B1 | 8/2002 | Stead |
| 6,437,799 | B1 | 8/2002 | Shinomi et al. |
| 6,446,065 | B1 | 9/2002 | Nishioka et al. |
| 6,446,089 | B1 | 9/2002 | Brodersen et al. |
| 6,446,200 | B1 | 9/2002 | Ball et al. |
| 6,446,256 | B1 | 9/2002 | Hyman et al. |
| 6,448,964 | B1 | 9/2002 | Isaacs et al. |
| 6,453,038 | B1 | 9/2002 | McFarlane et al. |
| 6,463,346 | B1 | 10/2002 | Flockhart et al. |
| 6,463,440 | B1 | 10/2002 | Hind et al. |
| 6,469,715 | B1 | 10/2002 | Carter et al. |
| 6,469,716 | B1 | 10/2002 | Carter et al. |
| 6,473,467 | B1 | 10/2002 | Wallace et al. |
| 6,473,748 | B1 | 10/2002 | Archer |
| 6,493,331 | B1 | 12/2002 | Walton et al. |
| 6,493,399 | B1 | 12/2002 | Xia et al. |
| 6,493,731 | B1 | 12/2002 | Jones et al. |
| 6,493,754 | B1 | 12/2002 | Rosborough et al. |
| 6,496,812 | B1 | 12/2002 | Campaigne et al. |
| 6,496,833 | B1 | 12/2002 | Goldberg et al. |
| 6,502,239 | B2 | 12/2002 | Zgarba et al. |
| 6,509,898 | B2 | 1/2003 | Chi et al. |

| | | | |
|---|---|---|---|
| 6,513,018 | B1 | 1/2003 | Culhane |
| 6,526,440 | B1 | 2/2003 | Bharat |
| 6,526,457 | B1 | 2/2003 | Birze |
| 6,529,217 | B1 | 3/2003 | Maguire, III et al. |
| 6,529,899 | B1 | 3/2003 | Kraft et al. |
| 6,529,900 | B1 | 3/2003 | Patterson et al. |
| 6,530,079 | B1 | 3/2003 | Choi et al. |
| 6,532,474 | B2 | 3/2003 | Iwamoto et al. |
| 6,539,374 | B2 | 3/2003 | Jung |
| 6,542,912 | B2 | 4/2003 | Meltzer et al. |
| 6,546,381 | B1 | 4/2003 | Subramanian et al. |
| 6,546,406 | B1 | 4/2003 | DeRose et al. |
| 6,549,904 | B1 | 4/2003 | Ortega et al. |
| 6,556,226 | B2 | 4/2003 | Gould et al. |
| 6,556,983 | B1 | 4/2003 | Altschuler et al. |
| 6,556,985 | B1 | 4/2003 | Karch |
| 6,559,864 | B1 | 5/2003 | Olin |
| 6,560,592 | B1 | 5/2003 | Reid et al. |
| 6,560,649 | B1 | 5/2003 | Mullen et al. |
| 6,567,419 | B1 | 5/2003 | Yarlagadda |
| 6,571,222 | B1 | 5/2003 | Matsumoto et al. |
| 6,577,769 | B1 | 6/2003 | Kenyon et al. |
| 6,583,800 | B1 | 6/2003 | Ridgley et al. |
| 6,584,464 | B1 | 6/2003 | Warthen |
| 6,584,569 | B2 | 6/2003 | Reshef et al. |
| 6,594,662 | B1 | 7/2003 | Sieffert et al. |
| 6,597,381 | B1 | 7/2003 | Eskridge et al. |
| 6,597,775 | B2 | 7/2003 | Lawyer et al. |
| 6,598,043 | B1 | 7/2003 | Baclawski |
| 6,606,613 | B1 | 8/2003 | Altschuler et al. |
| 6,625,657 | B1 | 9/2003 | Bullard |
| 6,629,138 | B1 | 9/2003 | Lambert et al. |
| 6,636,850 | B2 | 10/2003 | Lepien |
| 6,636,901 | B2 | 10/2003 | Sudhakaran et al. |
| 6,643,638 | B1 | 11/2003 | Xu |
| 6,643,652 | B2 | 11/2003 | Helgeson et al. |
| 6,661,889 | B1 | 12/2003 | Flockhart et al. |
| 6,661,908 | B1 | 12/2003 | Suchard et al. |
| 6,678,679 | B1 | 1/2004 | Bradford |
| 6,678,773 | B2 | 1/2004 | Marietta et al. |
| 6,678,882 | B1 | 1/2004 | Hurley et al. |
| 6,684,261 | B1 | 1/2004 | Orton et al. |
| 6,690,788 | B1 | 2/2004 | Bauer et al. |
| 6,691,067 | B1 | 2/2004 | Ding et al. |
| 6,691,230 | B1 | 2/2004 | Bardon |
| 6,701,314 | B1 | 3/2004 | Conover et al. |
| 6,711,565 | B1 | 3/2004 | Subramaniam et al. |
| 6,721,747 | B2 | 4/2004 | Lipkin |
| 6,728,702 | B1 | 4/2004 | Subramaniam et al. |
| 6,728,852 | B1 | 4/2004 | Stoutamire |
| 6,732,095 | B1 | 5/2004 | Warshavsky et al. |
| 6,732,111 | B2 | 5/2004 | Brodersen et al. |
| 6,748,422 | B2 | 6/2004 | Morin et al. |
| 6,750,858 | B1 | 6/2004 | Rosenstein |
| 6,751,663 | B1 | 6/2004 | Farrell et al. |
| 6,754,475 | B1 | 6/2004 | Harrison et al. |
| 6,756,994 | B1 | 6/2004 | Tlaskal |
| 6,763,351 | B1 | 7/2004 | Subramaniam et al. |
| 6,771,706 | B2 | 8/2004 | Ling et al. |
| 6,772,148 | B2 | 8/2004 | Baclawski |
| 6,772,350 | B1 | 8/2004 | Belani et al. |
| 6,778,971 | B1 | 8/2004 | Altschuler et al. |
| 6,782,091 | B1 | 8/2004 | Dunning, III |
| 6,785,341 | B2 | 8/2004 | Walton et al. |
| 6,788,114 | B1 | 9/2004 | Krenzke et al. |
| 6,792,420 | B2 | 9/2004 | Chen et al. |
| RE38,633 | E | 10/2004 | Srinivasan |
| 6,804,330 | B1 | 10/2004 | Jones et al. |
| 6,807,632 | B1 | 10/2004 | Carpentier et al. |
| 6,810,429 | B1 * | 10/2004 | Walsh et al. ................. 709/246 |
| 6,820,082 | B1 | 11/2004 | Cook et al. |
| 6,829,655 | B1 | 12/2004 | Huang et al. |
| 6,831,668 | B2 | 12/2004 | Cras et al. |
| 6,839,682 | B1 | 1/2005 | Blume et al. |
| 6,847,982 | B2 | 1/2005 | Parker et al. |
| 6,851,089 | B1 | 2/2005 | Erickson et al. |
| 6,856,575 | B2 | 2/2005 | Jones |
| 6,856,992 | B2 | 2/2005 | Britton et al. |
| 6,859,787 | B2 | 2/2005 | Fisher et al. |

(56) **References Cited**

U.S. PATENT DOCUMENTS


| | | | |
|---|---|---|---|
| 6,865,546 | B1 | 3/2005 | Song |
| 6,865,566 | B2 | 3/2005 | Serrano-Morales et al. |
| 6,865,575 | B1 | 3/2005 | Smith et al. |
| 6,867,789 | B1 | 3/2005 | Allen et al. |
| 6,918,222 | B2 | 7/2005 | Lat et al. |
| 6,920,615 | B1 | 7/2005 | Campbell et al. |
| 6,925,457 | B2 | 8/2005 | Britton et al. |
| 6,925,609 | B1 | 8/2005 | Lucke |
| 6,927,728 | B2 | 8/2005 | Vook et al. |
| 6,934,702 | B2 | 8/2005 | Faybishenko et al. |
| 6,940,917 | B2 | 9/2005 | Menon et al. |
| 6,944,644 | B2 | 9/2005 | Gideon |
| 6,954,737 | B2 | 10/2005 | Kalantar et al. |
| 6,956,845 | B2 | 10/2005 | Baker et al. |
| 6,959,432 | B2 | 10/2005 | Crocker |
| 6,961,725 | B2 | 11/2005 | Yuan et al. |
| 6,965,889 | B2 | 11/2005 | Serrano-Morales et al. |
| 6,966,033 | B1 | 11/2005 | Gasser et al. |
| 6,976,144 | B1 | 12/2005 | Trefler et al. |
| 6,985,912 | B2 | 1/2006 | Mullins et al. |
| 7,020,869 | B2 | 3/2006 | Abrari et al. |
| 7,028,225 | B2 | 4/2006 | Maso et al. |
| 7,031,901 | B2 | 4/2006 | El Ata |
| 7,035,808 | B1 | 4/2006 | Ford |
| 7,058,367 | B1 | 6/2006 | Luo et al. |
| 7,058,637 | B2 | 6/2006 | Britton et al. |
| 7,064,766 | B2 | 6/2006 | Beda et al. |
| 7,073,177 | B2 | 7/2006 | Foote et al. |
| 7,076,558 | B1 | 7/2006 | Dunn |
| 7,089,193 | B2 | 8/2006 | Newbold |
| 7,103,173 | B2 | 9/2006 | Rodenbusch et al. |
| 7,124,145 | B2 | 10/2006 | Surasinghe |
| 7,139,999 | B2 | 11/2006 | Bowman-Amuah |
| 7,143,116 | B2 | 11/2006 | Okitsu et al. |
| 7,171,145 | B2 | 1/2007 | Takeuchi et al. |
| 7,171,415 | B2 | 1/2007 | Kan et al. |
| 7,174,514 | B2 | 2/2007 | Subramaniam et al. |
| 7,178,109 | B2 | 2/2007 | Hewson et al. |
| 7,194,380 | B2 | 3/2007 | Barrow et al. |
| 7,289,793 | B2 | 10/2007 | Norwood et al. |
| RE39,918 | E | 11/2007 | Slemmer |
| 7,302,417 | B2 | 11/2007 | Iyer |
| 7,318,020 | B1 | 1/2008 | Kim |
| 7,318,066 | B2 | 1/2008 | Kaufman et al. |
| 7,334,039 | B1 | 2/2008 | Majkut et al. |
| 7,343,295 | B2 | 3/2008 | Pomerance |
| 7,353,229 | B2 | 4/2008 | Vilcauskas, Jr. et al. |
| 7,398,391 | B2 | 7/2008 | Carpentier et al. |
| 7,406,475 | B2 | 7/2008 | Dorne et al. |
| 7,412,388 | B2 | 8/2008 | Dalal et al. |
| 7,415,731 | B2 | 8/2008 | Carpentier et al. |
| 7,505,827 | B1 | 3/2009 | Boddy et al. |
| 7,526,481 | B1 | 4/2009 | Cusson et al. |
| 7,536,294 | B1 | 5/2009 | Stanz et al. |
| 7,555,645 | B2 | 6/2009 | Vissapragada |
| 7,574,494 | B1 | 8/2009 | Mayernick et al. |
| 7,596,504 | B2 | 9/2009 | Hughes et al. |
| 7,640,222 | B2 | 12/2009 | Trefler |
| 7,647,417 | B1 | 1/2010 | Taneja |
| 7,665,063 | B1 | 2/2010 | Hofmann et al. |
| 7,685,013 | B2 | 3/2010 | Gendler |
| 7,689,447 | B1 | 3/2010 | Aboujaoude et al. |
| 7,711,919 | B2 | 5/2010 | Trefler et al. |
| 7,779,395 | B1 | 8/2010 | Chotin et al. |
| 7,787,609 | B1 | 8/2010 | Flockhart et al. |
| 7,818,506 | B1 | 10/2010 | Shepstone et al. |
| 7,844,594 | B1 | 11/2010 | Holt et al. |
| 7,870,244 | B2 | 1/2011 | Chong et al. |
| 7,937,690 | B2 | 5/2011 | Casey |
| 7,971,180 | B2 | 6/2011 | Kreamer et al. |
| 7,983,895 | B2 | 7/2011 | McEntee et al. |
| 8,001,519 | B2 | 8/2011 | Conallen et al. |
| 8,037,329 | B2 | 10/2011 | Leech et al. |
| 8,073,802 | B2 | 12/2011 | Trefler |
| 8,250,525 | B2 | 8/2012 | Khatutsky |
| 8,335,704 | B2 | 12/2012 | Trefler et al. |
| 8,386,960 | B1 | 2/2013 | Eismann et al. |
| 8,468,492 | B1 | 6/2013 | Frenkel |
| 8,479,157 | B2 | 7/2013 | Trefler et al. |
| 8,516,193 | B1 | 8/2013 | Clinton et al. |
| 8,843,435 | B1 | 9/2014 | Trefler et al. |
| 8,880,487 | B1 | 11/2014 | Clinton et al. |
| 8,924,335 | B1 | 12/2014 | Trefler et al. |
| 8,959,480 | B2 | 2/2015 | Trefler et al. |
| 9,026,733 | B1 | 5/2015 | Clinton et al. |
| 2001/0013799 | A1 | 8/2001 | Wang |
| 2001/0035777 | A1 | 11/2001 | Wang et al. |
| 2001/0047355 | A1 | 11/2001 | Anwar |
| 2001/0049682 | A1 | 12/2001 | Vincent et al. |
| 2001/0052108 | A1 | 12/2001 | Bowman-Amuah |
| 2001/0054064 | A1 | 12/2001 | Kannan |
| 2002/0010855 | A1 | 1/2002 | Reshef et al. |
| 2002/0013804 | A1 | 1/2002 | Gideon |
| 2002/0029161 | A1 | 3/2002 | Brodersen et al. |
| 2002/0042831 | A1 | 4/2002 | Capone et al. |
| 2002/0049603 | A1 | 4/2002 | Mehra et al. |
| 2002/0049715 | A1 | 4/2002 | Serrano-Morales et al. |
| 2002/0049788 | A1 | 4/2002 | Lipkin et al. |
| 2002/0054152 | A1 | 5/2002 | Palaniappan et al. |
| 2002/0059566 | A1 | 5/2002 | Delcambre et al. |
| 2002/0070972 | A1 | 6/2002 | Windl et al. |
| 2002/0073337 | A1 | 6/2002 | Ioele et al. |
| 2002/0091677 | A1 | 7/2002 | Sridhar |
| 2002/0091678 | A1 | 7/2002 | Miller et al. |
| 2002/0091710 | A1 | 7/2002 | Dunham et al. |
| 2002/0091835 | A1 | 7/2002 | Lentini et al. |
| 2002/0093537 | A1 | 7/2002 | Bocioned et al. |
| 2002/0107684 | A1 | 8/2002 | Gao |
| 2002/0118688 | A1 | 8/2002 | Jagannathan |
| 2002/0120598 | A1 | 8/2002 | Shadmon et al. |
| 2002/0120627 | A1 | 8/2002 | Mankoff |
| 2002/0120762 | A1 | 8/2002 | Cheng et al. |
| 2002/0133502 | A1 | 9/2002 | Rosenthal et al. |
| 2002/0177232 | A1 | 11/2002 | Melker et al. |
| 2002/0178232 | A1 | 11/2002 | Ferguson |
| 2002/0181692 | A1 | 12/2002 | Flockhart et al. |
| 2002/0184610 | A1 | 12/2002 | Chong et al. |
| 2003/0001894 | A1 | 1/2003 | Boykin et al. |
| 2003/0004934 | A1 | 1/2003 | Qian |
| 2003/0004951 | A1 | 1/2003 | Chokshi |
| 2003/0009239 | A1 | 1/2003 | Lombardo et al. |
| 2003/0014399 | A1 | 1/2003 | Hansen et al. |
| 2003/0037145 | A1 | 2/2003 | Fagan |
| 2003/0050834 | A1 | 3/2003 | Caplan |
| 2003/0050927 | A1 | 3/2003 | Hussam |
| 2003/0050929 | A1 | 3/2003 | Bookman et al. |
| 2003/0061209 | A1 | 3/2003 | Raboczi et al. |
| 2003/0065544 | A1 | 4/2003 | Elzinga et al. |
| 2003/0066031 | A1 | 4/2003 | Laane |
| 2003/0074352 | A1 | 4/2003 | Raboczi et al. |
| 2003/0074369 | A1 | 4/2003 | Scheutze et al. |
| 2003/0084401 | A1 | 5/2003 | Abel et al. |
| 2003/0109951 | A1 | 6/2003 | Hsiung et al. |
| 2003/0115281 | A1 | 6/2003 | McHenry et al. |
| 2003/0135358 | A1 | 7/2003 | Lissauer et al. |
| 2003/0152212 | A1 | 8/2003 | Burok et al. |
| 2003/0154380 | A1 | 8/2003 | Richmond et al. |
| 2003/0191626 | A1 | 10/2003 | Al-Onaizan et al. |
| 2003/0198337 | A1 | 10/2003 | Lenard |
| 2003/0200254 | A1 | 10/2003 | Wei |
| 2003/0200371 | A1 | 10/2003 | Abujbara |
| 2003/0202617 | A1 | 10/2003 | Casper |
| 2003/0222680 | A1 | 12/2003 | Jaussi |
| 2003/0229529 | A1 | 12/2003 | Mui et al. |
| 2003/0229544 | A1 | 12/2003 | Veres et al. |
| 2004/0024603 | A1 | 2/2004 | Mahoney et al. |
| 2004/0034651 | A1 | 2/2004 | Gupta et al. |
| 2004/0049479 | A1 | 3/2004 | Dorne et al. |
| 2004/0049509 | A1 | 3/2004 | Keller et al. |
| 2004/0054610 | A1 | 3/2004 | Amstutz et al. |
| 2004/0064552 | A1 | 4/2004 | Chong et al. |
| 2004/0068517 | A1 | 4/2004 | Scott |
| 2004/0088199 | A1 | 5/2004 | Childress et al. |
| 2004/0103014 | A1 | 5/2004 | Teegan et al. |

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 2004/0117759 A1 | 6/2004 | Rippert et al. | |
| 2004/0122652 A1 | 6/2004 | Andrews et al. | |
| 2004/0133416 A1 | 7/2004 | Fukuoka et al. | |
| 2004/0133876 A1 | 7/2004 | Sproule | |
| 2004/0139021 A1 | 7/2004 | Reed et al. | |
| 2004/0145607 A1 | 7/2004 | Alderson | |
| 2004/0147138 A1 | 7/2004 | Vaartstra | |
| 2004/0162812 A1 | 8/2004 | Lane et al. | |
| 2004/0162822 A1 | 8/2004 | Papanyan et al. | |
| 2004/0167765 A1 | 8/2004 | El Ata | |
| 2004/0205672 A1 | 10/2004 | Bates et al. | |
| 2004/0220792 A1 | 11/2004 | Gallanis et al. | |
| 2004/0236566 A1 | 11/2004 | Simske | |
| 2004/0243587 A1 | 12/2004 | Nuyens et al. | |
| 2004/0268221 A1 | 12/2004 | Wang | |
| 2004/0268299 A1 | 12/2004 | Lei et al. | |
| 2005/0027563 A1 | 2/2005 | Fackler et al. | |
| 2005/0039191 A1 | 2/2005 | Hewson et al. | |
| 2005/0044198 A1 | 2/2005 | Okitsu et al. | |
| 2005/0050000 A1 | 3/2005 | Kwok et al. | |
| 2005/0055330 A1 | 3/2005 | Britton et al. | |
| 2005/0059566 A1 | 3/2005 | Brown et al. | |
| 2005/0060372 A1 | 3/2005 | DeBettencourt et al. | |
| 2005/0071211 A1 | 3/2005 | Flockhart et al. | |
| 2005/0104628 A1 | 5/2005 | Tanzawa et al. | |
| 2005/0125683 A1 | 6/2005 | Matsuyama et al. | |
| 2005/0132048 A1 | 6/2005 | Kogan et al. | |
| 2005/0138162 A1 | 6/2005 | Byrnes | |
| 2005/0144023 A1 | 6/2005 | Aboujaoude et al. | |
| 2005/0165823 A1 | 7/2005 | Ondrusek et al. | |
| 2005/0198021 A1 | 9/2005 | Wilcox et al. | |
| 2005/0216235 A1 | 9/2005 | Butt et al. | |
| 2005/0228875 A1 | 10/2005 | Monitzer et al. | |
| 2005/0234882 A1 | 10/2005 | Bennett et al. | |
| 2005/0267770 A1 | 12/2005 | Banavar et al. | |
| 2005/0288920 A1 | 12/2005 | Green et al. | |
| 2006/0004845 A1 | 1/2006 | Kristiansen et al. | |
| 2006/0015388 A1 | 1/2006 | Flockhart et al. | |
| 2006/0020783 A1 | 1/2006 | Fisher | |
| 2006/0041861 A1 | 2/2006 | Trefler et al. | |
| 2006/0053125 A1 | 3/2006 | Scott | |
| 2006/0063138 A1 | 3/2006 | Loff et al. | |
| 2006/0064486 A1 | 3/2006 | Baron et al. | |
| 2006/0064667 A1 | 3/2006 | Freitas | |
| 2006/0075360 A1 | 4/2006 | Bixler | |
| 2006/0080082 A1 | 4/2006 | Ravindra et al. | |
| 2006/0080401 A1 | 4/2006 | Gill et al. | |
| 2006/0092467 A1 | 5/2006 | Dumitrescu et al. | |
| 2006/0100847 A1 | 5/2006 | McEntee et al. | |
| 2006/0101386 A1 | 5/2006 | Gerken et al. | |
| 2006/0101393 A1 | 5/2006 | Gerken et al. | |
| 2006/0106846 A1 | 5/2006 | Schulz et al. | |
| 2006/0139312 A1 | 6/2006 | Sinclair et al. | |
| 2006/0149751 A1 | 7/2006 | Jade et al. | |
| 2006/0167655 A1 | 7/2006 | Barrow et al. | |
| 2006/0173724 A1 | 8/2006 | Trefler et al. | |
| 2006/0173871 A1 | 8/2006 | Taniguchi et al. | |
| 2006/0206303 A1 | 9/2006 | Kohlmeier et al. | |
| 2006/0206305 A1 | 9/2006 | Kimura et al. | |
| 2006/0218166 A1 | 9/2006 | Myers et al. | |
| 2006/0271559 A1 | 11/2006 | Stavrakos et al. | |
| 2006/0271920 A1 | 11/2006 | Abouelsaadat | |
| 2006/0288348 A1 | 12/2006 | Kawamoto et al. | |
| 2007/0005623 A1 | 1/2007 | Self et al. | |
| 2007/0010991 A1 | 1/2007 | Lei et al. | |
| 2007/0028225 A1 | 2/2007 | Whittaker et al. | |
| 2007/0038765 A1 | 2/2007 | Dunn | |
| 2007/0055938 A1 | 3/2007 | Herring et al. | |
| 2007/0061789 A1 | 3/2007 | Kaneko et al. | |
| 2007/0094199 A1 | 4/2007 | Deshpande et al. | |
| 2007/0118497 A1 | 5/2007 | Katoh | |
| 2007/0130130 A1* | 6/2007 | Chan et al. | 707/3 |
| 2007/0136068 A1 | 6/2007 | Horvitz | |
| 2007/0143163 A1 | 6/2007 | Weiss et al. | |
| 2007/0143851 A1 | 6/2007 | Nicodemus et al. | |
| 2007/0203756 A1 | 8/2007 | Sears et al. | |
| 2007/0208553 A1 | 9/2007 | Hastings et al. | |
| 2007/0226031 A1 | 9/2007 | Manson et al. | |
| 2007/0233902 A1 | 10/2007 | Trefler et al. | |
| 2007/0239646 A1 | 10/2007 | Trefler | |
| 2007/0260584 A1 | 11/2007 | Marti et al. | |
| 2007/0294644 A1 | 12/2007 | Yost | |
| 2008/0002823 A1 | 1/2008 | Fama et al. | |
| 2008/0046462 A1 | 2/2008 | Kaufman et al. | |
| 2008/0077384 A1 | 3/2008 | Agapi et al. | |
| 2008/0085502 A1 | 4/2008 | Allen et al. | |
| 2008/0109467 A1 | 5/2008 | Brookins et al. | |
| 2008/0163253 A1 | 7/2008 | Massmann et al. | |
| 2008/0184230 A1 | 7/2008 | Leech et al. | |
| 2008/0189679 A1 | 8/2008 | Rodriguez et al. | |
| 2008/0195377 A1 | 8/2008 | Kato et al. | |
| 2008/0196003 A1 | 8/2008 | Gerken et al. | |
| 2008/0208785 A1 | 8/2008 | Trefler et al. | |
| 2008/0216055 A1 | 9/2008 | Khatutsky | |
| 2008/0216060 A1 | 9/2008 | Vargas | |
| 2008/0263510 A1 | 10/2008 | Nerome et al. | |
| 2009/0007084 A1 | 1/2009 | Conallen et al. | |
| 2009/0018998 A1 | 1/2009 | Patten, Jr. et al. | |
| 2009/0075634 A1 | 3/2009 | Sinclair et al. | |
| 2009/0083697 A1 | 3/2009 | Zhang et al. | |
| 2009/0132232 A1 | 5/2009 | Trefler | |
| 2009/0138844 A1 | 5/2009 | Halberstadt et al. | |
| 2009/0158407 A1 | 6/2009 | Nicodemus et al. | |
| 2009/0164494 A1 | 6/2009 | Dodin | |
| 2009/0171938 A1 | 7/2009 | Levin et al. | |
| 2009/0276206 A1 | 11/2009 | Fitzpatrick et al. | |
| 2009/0282384 A1 | 11/2009 | Keppler | |
| 2010/0011338 A1 | 1/2010 | Lewis | |
| 2010/0088266 A1 | 4/2010 | Trefler | |
| 2010/0107137 A1 | 4/2010 | Trefler et al. | |
| 2010/0217737 A1 | 8/2010 | Shama | |
| 2012/0041921 A1* | 2/2012 | Canaday et al. | 707/607 |
| 2013/0007267 A1 | 1/2013 | Khatutsky | |
| 2013/0231970 A1 | 9/2013 | Trefler et al. | |
| 2013/0254833 A1 | 9/2013 | Nicodemus et al. | |
| 2014/0019400 A1 | 1/2014 | Trefler et al. | |
| 2015/0089406 A1 | 3/2015 | Trefler et al. | |

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| EP | 0 669 717 | A1 | 8/1995 |
| EP | 0 996 916 | A1 | 5/2000 |
| EP | 1 015 997 | A2 | 7/2000 |
| EP | 1 019 807 | A2 | 7/2000 |
| EP | 1 073 955 | A1 | 2/2001 |
| EP | 1 073 992 | A1 | 2/2001 |
| EP | 1 135 723 | A1 | 9/2001 |
| EP | 1 163 604 | A2 | 12/2001 |
| EP | 1 183 636 | A1 | 3/2002 |
| EP | 1 196 882 | A1 | 4/2002 |
| EP | 1 203 310 | A1 | 5/2002 |
| EP | 1 208 482 | A1 | 5/2002 |
| EP | 1 212 668 | A2 | 6/2002 |
| EP | 1 240 592 | A1 | 9/2002 |
| EP | 1 277 102 | A2 | 1/2003 |
| EP | 1 277 119 | A1 | 1/2003 |
| EP | 1 277 120 | A1 | 1/2003 |
| EP | 1 277 153 | A1 | 1/2003 |
| EP | 1 277 155 | A1 | 1/2003 |
| EP | 1 277 329 | A1 | 1/2003 |
| EP | 1 374 083 | A1 | 1/2004 |
| EP | 1 382 030 | A2 | 1/2004 |
| EP | 1 386 241 | A1 | 2/2004 |
| EP | 1 393 172 | A2 | 3/2004 |
| EP | 1 393 188 | A1 | 3/2004 |
| EP | 1 402 336 | A2 | 3/2004 |
| EP | 1 407 384 | A1 | 4/2004 |
| EP | 1 430 396 | A1 | 6/2004 |
| EP | 1 438 649 | A1 | 7/2004 |
| EP | 1 438 654 | A1 | 7/2004 |
| EP | 1 438 672 | A1 | 7/2004 |
| EP | 1 483 685 | A1 | 12/2004 |
| EP | 1 490 747 | A1 | 12/2004 |
| EP | 1 490 809 | A1 | 12/2004 |

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| EP | 1 492 232 | A1 | 12/2004 |
| EP | 1 782 183 | A2 | 5/2007 |
| EP | 1 830 312 | A1 | 9/2007 |
| EP | 1 840 803 | A1 | 10/2007 |
| EP | 2 115 581 | A1 | 11/2009 |
| WO | 98/38564 | A2 | 9/1998 |
| WO | 98/40807 | A2 | 9/1998 |
| WO | 99/05632 | A1 | 2/1999 |
| WO | 99/45465 | A1 | 9/1999 |
| WO | 99/50784 | A1 | 10/1999 |
| WO | 00/33187 | A1 | 6/2000 |
| WO | 00/33217 | A1 | 6/2000 |
| WO | 00/33226 | A1 | 6/2000 |
| WO | 00/33235 | A1 | 6/2000 |
| WO | 00/33238 | A2 | 6/2000 |
| WO | 00/52553 | A2 | 9/2000 |
| WO | 00/52603 | A1 | 9/2000 |
| WO | 00/67194 | A2 | 11/2000 |
| WO | 01/40958 | A1 | 6/2001 |
| WO | 01/75610 | A1 | 10/2001 |
| WO | 01/75614 | A1 | 10/2001 |
| WO | 01/75747 | A1 | 10/2001 |
| WO | 01/75748 | A1 | 10/2001 |
| WO | 01/76206 | A1 | 10/2001 |
| WO | 01/77787 | A2 | 10/2001 |
| WO | 01/79994 | A2 | 10/2001 |
| WO | 02/21254 | A2 | 3/2002 |
| WO | 02/44947 | A2 | 6/2002 |
| WO | 02/056249 | A2 | 7/2002 |
| WO | 02/080006 | A1 | 10/2002 |
| WO | 02/080015 | A1 | 10/2002 |
| WO | 02/082300 | A1 | 10/2002 |
| WO | 02/084925 | A2 | 10/2002 |
| WO | 02/088869 | A2 | 11/2002 |
| WO | 02/091346 | A1 | 11/2002 |
| WO | 02/101517 | A1 | 12/2002 |
| WO | 02/103576 | A1 | 12/2002 |
| WO | 03/021393 | A2 | 3/2003 |
| WO | 03/029923 | A2 | 4/2003 |
| WO | 03/029955 | A1 | 4/2003 |
| WO | 03/030005 | A1 | 4/2003 |
| WO | 03/030013 | A1 | 4/2003 |
| WO | 03/030014 | A1 | 4/2003 |
| WO | 03/058504 | A1 | 7/2003 |
| WO | 03/069500 | A1 | 8/2003 |
| WO | 03/071380 | A2 | 8/2003 |
| WO | 03/071388 | A2 | 8/2003 |
| WO | 03/073319 | A2 | 9/2003 |
| WO | 03/077139 | A1 | 9/2003 |
| WO | 03/085503 | A1 | 10/2003 |
| WO | 03/085580 | A1 | 10/2003 |
| WO | 2004/001613 | A1 | 12/2003 |
| WO | 2004/003684 | A2 | 1/2004 |
| WO | 2004/003766 | A1 | 1/2004 |
| WO | 2004/003885 | A1 | 1/2004 |
| WO | 2004/046882 | A2 | 6/2004 |
| WO | 2004/061815 | A1 | 7/2004 |
| WO | 2004/086197 | A2 | 10/2004 |
| WO | 2004/086198 | A2 | 10/2004 |
| WO | 2004/095207 | A2 | 11/2004 |
| WO | 2004/095208 | A2 | 11/2004 |
| WO | 2004/114147 | A1 | 12/2004 |
| WO | 2005/001627 | A2 | 1/2005 |
| WO | 2005/003888 | A2 | 1/2005 |
| WO | 2005/010645 | A2 | 2/2005 |
| WO | 2005/117549 | A2 | 12/2005 |
| WO | 2006/081536 | A2 | 8/2006 |
| WO | 2007/033922 | A2 | 3/2007 |
| WO | 2008/109441 | A1 | 9/2008 |
| WO | 2009/097384 | A1 | 8/2009 |

OTHER PUBLICATIONS

[No Author Listed] How to Configure and Customize the Universal Worklist. SAP Netweaver '04 and SAP Enterprise Portal 6.0. SAP AG. Version 1, May 2004, 65 pages. <http://www.erpgenie.com/sap/netweaver/ep/Configuring%20the%20UWL.pdf>.

[No Author Listed] How to configure the IWM/IAC gateway. Pegasystems, Inc., Apr. 30, 2009, 4 pages, <http://pdn-dev/DevNet/PRPCv5/KB/TMP9cf8fzurq4.asp>.

[No Author Listed] How to install the Integrated Work Manager (IWM). Pegasystems, Inc., Apr. 30, 2009, 6 pages, <http://pdn-dev/DevNet/PRPCv5/KB/TMP9br1ezurp8.asp>.

[No Author Listed] HP Integrated Lights-Out 2, User Guide, Part No. 394326-004, HP, Aug. 2006, 189 pages.

[No Author Listed] IP Prior Art Database, Options when returning work items in workflow management systems. IBM, IPCOM00002798D, 2004, 3 pages.

[No Author Listed] IP Prior Art Database, Staff Queries and Assignments in Workflow Systems. IBM, IPCOM000142382D, 2006, 4 pages.

[No Author Listed] IP Prior Art Database, Using work items to manage user interactions with adaptive business services. IBM TDB, IPCOM000015953D, 2003, 4 pages.

[No Author Listed] Integrating with External Systems, PegaRULES Process Commander 5.2. Process Commander 5.2 reference. Pegasystems Inc, Cambridge, MA, 2006, 103 pages. <http://pdn.pega.com/ProductSupport/Products/PegaRULESProcessCommander/documents/PRPC/V5/502/iwes/PRPC52__Integrating__with__External__Systems.pdf>.

[No Author Listed] Localizing an Application, PegaRULES Process Commander. Process Commander 4.2 reference. Pegasystems Inc., Cambdrige, MA, 2006, 92 pages <http://pdn.pega.com/DevNet/PRPCv4/TechnologyPapers/documents/Localization0402.pdf>.

[No Author Listed] Oracle Universal Work Queue: Implementation Guide. Release 11i for Windows NT. Oracle Corporation. Jul. 2001, 136 pages. <http://docs.oracle.com/cd/A85964_01/acrobat/ieu115ug.pdf>.

Bierbaum, A., et al., VR juggler: A virtual platform for virtual reality application development. Proceedings of the Virtual Reality 2001 Conference, IEEE, 2001, 8 pages, <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&amumber-913774>.

Deelman, E., et al., Pegasus: A framework for mapping complex scientific workflows onto distributed systems, submitted to Scientific Programming, Jan. 2005. Pre-journal publication.

Deelman, E., et al., Pegasus: A framework for mapping complex scientific workflows onto distributed systems. Scientific Programming, 13, pp. 219-237, 2005.

Fayad, M.E., et al., Object-oriented application frameworks. Communications of the ACM, Oct. 1997, vol. 40, issue 10, pp. 32-38, <http://dl.acm.org/citation.cfm?id=262798>.

Hague, Darren, Universal Worklist with SAP Netweaver Portal. Galileo Press, 2008, pp. 11-31. <http://www.sap-hefte.de/download/dateien/1461/146__leseprobe.pdf>.

International Search Report and Written Opinion for Application No. PCT/GB2004/000677, mailed Aug. 2, 2004 (15 pages).

International Search Report for Application No. PCT/US2004/020783, mailed Nov. 8, 2005 (2 pages).

International Preliminary Report on Patentability for Application No. PCT/US2004/020783, issued Feb. 13, 2006 (6 pages).

LaRue, J., Leveraging Integration and Workflow. Integrated Solutions, Accounting Today, SourceMedia, Aug. 2006, pp. 18-19.

Mandal, et al., Integrating existing scientific workflow systems: The kepler/pegasus example. USC Information Sciences Institute, 2007, 8 pages.

Markiewicz, M.E., et al., Object oriented framework development. ACM, 2001, 13 pages, <http://dl.acm.org/citation.cfm?id=372771>.

Marmel, Elaine, Microsoft Office Project 2007 Bible, ISBN 0470009926, Wiley Publishing, Inc., 2007, 961 pages.

Pientka, B., et al., Programming with proofs and explicit contexts. International Symposium on Principles and Practice of Declarative Programming, ACM, 2008, pp. 163-173, <http://delivery.acm.org/10.1145/1390000/1389469/p163-pientka.pdf?>.

Richner, T., et al., Recovering high-level views of object-oriented applications from static and dynamic information. IEEE, 1999, 10 pages, <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=792487>.

(56) **References Cited**

OTHER PUBLICATIONS

Singh, G., et al., Workflow task clustering for best effort systems with pegasus, Pegasus, 2008, 8 pages.
Srinivasan, V., et al., Object persistence in object-oriented applications. IBM Systems Journal, 1997, vol. 36, issue 1, pp. 66-87, <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber-5387186>.
Breiman, L., et al., Bagging predictors, Machine Learning, vol. 24, No. 2, Aug. 31, 1996, pp. 123-140, Kluwer Academic Publishers, Netherlands.
Mitchell, T.M., Machine Learning, Chapter 3, 1997, McGraw-Hill, pp. 52-80.
Mitchell, T.M., Machine Learning, Chapter 6, 1997, McGraw-Hill, pp. 154-200.
[No Author Listed] FreeBSD Project. "EDQUOTA(8)" in Free BSD System Manager's Manual. FreeBSD 8.2 Jun. 6, 1993. pp. 1-2. Retrieved from freebsd.org on Oct. 27, 2011.
[No Author Listed] "How SmartForms for Fair Blaze Advisor works", Fair Issac White Paper, http://www.FAIRISAAC.COM/, Oct. 31, 2005 (website no longer active).
[No Author Listed] Solaris 9 resource manager software. A technical white paper. Sun Microsystems, Inc., Palo Alto CA, 2002, 37 pages. XP-002291080. Retrieved Aug. 3, 2004 from <http://wwws.sun.com/software/whitepapers/solaris9/srm.pdf>.
Bertino and P. Foscoli, "Index Organizations for Object-Oriented Database Systems," IEEE Trans. on Knowledge and Data Engineering, 7(2)193-209 (1995).
Brusilovsky, P., and De Bra, P., Editors, "Second Workshop on Adaptive Hypertext and Hypermedia Proceedings," Jun. 20-24, 1998. Ninth ACM Conference on Hypertext and Hypermedia, Hypertext'98. pp. 1-2.
Burleson, "Adding behaviors to relational databases," DBMS, 8(10): 68(5) (1995).
Busse, Ralph et al., "Declarative and Procedural Object Oriented Views", 1998, IEEE retrieved Mar. 22, 2007.
Buyya et al., "Economic Models for Resource Management and Scheduling in Grid Computing," 2002. Concurrency and Computation: Practice and Experience. vol. 14. pp. 1507-1542.
Chan and W. Hwang, "Towards Integrating Logic, Object, Frame, and Production," Proc. Fourth Int'l. Conf. on Software Engineering and Knowledge Engineering, pp. 463-469, Jun. 1992.
Cheng and Smith, "Applying Constraint Satisfaction Techniques to Job Shop Scheduling," 1997. Annals of Operations Research. 70: 327-357 (1997).
Cheng, Cheng-Chung; Smith, Stephen F.; "A Constraint Satisfaction Approach to Makespan Scheduling," AIPS 1996 Proceedings, pp. 45-52 (1996).
Cochrane, Roberta et al., "Integrating Triggers and Declarative Constraints in SQL", p. 567-578, Proceedings of the 22nd VLDB Conference Mumbai (Bombay), India, 1996, retrieved Mar. 22, 2007.
Damerau, F.J., Problems and some solutions in customization of natural language database front ends. ACM Transactions on Information Systems, vol. 3, No. 2, Apr. 1, 1985, pp. 165-184.
Danforth, "Integrating Object and Relational Technologies," Proc. Sixteenth Annual Int'l. Computer Software and Applications Conf., pp. 225-226, Sep. 1992 (abstract).
DeMichiel, et al., "Polyglot Extensions to Relational Databases for Sharable Types and Functions in a Multi Language Environment," Proc. Ninth Int'l. Conf. on Data Engineering, pp. 651-660, Apr. 1993.
Devarakonda et al., Predictability of process resource usage: A measurement-based study on UNIX. IEEE Transactions on Software Engineering. 1989;15(12):1579-1586.
Communication for European Patent Application No. 05755530.2, dated Sep. 6, 2007.
European Search Report for Application No. 05755530.2, dated Mar. 26, 2012 (3 Pages).
European Office Action issued Aug. 31, 2012 for Application No. 05755530.2 (4 Pages).
Communication for European Patent Application No. 07250844.3 enclosing European Search Report, dated Jul. 11, 2007.
Communication for European Patent Application No. 07250844.3, dated Mar. 28, 2008.
European Office Action issued Jul. 9, 2012 for Application No. 07250844.3 (8 Pages).
Communication for European Patent Application No. 07250848.4, dated Aug. 13, 2007 (EESR enclosed).
Communication for European Patent Application No. 07250848.4, dated May 29, 2008.
Communication for European Patent Application No. 08731127.0, dated Oct. 13, 2009.
Extended European Search Report issued Oct. 29, 2012 for Application No. 08731127.0 (8 Pages).
Francisco, S. et al. "Rule-Based Web Page Generation" Proceedings of the 2nd Workshop on Adaptive Hypertext and Hypermedia, Hypertext'98, Jun. 20-24, 1998.
Gajos et al. SUPPLE: Automatically Generating User Interfaces. IUI 2004, 8 pages.
International Search Report for PCT/US051018599, dated May 15, 2007.
International Preliminary Report on Patentability for PCT/US2005/018599, dated Jun. 5, 2007.
International Search Report & Written Opinion for PCT/US06/03160, mailed Jul. 21, 2008.
International Preliminary Report on Patentability for PCT/US06/03160, dated Apr. 9, 2009.
International Search Report for PCT/US08/55503, mailed Jul. 28, 2008.
International Preliminary Report on Patentability for PCT/US2008/055503, mailed Sep. 17, 2009.
International Search Report & Written Opinion for PCT/US09/32341, mailed Mar. 11, 2009.
International Preliminary Report on Patentability for PCT/US2009/032341, mailed Aug. 12, 2010.
Johnson et al., Sharing and resuing rules-a feature comparison of five expert system shells. IEEE Expert, IEEE Services Center, New York, NY, vol. 9, No. 3, Jun. 1, 1994, pp. 3-17.
Jones et al., A user-centered approach to functions in excel. International Conference on Functional Programming, Uppsala, Jun. 30, 2003, pp. 1-12.
Kim, "Object-Oriented Databases: Definition and Research Directions," IEEE Trans. on Knowledge and Data Engineering, vol. 2(3) pp. 327-341, Sep. 1990.
Kuhn, H.W. "The Hungarian Method for the Assignment Problem," Naval Research Logistics Quarterly, 2 (1955), pp. 83-97.
Kuno and E.A. Rundensteiner, "Augmented Inherited Multi-Index Structure for Maintenance of Materialized Path Query Views," Proc. Sixth Int'l. Workshop on Research Issues in Data Engineering, pp. 128-137, Feb. 1996.
Lippert, Eric, "Fabulous Adventures in Coding: Metaprogramming, Toast and the Future of Development Tools," Microsoft.com Blog, MSDN Home, published Mar. 4, 2004, 6 pgs.
Manghi, Paolo et. al. "Hybrid Applications Over XML: Integrating the Procedural and Declarative Approaches", 2002 ACM, pp. 1-6. Retrieved Mar. 22, 2007.
Markowitz and A. Shoshani, "Object Queries over Relational Databases: Language, Implementation, and Applications," IEEE Xplore, pp. 71-80, Apr. 1993.
Maryanski, et al., "The Data Model Compiler: A Tool for Generating Object-Oriented Database Systems," 1986 Int'l. Workshop on Object-Oriented Database Systems, 73-84 (1986).
McConnell, Steven C., "Brooks' Law Repealed," IEEE Software, pp. 6-9, Nov./Dec. 1999.
Mecca, G. et al. "Cut and Paste", ACM, pp. 1-25 and Appendix I-IV (1999). Retrieved Mar. 22, 2007.
Morizet-Mahoudeaux, "A Hierarchy of Network-Based Knowledge Systems," IEEE Trans. on Systems, Man, and Cybernetics, vol. 21(5), pp. 1184-1191, Sep. 1991.
Reinersten, Don, "Is It Always a Bad Idea to Add Resources to a Late Project?," Oct. 30, 2000. Electronic Design. vol. 48, Issue 22, p. 70.
Riccuiti, M., Oracle 8.0 on the way with objects: upgrade will also build in multidimensional engine. InfoWorld. Sep. 25, 1995;17(39):16.

(56) **References Cited**

OTHER PUBLICATIONS

Salvini and M.H. Williams, "Knowledge Management for Expert Systems," IEE Colloquium on 'Knowledge Engineering', 3 pages, May 1990.

Schiefelbein, Mark A Backbase Ajax Front-end for J2EE Applications, Internet Article, http://dev2dev.bea.com/1pt/a/433>, Aug. 29, 2005.

Sellis, et al., "Coupling Production Systems and Database Systems: A Homogeneous Approach," IEEE Trans. on Knowledge and Data Engineering, vol. 5(2), pp. 240-256, Apr. 1993.

Shyy and S.Y.W. Su, "Refinement Preservation for Rule Selection in Active Object-Oriented Database Systems," Proc. Fourth Int'l Workshop on Research Issues in Data Engineering, pp. 115-123, Feb. 1994.

Smedley, T.J. et al., "Expanding the Utility of Spreadsheets Through the Integration of Visual Programming and User Interface Objects," School of Computer Science, Technical University of Nova Scotia, ACM, 1996; pp. 148-155.

Stonebraker, "The Integration of Rule Systems and Database Systems," IEEE Trans. on Knowledge and Data Engineering, vol. 4(5), pp. 415-423, Oct. 1992.

Sun, et al., "Supporting Inheritance in Relational Database Systems," IEEE, pp. 511-518, Jun. 1992.

Thuraisingham, "From Rules to Frames and Frames to Rules," AI Expert, pp. 31-39, Oct. 1989.

Vranes, S. "Integrating Multiple Paradigms within the Blackboard Framework," IEEE Transactions on Software Engineering, vol. 21, No. 3, Mar. 1995, pp. 244-262.

Yang, Bibo; Geunes, Joseph; O'Brien, William J.; "Resource-Constrained Project Scheduling: Past Work and New Directions," Apr. 2001.

* cited by examiner

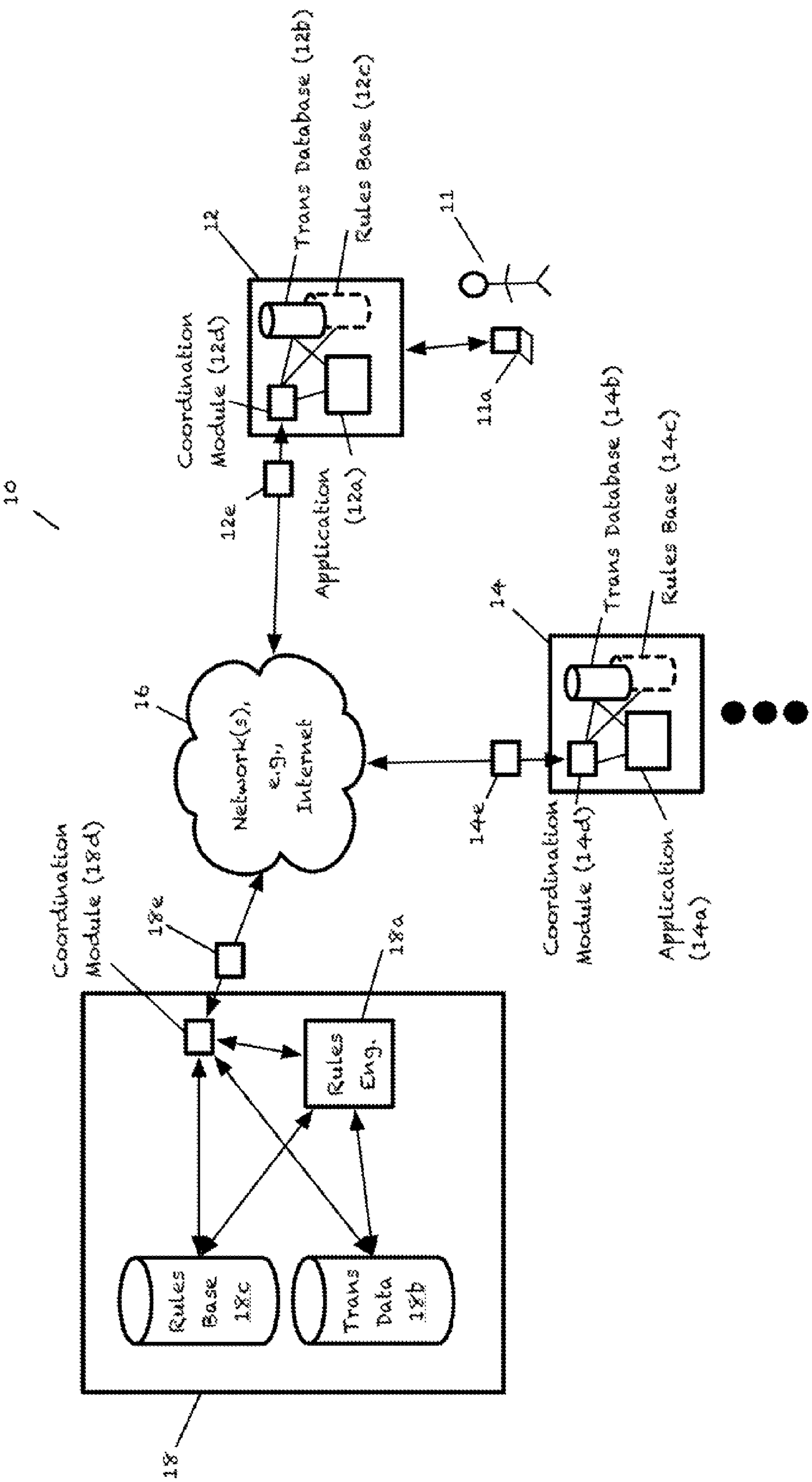
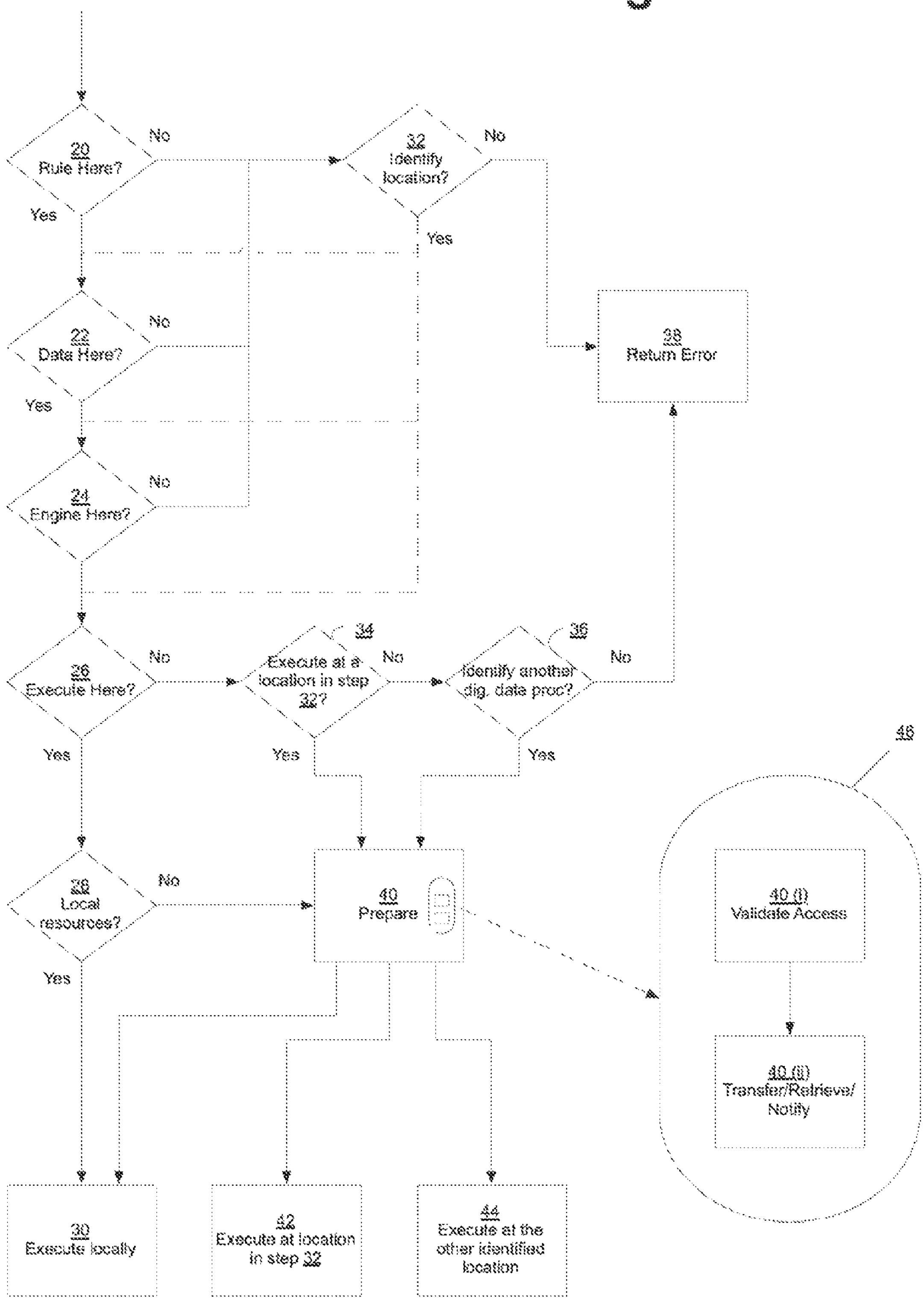

10
12
Trans Database (12b)
Rules Base (12c)
11
Coordination Module (12d)
11a
12e
Application (12a)
16
Network(s), e.g., Internet
14
Trans Database (14b)
Rules Base (14c)
14e
Coordination Module (14d)
Application (14a)
Coordination Module (18d)
18e
18a
Rules Eng.
Rules Base 18c
Trans Data 18b
18

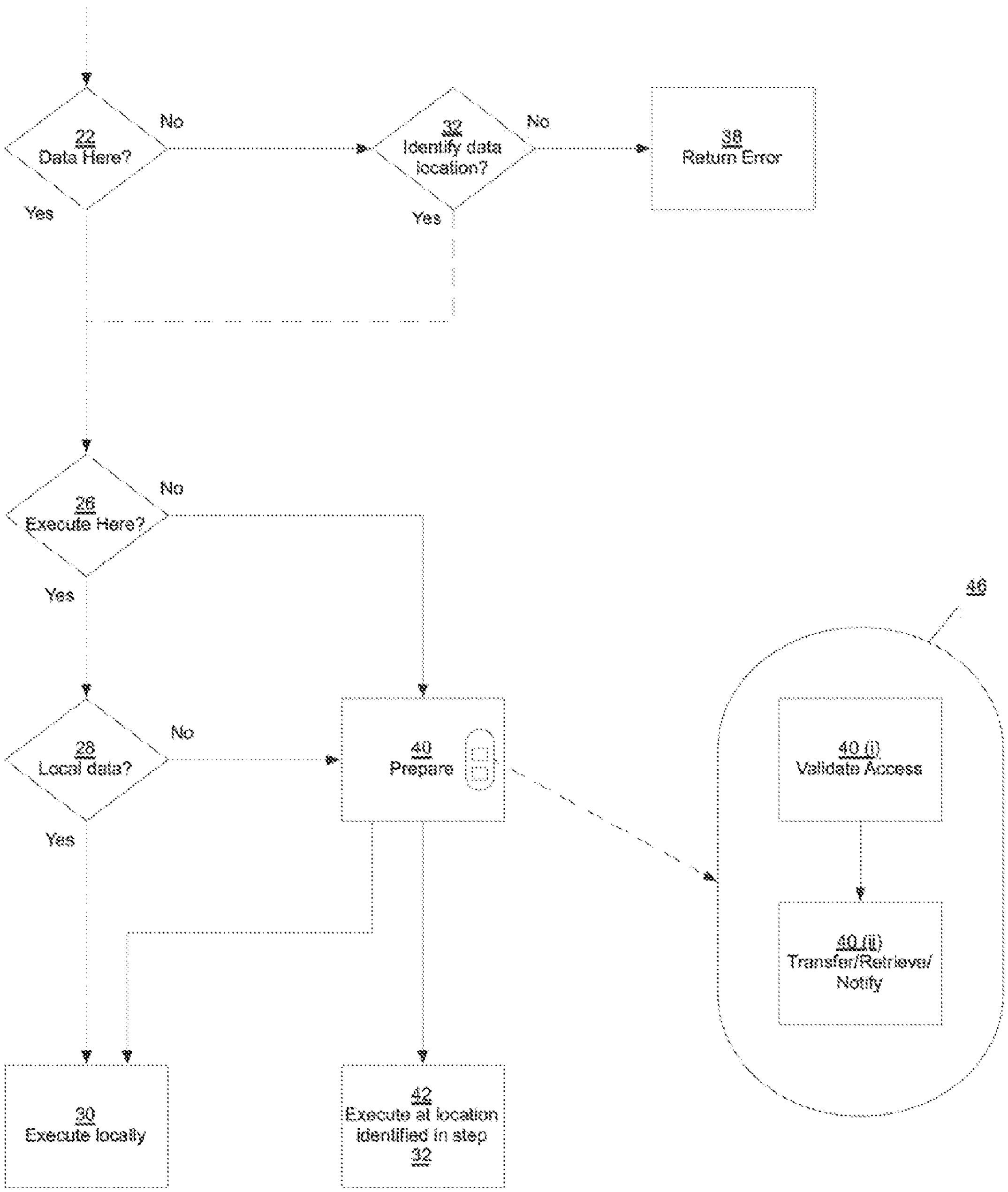
Figure 1

Figure 2



20
Rule Here?
No
Yes
32
Identify location?
No
Yes
22
Data Here?
No
Yes
38
Return Error
24
Engine Here?
No
26
Execute Here?
No
Yes
34
Execute at a location in step 32?
No
Yes
36
Identify another dig. data proc?
No
Yes
46
28
Local resources?
No
Yes
40
Prepare
40 (i)
Validate Access
40 (ii)
Transfer/Retrieve/Notify
30
Execute locally
42
Execute at location in step 32
44
Execute at the other identified location

Figure 3


22
Data Here?
No
Yes
32
Identify data location?
No
Yes
38
Return Error
26
Execute Here?
No
Yes
28
Local data?
No
Yes
40
Prepare
46
40 (i)
Validate Access
40 (ii)
Transfer/Retrieve/
Notify
30
Execute locally
42
Execute at location identified in step 32

## SYSTEMS AND METHODS FOR DISTRIBUTED RULES PROCESSING

### BACKGROUND OF THE INVENTION

The invention relates to digital data processing and, more particularly, for example, to distributed processing of rules bases.

Computer systems that facilitate business operations based on information specific to an industry or enterprise are well known in the art. These typically rely on rules identifying situations that are expected to arise during enterprise operation and the applicable responses. Such systems have been used in a range of applications, from health care to automotive repair. The rules on which they rely come from experts in the field, from the collective experience of workers on the "front line," or a combination of these and other sources.

Though many computer systems of this sort incorporate application-specific knowledge directly into source code (using, for example, a sequence of "if . . . then . . . else" statements, or the like), more complex systems store that knowledge separately from the programs that access it. Some use "rules bases" that store application-specific information in tables, database records, database objects, and so forth. Examples of systems of this type are disclosed in commonly assigned U.S. Pat. No. 5,826,250, entitled "Rules Bases and Methods of Access Thereof" and U.S. Pat. No. 7,640,222, entitled "Rules Base Systems and Methods with Circumstance Translation," the teachings of both of which are incorporated herein by reference.

These and other rules-based business process management (BPM) applications are commonly used in enterprise computing, for example, where they facilitate a range of business operations, from marketing to manufacturing to distribution to technical support. By way of example, a BPM application can implement data-processing workflows to support the processing of transactional data ranging from customer service requests received by retail and banking enterprises to the routing and resolution of health care claims by insurance enterprises.

With increasing frequency, enterprise software applications incorporate architectures that permit their use "in the cloud," that is, over the Internet, with computing resources delivered up to each user on demand. In a sense, this extends the client-server model of past eras from the physical confines of the enterprise to the expanse of the world.

Where a common architecture of the past might provide for software that executes on a server, e.g., located at enterprise headquarters, and that processes requests entered by support personnel at the enterprise's branch offices, the new cloud architectures permit servicing of requests by servers located around the world. In operation, any given request by a user on a client device might as well be attended to by a server located in a neighboring state as in a neighboring country. Thus, while cloud applications are often initially tested behind an enterprise firewall, they are typically architected for final deployment outside that firewall, on a dynamically changing set of third-party servers (e.g., owned by Amazon, SalesForce, Google, or other cloud-computing providers).

BPM applications can be deployed in the cloud, like other enterprise applications. However since business process management often goes to the heart of the enterprise, chief executives, IT directors, and corporate boards have yet to fully embrace this model, mainly, for fear that storing rules bases and/or transactional data exposes them to theft or wrongful disclosure.



Other software applications are evolving similarly. Those that traditionally ran solely on the "desktop," are now increasingly being executed in the cloud. Word processing is one example. Microsoft, Google and other software providers would as soon enterprise (and other) customers store documents and execute word processing via the cloud, as via locally deployed desktop applications. Unfortunately, this results in uneven usage of information technology resources, with network infrastructure and desktop computers being alternately overwhelmed and underutilized, depending on the cycle of the day, month and year.

An object of this invention is to provide improved systems and methods for digital data processing. A more particular object is to provide improved systems and methods for business process management, for example, rules processing.

A further object is to provide such improved systems and methods as facilitate deployment of BPM and other rules-processing applications on multiple digital data processors.

A still further object is to provide such improved systems and methods as facilitate such deployment in distributed environments, such as, for example, in cloud computing environments.

Yet a still further object is to provide such improved systems and methods as provide better security for BPM and other rules-processing applications in such distributed environments.

Still yet a further object is to provide such improved systems and methods as better utilize computing and networking resources in applications so distributed.

### SUMMARY OF THE INVENTION

The foregoing are among the objects attained by the invention, which provides in some aspects a distributed rules processing system that includes first and second digital data processors that are coupled to one another by one or more networks. A rules base and a transactional data base are each coupled to one of the digital data processors; both may be coupled to the same digital data processor or otherwise.

One or more coordination modules (e.g., "proxies"), each of which is associated with a respective one of the digital data processors, makes available to a selected one of those digital data processors from the other of those digital data processors (i) one or more selected rules from the rules base, and/or (ii) one or more data from the transactional database on which those rules are to be executed. The selected digital data processor executes one or more of the selected rules as a rules engine, executes one or more of the selected rules using a rules engine, and/or processes one or more data from the transactional database with rules executing using a rules engine.

According to related aspects of the invention, the first and second digital data processors of a distributed rules processing system, e.g., of the type described above, can be disposed remotely from one another and can coupled for communication by the Internet, as well optionally by local area networks, wide area networks, and so forth. A firewall and/or other such functionality that is coupled to one or more of those networks prevents the selected digital data processor from accessing from the other digital data processor (i) the selected rules and/or (i) the data on which those rules are to be executed.

Further related aspects of the invention provide a distributed rules processing system, e.g., of the type described above, wherein one or more of the coordination modules make the selected rules and/or data available to the selected digital data processor from the other digital data processor in response to a request from the rules engine.

Thus, by way of example, in a system according to the foregoing aspects of the invention, the first digital data processor can include a rules base, e.g., for processing credit card information. The second digital data processor can, likewise, include a data base of transactional data, e.g., pertaining to opening of credit card account, purchases against the credit cards, refunds, and so forth.

According to one operational scenario of such a system (and to illustrate methods according to further aspects of the invention) a rules engine operating, for example, on the first digital data processor can utilize a proxy operating, for example, on the second digital data processor to access transactional data that is "behind the firewall" on the second digital data processor for processing by the rules engine with rules already accessible to the first data data processor (e.g., on account of its inclusion of and/or coupling to the rules base).

To that end, by way of non-limiting example, in related aspects of the invention, the coordination modules (or proxies) make the selected rules and/or data available to the selected digital data processor from the other digital data processor by opening one or more communications ports on that other digital data processor.

Continuing the above example, in a related operational scenario, a coordination module executing on the first data processor can respond to transactional data base access requests generated by the rules engine to determine whether that data base is coupled to the first digital data processor and, if not, to cooperate with the coordination module on the second digital data processor to make the transactional data available to the rules engine from the second digital data processor.

Conversely, according to the operational scenario of a system paralleling those described in the examples above, a rules engine executing on the second digital data processor can utilize a proxy operating, for example, on the first digital data processor, to access rules necessary to process transactional data already accessible to the data processor (e.g., on account of its inclusion of and/or coupling to the transactional data base).

In other related aspects, the invention provides a distributed rules processing system, e.g., of the type described above, in which one or more of the coordination modules make the selected rules and/or data available to the selected digital data processor from the other digital data processor in response to a request from that other digital data processor.

In further related aspects of the invention, a request made from the other digital data processor in a distributed rules processing system, e.g., of type described above, is made by a rules engine executing on that other digital data processor.

Continuing the example above (and to illustrate methods according to still further aspects of the invention), in a system according to the foregoing aspects of the invention, a rules engine operating on the first digital data processor can utilize the proxy operating on the second digital data processor to access some transactional data in the data base on the second digital data processor for processing by the rules engine on the first digital data processor (and/or, conversely, to store transactional data processed by that rules engine to that transactional data base). It can also effect, through use of that proxy and/or its counterpart on the first digital data processor, transfer of selected rules to the second digital data processor for execution by its rules engine, e.g., on other data stored (and/or to be stored) in the transactional database.

These and other aspects of the invention are evident in the drawings and in the description that follows.

## BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention may be attained by reference to the drawings, in which

FIG. **1** depicts a digital data processing system for distributed rules processing according to one practice of the invention;

FIG. **2** depicts a method of operation of a coordination module in a system of FIG. **1**; and

FIG. **3** depicts operation of a coordination module in a system according to the invention within a multi-tenant cloud-based environment.

## DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

FIG. **1** depicts a digital data processing system **10** for distributed processing in a rules-based system according to one practice of the invention. The illustrated system includes client (or "tenant") digital data processors **12**, **14** that are coupled via network **16** for communication with server digital data processor **18**.

The client digital data processors **12**, **14** are conventional desktop computers, workstations, minicomputers, laptop computers, tablet computers, PDAs or other digital data processing apparatus of the type that are commercially available in the marketplace and that are suitable for operation in the illustrated system as described herein, all as adapted in accord with the teachings hereof.

The server digital data processor **18** is, likewise, a digital data processing apparatus of the type commercially available in the marketplace suitable for operation in the illustrated system as described herein, as adapted in accord with the teachings hereof. Though the server **18** is typically implemented in a server-class computer, such as a minicomputer, it may also be implemented in a desktop computer, workstation, laptop computer, tablet computer, PDA or other suitable apparatus (again, as adapted in accord with the teachings hereof).

Network **16** comprises one or more networks suitable for supporting communications among and between illustrated digital data processors **12**, **14**, **18**. Illustrated network **16** comprises one or more public networks, specifically, the Internet, though, in other embodiments, it may include (instead or in addition) one or more other networks of the type known in the art, e.g., local area networks (LANs), wide area networks (WANs), metropolitan area networks (MANs), and or Internet(s).

Illustrated client computer **12** comprises central processing, memory, storage and input/output units and other constituent components (not shown) of the type conventional in the art that are configured to form application **12***a*, transaction database **12***b*, rules base **12***c*, and coordination module **12***d*, in accord with the teachings hereof. One or more of these constituent components, and/or portions thereof, may be absent in various embodiments of the invention. Thus, for example, as suggested by dashed lines, the digital data processor **12** may not include a rules base. Conversely, it may include a portion of a rules base but not transaction database or it may include neither. In other embodiments, it may include a coordination module **12***d* (described below) but not a transaction database, rules base or an application, all by way of non-limiting example.

The central processing, memory, storage and input/output units of client digital data processor **12** may be configured to form and/or may be supplemented by other elements of the type known in the art desirable or necessary to support elements **12**a-**12**d in accord with the teachings hereof, as well as to support other operations of the digital data processor **12**. These can include, by way of non-limiting example, peripheral devices (such as keyboards and monitors), operating systems, database management systems, and network interface cards and software, e.g., for supporting communications between digital data processor **12** and other devices over network **16**.

Digital data processor **12** is coupled to network **16** via firewall **12**e. This is a conventional device of the type known in the art (as otherwise configured in accord with the teachings hereof) suitable for blocking unauthorized access, yet, permitting authorized access, to the digital data processor **12**, including (but not limited to) data and rules bases **12**b, **12**c.

Firewall **12**e, which is constructed and operated in the conventional manner known in the art, may comprise a "hardware" (or stand-alone) firewall and/or it may comprise a software firewall configured from the constituent and/or other components of digital data processor **12**, again, in the conventional manner known in the art.

The constituent components of illustrated client digital data processor **14** may similarly be configured in accord with the teachings hereof to form application **14**a, transaction database **14**b, rules base **14**c, and coordination module **14**d. As well, they may be supplemented by other elements of the type known in the art desirable or necessary to support elements **14**a-**14**d in accord with the teachings hereof, as well as to support other operations of the digital data processor **14**. The client digital data processor **14** may also include a firewall **14**e, e.g., constructed and operated like device **12**e, discussed above, to block unauthorized access, yet, permit authorized access, to the digital data processor **14**, including (but not limited to) data and rules bases **14**b, **14**c.

Although digital data processors **12** and **14** are depicted and described in like manner here, it will be appreciated that this is for sake of generality and convenience: in other embodiments, these devices may differ in architecture and operation from that shown and described here and/or from each other, all consistent with the teachings hereof. Moreover, it will be appreciated that although only two closely positioned client devices **12**, **14** are shown, other embodiments may have greater or fewer numbers of these devices disposed near and/or far from one another, collocated behind one or more common firewalls **12**e, **14**e or otherwise.

Like client digital data processors **12**, **14**, server digital data processor **18** comprises central processing, memory, storage and input/output units and other constituent components (not shown) of the type conventional in the art that are configured in accord with the teachings hereof to form rules engine **18**a, transaction database **18**b, rules base **18**c, and coordination module **18**d, one or more of which (and/or portions thereof) may be absent in various embodiments of the invention. The digital data processor **18** may also include a firewall **18**e, e.g., constructed and operated like device **12**e, discussed above, to block unauthorized access, yet, permit authorized access, to the digital data processor **18**, including (but not limited to) data and rules bases **18**b, **18**c.

Although only a single server digital data processor **18** is depicted and described here, it will be appreciated that other embodiments may have greater or fewer numbers of these devices disposed near and/or far from one another, collocated behind one or more common firewalls **18**e or otherwise. Indeed, in preferred such embodiments, the digital data processor **18** is configured as a server on a "cloud" platform, e.g., of the type commercially available from Amazon, SalesForce, Google, or other cloud-computing providers. As above, those other servers may differ in architecture and operation from that shown and described here and/or from each other, all consistent with the teachings hereof.

Rules bases **12**c, **14**c, **18**c comprise conventional rules bases of the type known in the art (albeit configured in accord with the teachings hereof) for storing rules (e.g., scripts, logic, controls, instructions, metadata etc.) and other application-related information in tables, database records, database objects, and so forth. Preferred such rules and rules bases are of the type described in the aforementioned incorporated-by-reference U.S. Pat. No. 5,826,250, entitled "Rules Bases and Methods of Access Thereof" and U.S. Pat. No. 7,640,222, entitled "Rules Base Systems and Methods with Circumstance Translation," though, rules and rules bases that are architected and/or operated differently may be used as well.

As noted above, not all of these rules bases may be present in any given embodiment. Conversely, some embodiments may utilize multiples rules bases, e.g., an enterprise-wide rules base **18**c on the server **18** and domain-specific rules bases on the client devices **12**, **14**, all by way of example. Moreover, to the extent that multiple rules bases are provided in any given embodiment, they may be of like architecture and operation as one another; though, they may be disparate in these regards, as well.

In some embodiments, rules may comprise meta-information structures. These are structures that can include data elements and/or method elements. The latter can be procedural or declarative. In the former regard, for example, such a structure may be procedural insofar as it comprises one or more of a series or ordered steps. In the latter regard, such a structure may be declarative, for example, insofar as it sets forth (declares) a relation between variables, values, and so forth (e.g., a loan rate calculation or a decision-making criterion), or it declares the desired computation and/or result without specifying how the computations should be performed or the result achieved. By way of non-limiting example, the declarative portion of a meta-information structure may declare the desired result of retrieval of a specified value without specifying the data source for the value or a particular query language (e.g., SQL, CQL, .QL etc.) to be used for such retrieval. In other cases, the declarative portion of a meta-information structure may comprise declarative programming language statements (e.g., SQL). Still other types of declarative meta-information structures are possible.

While some rules may comprise meta-information structures that are wholly procedural and others may comprise those that are wholly declarative, the illustrated embodiment also contemplates rules that comprise both procedural and declarative meta-information structures, i.e., rules that have meta-information structure portions that are declarative, as well as meta-information structure portions that are procedural.

Furthermore, rules of the illustrated embodiment that comprise meta-information structures may also reference and/or incorporate other such rules, which themselves may, in turn, reference and/or incorporate still other such rules. As a result, editing such rule may affect one or more rules (if any) that incorporate it.

An advantage of rules that comprise meta-information structures over conventional rules is that they provide users with the flexibility to apply any of code-based and model-driven techniques in the development and modification of software applications and/or computing platforms. Particularly, like models in a model-driven environment, meta-information structures comprise data elements that can be used to define any aspect of a complex system at a higher level of abstraction than source code written in programming languages such as Java or C++. On the other hand, users may also embed programming language statements into meta-information structures if they deem that to be the most efficient design for the system being developed or modified. At run-time, the data elements of the meta-information structures along with programming language statements (if any) are automatically converted into executable code by a rules engine (e.g., **18***a*).

Thus, in some embodiments, rules may be the primary artifacts that get created, stored (e.g., in a rules base) or otherwise manipulated to define and/or modify the overall functionality of rules-based applications that may automate and/or manage various types of work in different business domains at run-time. By way of non-limiting example, a plurality of rules stored in a rules base (e.g., **12***c*, **14***c*, **18***c*) may be configured to define all aspects (e.g., user interface, decision logic, integration framework, process definition, data model, reports, security settings etc.) of a software application. Such a software application may include specialized software that is used within a specific industry or a business function (e.g., human resources, finance, healthcare, telecommunications etc.), or it may include a cross-industry application (e.g., a project management application), or any other type of software application. As the software application executes on a digital data processor (e.g. any of **12**, **14** and **18**), any portion of the rules that define the application may be retrieved from a rules bases (e.g. any of **12***c*, **14***c* and **18***c*) and processed/executed (e.g., using a rules engine **18***a* as defined below) in response to requests/events signaled to and/or detected by the digital data processor at run-time.

Transactional data bases **12***b*, **14***b*, **18***b* comprise conventional data bases of the type known in the art (albeit configured in accord with the teachings hereof) for storing corporate, personal, governmental or other data that may be any of generated, stored, retrieved and otherwise processed (hereinafter, collectively referred to as "processed") by rules in one or more of the rules bases **12***c*, **14***c*, **18***c*. The data may be financial data, customer records, personal data, run-time data related to an application, or other type of data and it may be stored in tables, database records, database objects, and so forth.

As above, not all of the illustrated transactional data bases may be present in any given embodiment. Conversely, some embodiments may utilize multiple transactional database bases, e.g., an enterprise-wide data base **18***b* on the server **18** and branch-office specific data bases on the client devices **12**, **14**, all by way of example. Moreover, to the extent that multiple transactional data bases are provided in any given embodiment, they may be of like architecture and operation as one another; though, they be disparate in these regards, as well.

Illustrated digital data processor **18** also includes rules engine **18***a* of the type conventionally known in the art (albeit configured in accord with the teachings hereof) for use in processing/executing rules from a rules base in order to process data in (and/or for storage to) a transactional database, e.g., in connection with events signaled to and/or detected by the engine. Preferred such rules engines are of the type described in the aforementioned incorporated-by-reference U.S. Pat. No. 5,826,250, entitled "Rules Bases and Methods of Access Thereof" and U.S. Pat. No. 7,640,222, entitled "Rules Base Systems and Methods with Circumstance Translation" and/or U.S. patent application Ser. No. 11/681,269, filed Mar. 2, 2007, entitled "Proactive Performance Management For Multi-User Enterprise Software Systems," the teachings too of which are incorporated by reference herein—all as adapted in accord without the teachings hereof.

The rules engine **18***a* may be implemented in a single software program, in multiple software programs/modules, or a combination of software modules/programs. Moreover, it may comprise programming instructions, scripts, or rules (e.g., rules stored in rules base **18***c*) and/or a combination thereof.

Though, in the illustrated embodiment in FIG. **1**, the rules engine **18***a* executes on the server **18**, in other embodiments, the techniques described herein may be employed to execute the rules engine **18***a* on or over multiple digital data processors (e.g., **12**, **14** and **18**). For instance, the rules engine **18***a* may initially be invoked for execution on a single digital data processor (e.g., **18**). Subsequently, portions of it (or, potentially, the entirety of it) may be apportioned, distributed and executed over multiple digital data processors using the techniques described herein.

Such distributed execution of the rules engine can be advantageous, by way of non-limiting example, when execution of an enterprise-wide BPM application necessitates access to sensitive corporate or personal data during intermediate processing steps. For example, in an enterprise with decentralized record-keeping, the rules engine **18***a* can be utilized to generate a summary report that requires analysis of sensitive personnel-related data maintained in local branch offices. To that end, the engine **18***a* executes rules for performing preparatory tasks, such as, zeroing out data collection variables and identifying local offices to be queried. The engine **18***a* also retrieves from rules base **18***c* or otherwise generate rules that will serve as rules engines (e.g., **12***a*, **14***a*) customized or otherwise suited for execution on digital data processing equipment **12**, **14** at those offices, as well as rules for execution on those engines **12***a*, **14***a* to analyze (and anonymize) sensitive data from the respective offices. Both the rules engine-defining rules and the data analysis rules are distributed to the equipment **12**, **14**, where they perform these functions and send the requisite information back to server **18** for reporting the BPM application executing there. Such distributed execution has the advantage of permitting the BPM application executing using engine **18***a* to generate an enterprise-wide report, without necessitating the transmission of sensitive data outside the confines of the local offices.

By way of further example, the rules engine **18***a* can have two distinct portions, e.g., one that embodies the algorithm for rule selection (e.g., in the manner of the rule finder disclosed in U.S. Pat. No. 5,825,260, assigned to the assignee hereof and incorporated by reference herein), and the other that generates/executes the executable code once the requisite rule has been selected. The rules engine **18***a* (or other functionality) can apportion and distributed these portions separately as required.

Take, for example, an instance where server **18** gets a request for executing a "loan validation" process for a specific context. Server **18** stores rules for multiple versions of the "loan validation" process for different contexts. However, the server does not have the computing power to execute the 'rule finder' algorithm to select the right version and/or the server doesn't have the code generation portion of the engine to execute the selected rule. Server retrieves the rules for all versions of "loan validation" process and transmits them along with the rule selection portion of the engine to a remote digital data processor that has installed thereon the code generation portion of a rules engine. Upon receiving the rule finder portion of the engine along with the rules for all versions, the correct loan validation process is selected and executed on the target digital data processor.

The foregoing are examples those skilled in the art will appreciate that still other ways of implementing/executing the rules engine **18***a* are possible. By way of non-limiting example, the rules engine **18***a* may have additional distinct components/portions that can be apportioned and distributed separately. These may include (but are not limited to) a data access component used for processing data during rule execution, a session management component for keeping track of activity across sessions of interaction with a digital data processor and/or a performance monitoring component for monitoring and interacting with various system resources/event logs in order to manage performance thresholds. Still other types of distinct components/portions may be part of the rules engine **18***a*.

Applications **12***a* and **14***a*, of digital data processors **12**, **14**, respectively, may too comprise rules engines of the type described above, as adapted in accord with the teachings hereof. These applications may be configured (e.g., at least partially using rules stored in a rules base as described above) as stand-alone applications and/or may be embedded in (or coupled) to other software applications, e.g., web browsers. While in some embodiments, such applications **12***a*, **14***a* are architected and operated similarly to rules engine **18***a*, in other embodiments they embody a subset of the functionality of engine **18***a*, e.g., suited to the processing resources and/or demands of the digital data processors **12**, **14** upon which they operate. Instead or in addition, such applications **12***a*, **14***a* can comprise other functionality than that provided in rules engine **18***a*, again, for example, suited to the processing resources and/or demands of the digital data processors **12**, **14** upon which they operate.

For sake of simplicity, the discussion that follows focuses on aspects of operation of rules engine **18***a*; it will be appreciated that other rules engines (e.g., **12***a*, **14***a* in certain embodiments) may operate similarly in these regards.

As noted above, rules engine **18***a* processes/executes rules from a rules base in order to process data in (and/or for storage to) a transactional database. In instances where the engine **18***a* executes rules from rules base **18***c* in order to process data in (and/or store data to) database **18***b*, the engine **18***a* may operate in the conventional manner known in the art. However, where any of (i) the data to be accessed (or stored) is resident in a data base **12***b*, **14***b* of another of the digital data processors, (ii) the rules to be executed (including, potentially, those defining the rules engine **18***a* or a portion thereof) are contained in a rules base **12***c*, **14***c* of another of those digital data processors, and (iii) the rules (again, potentially, those defining the rules engine **18***a* or a portion thereof) are to be executed using the rules engine **12***a*, **12***b* of another of those digital data processors, the rules engine **18***a* works with one or more of the coordination modules to effect the desired processing. Even in instances where the rules, portions of the engine, and/or data required to effect the desired processing is local to digital data processor **18**, the rules engine **18***a* may work with the coordination modules (e.g., **12***d*, **14***d*, **18***d*) to effect the desired processing over multiple digital data processors (e.g., for access to more computing resources/power) in accord with the teachings hereof.

In this regard, coordination modules **12***d*, **14***d*, **18***d* comprise functionality resident on (and/or coupled to) each of the respective processors **12**, **14**, **18** that facilitate access to and transfer of rules, the rules engine or portion thereof, or data (and, preferably, all three) between the digital data processors. In this regard, operation of the module(s) **12***d*, **14***d*, **18***d* can include one or more of (i) obviating obstacles presented by firewalls **12***e*, **14***e*, **18***e* or other functionality to such interprocessor accesses and transfers, (ii) effecting such access and transfers, and (iii) querying a digital data processor to determine whether it has resources (e.g., a rules base, a transactional data base, a portion of or the entire rules engine, and/or computing power) to facilitate the completion of a task (e.g., by executing a given one or more rules on a given set of data).

As above, not all of the coordination modules **12***d*, **14***d*, **18***d* are utilized in all embodiments. Conversely, other embodiments may utilize additional such modules, e.g., one module per digital data processor for facilitating rules access/transfer between digital data processors, one module for facilitating transaction access/transfer, and so forth. Likewise, some such modules could be directed to querying digital data processors for resources, while others are directed to access and transfers. These and other such variations are within the ken of those of ordinary skill in the art based on the teachings hereof.

The modules **12***d*, **14***d*, **18***d* may comprise stand-alone functionality stored and executing within each respective digital data processors **12**, **14** **18**. Alternatively, they may comprises functionality that is embedded in the rules engine **18***a* and/or applications **12***a*, **14***a* and/or into other applications or operating system functions resident on the respective devices **12**, **14**, **18**. Moreover, in embodiments that include multiple such modules **12***d*, **14***d*, **18***d*, functionality may be distributed and/or divided among them.

Still further, although the modules **12***d*, **14***d*, **18***d* are shown forming part of the respective digital data processors **12**, **14**, **18** in the illustrated embodiment, in other embodiments one or more of those modules may execute on still other digital data processors (not shown) that are in communication coupling with the respective processors **12**, **14**, **18** and that otherwise provide the functionality described here.

Operation of a coordination module **18***d* in accord with one practice of the invention is illustrated in FIG. **2**. It will be appreciated that the sequence of steps shown in that drawing and discussed below is by way of example and that other embodiments may perform the same or different functions using alternate sequences of steps.

In step **20**, the module, which may be coupled to a local rules engine **18***a*, responds to a request for access to a rule by determining if that rule is present in a rules base **18***c* local to the digital data processor **18**—and, for example, it is therefore accessible to a local engine **18***a* without crossing the firewall **12***e*, **14***e* of another digital data processor. The module **18***d* can make that determination by checking for the presence of the local rules base **18***c* and/or, if present, by determining if the requested rule itself is present. Alternatively, or in addition, the module **18***d* can make the determination by checking parameters or other indicators of rule presence, e.g., in the rule request signaled to any of the module **18***a* and the engine **18***a* and/or request made by the engine **18***a*. The parameters or other indicators of rule presence may also be found in a registry of the digital data processor **18** and/or elsewhere.

If the determination of step **20** is in the affirmative, operation proceeds to step **22**, where the module **18***d* determines if data implicated by the rule (e.g., data to be processed by the rule or otherwise necessary for its execution) is present in a data base **18***b* local to the digital data processor **18**—and, again, for example, it is therefore accessible to the local engine **18***a* without crossing the firewall **12***e*, **14***e* of another digital data processor. The module **18***d* can make that determination by checking for the presence of the local data base **18***b* and/or, if present, by determining if the requested data are present. Alternatively, or in addition, the module **18***d* can make the determination by checking parameters or other indicators of data presence, e.g., in the rule request signaled to any of the module **18***d* and the engine **18***a* and/or request made by the engine **18***a*. The parameters or other indicators of rule presence may also be found in a registry of the digital data processor **18** and/or elsewhere.

If the determination of step **22** is affirmative, operation proceeds to step **24**, where the module **18***d* determines if the portion of rules engine (e.g., **18***a*) that is required to execute the requested rule is present locally on digital data processor **18**. To this end, the module can query for local presence on digital data processor **18** of component(s)/module(s) that make up requisite portions(s) of rules engine. In other embodiments, e.g., where those requisite portion(s) are implemented using rules, the module **18***d* can determine, for example, if those rules are locally present by querying a local database/repository (e.g., rules base **18***c*, transaction data base **18***b*). Alternatively, or in addition, the module can check parameters or other indicators of engine presence, e.g., in the rule request signaled to any of the module **18***d* and the engine **18***a* and/or request made by the engine **18***a*, in a registry of the digital data processor **18** and/or elsewhere.

If the determination of step **24** is in the affirmative, operation proceeds to step **26**, where the module **18***d* determines if the rule is to be executed locally, i.e., on digital data processor **18** or whether it is to be executed remotely, e.g., on digital data processors **12**, **14**. The module **18***d* can make that determination using a variety of methods including, but not limited to, querying a local rules engine (e.g., **18***a*) and/or by checking parameters or other indicators, e.g., in the rule request signaled to any of the module **18***d* and the engine **18***a* and/or request made by the engine **18***a*. The parameters or other indicators of rule presence may also be found in a registry of the digital data processor **18** and/or elsewhere. Alternatively, or in addition, the module **18***d* can make the determination based on load-balancing, network speed and traffic, data coherency or other factors within the ken of those of ordinary skill in the art based on the teachings hereof.

If the determination in steps **20**, **22**, **24** and **26** is in the affirmative—that is, all resources required to execute the requested rule are present locally at digital data processor **18** and the rule is to be executed there, the determination in step **28** is affirmative and the operation proceeds to step **30**, where the module **18***d* defers to local engine **18***a* for execution of the requested rule on the required data. The engine **18***a* (or the required portion thereof) proceeds by accessing the rule and data in the local rules and data bases **18***b*, **18***c*, and by executing the rule to process the data accordingly.

If the determination in any of steps **20**, **22** and **24** is in the negative—that is, if any of the requested rule, required data and engine (or portion thereof) are not locally present on digital data processor **18**, the operation proceeds to step **32**, where the module queries one or more other digital data processors (e.g., **12**, **14**) to determine the location(s) of any of the requested rule, required data and engine (or portion thereof). By way of non-limiting example, the module **18***d* can determine the location of the requested rule (and corresponding rules base), required data and engine (or portion thereof) by checking parameters or other indicators, e.g., in the rule request signaled to any of the module **18***d* and the engine **18***a* and/or request made by the engine **18***a*, in a registry of the digital data processor **18** and/or elsewhere. Alternatively, or in addition, module **18***d* can query the digital data processors **12**, **14** directly to determine if any of the required/requested resources are maintained by them. Preferably, this is accomplished by communication between module **18***d* and its counterparts **12***d*, **14***d* on each of digital data processors **12**, **14**—which modules **12***d*, **14***d* can, themselves, query the local digital data processor **12**, **14** for the requisite resource(s).

If the determination in step **32** is in the negative for any of the required/requested resources, the operation proceeds to and terminates at step **38** where the coordination module returns an error message in response to the requested rule indicating the absence or unavailability of any of the requested rule, required data and engine (or portion thereof).

If the determination in step **32** is in the affirmative for any of the requested/required resources that were not already present locally at digital data processor **18** (as previously determined by steps **20**-**24**), the operation proceeds to step **26** to make the decision of local versus remote execution of the requested rule as described above. If the determination in step **26** is affirmative, at least one of the requested rule, required data and engine (or portion thereof) that is located remotely at another digital data processor (e.g., **12** or **14**) as identified in step **32**, is retrieved in step **40** before executing the requested rule locally on digital data processor **18** in step **30**. As indicated by the callout **46**, such retrieval is performed by the module **18***d*, following a negative determination in step **28** by (i) validating that the one or more digital data processors identified in step **32** (e.g., **12** and/or **14**) will grant access to the requested/required resource(s) and, (ii) retrieving that/those resource(s) from those one or more digital data processors (i.e., **12** and/or **14**) to digital data processor **18**.

In regard to step **40**(*i*), the module **18***d* can validate that the one or more identified digital data processors will grant access by querying the digital data processor(s) identified in step **32** accordingly. This can be done, for example, through communication with the module **12***d*, **14***d* of the identified digital data processor, which module can validate the presence of any of the requested/required resource (if it has not already done so). In some embodiments, the validating module (e.g., **12***d* or **14***d*) can open a communications port in the respective digital data processor and can prepare the requested/resource for access via that port.

In regard to step **40**(*ii*), the module **18***d* retrieves and/or transfers the requested/required resource from the one or more identified digital data processors to digital data processor **18** for local execution. In some embodiments, a local rules engine **18***d* (if already present) may access the requested/required resource (e.g., data, transaction database, rule and/or rules base) directly from the identified digital data processor, e.g., via a port opened in step **40**(*i*). In other embodiments, the module **18***d* may also transfer one or more requested/required resources to an identified digital data processor (e.g., **12** or **14**) for the requested processing to be performed remotely at the identified digital data processor. Alternatively, or in addition, the module **18***d* may also notify the identified digital data processor (e.g., **12** or **14**) and, preferably, its respective coordination module, identified in step **32**, passing to it the relevant information for the requested processing to be performed (e.g., identity of the rule to be executed). The identified digital data processor may perform the requested processing using the resources/information provided to it. In other embodiments where the required resources are not transferred along with the relevant information, the identified digital data processor may perform the requested processing by utilizing the methodology of FIG. **2** itself in order to access the required resources in connection therewith. The discussion that follows provides further details about this step.

Upon completion of step **40**, control transfers to any of steps **30**, **42** or **44** depending upon the outcome of the previous steps in the operation of the coordination module **18***d*, as indicated in the drawing. Thus, continuing with the current example of retrieving requested/required resources in step **40** from one or more identified digital data processors (e.g., **12** and/or **14**) for local execution at digital data processor **18**, control transfers to step **30** to complete the requested processing. However, if the determination in step **26** is in the negative—that is, it is determined that the requested rule is to be executed remotely, then the appropriate location for the completion of such remote processing is based upon a combination of steps **34**-**44** as well as the outcome of previous steps **20**-**24**.

By way of non-limiting example, despite the local presence of all the requested/required resources on digital data processor **18** (i.e., affirmative responses in steps **20**-**24**), a negative determination in step **26** may be due to parameters or other indicators in a local registry of the digital data processor **18** and/or e.g., in the rule request signaled to any of the module **18***d* and the engine **18***a* and/or request made by the engine **18***a*. In this case, there is no previously identified location from step **32**. Thus, the response to step **34** is in the negative and the operation proceeds to step **36** where the module **18***d* determines if there is another digital data processor (e.g., **12**, **14**) suited for executing the requested rule. In some embodiments, it makes that determination by querying the local rules engine **18***a* and/or by checking the parameters or other indicators as mentioned above. Alternatively, or in addition, the module **18***d* can make the determination based on load-balancing, network speed and traffic, availability of the required/requested resources (or portions thereof) on one or more other digital data processors, data coherency or other factors within the ken of those of ordinary skill in the art based on the teachings hereof. For example, a query during the operation at step **36** (or at a prior step) may reveal that an alternative digital data processor with higher computing power than processor **18** and/or another digital data processor identified in a local registry, has all of the required/requested resources. In that case, module **18***d* may simply notify the alternative digital data processor (and/or its coordination module) to perform the requested processing as opposed to performing it locally or remotely at the other digital data processor that was identified in the local registry. More generally, this example is also reflective of some embodiments discussed throughout this document that may involve scenarios and/or steps where duplicate versions, or at least versions that are comparable in terms of functionality, of one or more requested/required resources may exist at multiple locations

If the determination in step **36** is negative, the operation proceeds to and terminates at step **38** in the illustrated embodiment where the coordination module **18***d* returns an error message indicating the absence or unavailability of a suitable digital data processor for remote execution of the requested processing/rule. In other embodiments, if the requested/required resources are present locally, the coordination module may ignore the negative outcome of step **26** and execute the requested rule locally as default if a suitable remote digital data processor (e.g., **12** and **14**) is not identified in step **36**.

If the determination in step **36** is in the affirmative, coordination module **18***d* any of transfers the requested/required resources from the digital data processor **18** and/or provides the relevant information to the other identified digital data processor in step **36** e.g., by employing the methodology discussed above in connection with steps **40**(*i*) and (*ii*). In some embodiments, coordination module **18***d* may only transfer a portion of the requested/required resources if it is determined (as mentioned above) that another identified digital data processor(s) already possesses the remaining portion of the requested/required resources. Once any such transfer and/or notification is completed in step **40** from digital data processor **18**, processing is completed by executing the requested rule remotely in step **44** at the other digital data processor that is identified in step **36**.

Preceding the negative determination in step **26**, a negative outcome in any of steps **20**-**24** indicates that at least one of the requested/required resources is not locally present on digital data processor **18** and that one or more digital data processors (e.g., **12** and/or **14**) may have been identified in step **32** to locate such requested/required resource as previously discussed. In situations where (i) at least one but not all of the determinations in steps **20**-**24** are in the affirmative, (ii) the determination in step **26** is in the negative, and (iii) the determination in step **34** is affirmative, the operation proceeds to remotely execute the requested rule. If only one digital data processor was identified in step **32**, then module **18***d* transfers the portion of the requested/required resources at digital data processor **18** (e.g., by employing the methodology discussed above in connection with steps **40**(*i*) and (*ii*)) to the single digital data processor identified in step **32**, where the remaining requested/required resources are located. Once that transfer is completed in step **40**, the requested rule/processing is performed remotely in step **42** at the location identified in step **32**.

In other embodiments, two or more locations may be identified in step **32** e.g., the required data may be located at digital data processor **12** and the engine may be located at digital data processor **14**. In such embodiments, where the step **26** response is negative and the step **34** response is affirmative, module **18***d* may prioritize all available location options based upon various factors including, but not limited to, prioritization criteria specified in the rule request signaled to module **18***d* and/or the engine **18***a*, prioritization rules stored in rules base **18***c* and/or elsewhere on digital data processor **18**. Alternatively, or in addition, module **18***d* may prioritize all available location options based upon the relative computing resources (e.g., CPU, memory etc.) at each location, network traffic or any other factors within the ken of those of ordinary skill in the art based on the teachings hereof. In any event, module **18***d* will transfer the portion of the requested/required resources from digital data processor **18** to the highest priority location and once the transfer(s) is completed in step **40**, the requested rule/processing is performed remotely at that location in step **42**.

A negative determination in step **26** may be followed by a negative determination in step **34**. Following the combined negative determinations, an attempt is made via step **36** (as described above) to identify one or more digital data processors other than local processor **18** or the one or more digital data processors identified in step **32**.

By way of example, a request may be signaled to coordination module **18***d* to execute one or more rules that define a plurality of reports. These report rules may be stored locally in rules base **18***c* and the rules engine **18***a* required to execute the requested report rules may also be locally present on server digital data processor **18**. However, the determination in step **22** may be in the negative because the data to be processed by the requested report rules is not locally present. In such an instance, operation proceeds to step **32** where the coordination module **18***d* attempts to locate the one or more digital data processors that maintain the required data for reports execution. In one embodiment, the coordination module **18***d* identifies the location of such digital data processors (e.g., **12**, **14**) by querying a local registry on digital data processor **18** using parameters or other indicators of data location specified in the rule request that was signaled to the coordination module **18***d*. The query of the local registry may, for example, reveal that a portion of the required data is located in the transaction database **12***b* on digital data processor **12** and the remaining portion of the required data is located in the transaction database **14***b* on digital data processor **14**. Next, operation proceeds to step **26** where it may be determined, for example, that the reports will not be executed locally at digital data processor **18** because a pre-requisite for such local execution is data retrieval from digital data processors **12** and **14** over a very slow network connection (e.g., **16**). In such an instance, a negative outcome of step **26** is followed by a determination in step **34** of whether to execute the requested report rules remotely on digital data processor **12**, **14** or at both locations. This determination may be based on various factors including, but not limited to, load balancing and the correlation between the requested report rules and the required data for requested rule execution at each location. Thus, for example, if CPU speed is sufficient for both digital data processors **12**, **14** (e.g., as determined by the registry query mentioned above) and the requested rules can be apportioned to be separately executed at both locations, the operation may proceed through steps **34**, **40** and **42** such that the respective portions of the report rules along with the required engine **18***a* may be transferred appropriately to digital data processors **12** and **14** for remote execution. Alternatively, the determination in step **34** may be that the requested report rules cannot be independently executed at different locations. In that case, the required data and/or transaction data base (e.g., **12***b*, **14***b*) is retrieved and/or transferred, along with the requested report rules and engine **18***a*, to a single digital data processor for execution. In that case, the transfer destination may, for example, be determined based upon a higher CPU speed or any other factor.

As previously mentioned, a retrieval and/or transfer of rules, engine or data between digital data processors **12**, **14** and **18** can be accomplished by employing the methodology discussed above in connection with steps **40**(*i*) and **40**(*ii*). Thus, for example, after the determination in step **34** is in the affirmative, the location(s) of the required data for the report rules may be validated (if not already done) through communication between coordination modules **12***d*, **14***d* and **18***d*. In some embodiments, the validating module (e.g., **12***d* or **14***d*) can open a communications port in the respective digital data processor and can prepare the required data for access via that port.

Once the ports are opened, the digital data processors **12**, **14** and **18** can freely communicate information among each other in step **40**(*ii*). Thus, if it has been determined that digital data processor **12** is to execute the requested report rules, module **18***d* retrieves the required data portion and/or transaction data base **14***b* from digital data processor **14** and transfers it to the digital data processor **12**. Furthermore, the requested report rules and the required engine **18***a* are transferred from digital data processor **18** to the target digital data processor **12**. Once such retrieval and transfer is completed, the requested report rules are executed in step **42**.

In some embodiments, local registries, files or databases (e.g., **12***b*, **12***c*, **14***b*, **14***c*, **18***b*, **18***c*) on any of digital data processors **12**, **14** and **18** are updated following the retrieval and/or transfer of rules, rule bases, engine (or any portion thereof), data and transaction data bases from/to such digital data processors. This allows digital data processors **12**, **14** and **18** to handle future requests for rule execution accurately and/or efficiently. By way of illustration, once the requested report rules and engine **18***a* are transferred from digital data processor **18** to digital data processor **12** in the example above, the local registries on any of digital data processors **12**, **18** can be updated to reflect such transfer. The operation of coordination module **18***d* is adjusted accordingly to respond to subsequent requests for execution of those report rules that are any of signaled to and received by the module and/or digital data processor **18**.

It will be appreciated that the illustrated embodiment of the operation of coordination module **18***d* in FIG. **2** is merely exemplary and that certain steps may be omitted, modified or re-ordered without departing from the scope of the disclosure herein. In some embodiments, for example, any of the modules **12***d*, **14***d* and **18***d* may be configured differently based on the business and/or technical requirements that drive the use of the techniques and systems described herein.

By way of non-limiting example, the systems and techniques described herein may be used for provisioning a computing platform as a service (e.g., commercially available Platform-as-a-Service or "PaaS" offerings) over the internet to multiple concurrent users (e.g., from different companies or "tenant" organizations) for application development, testing and/or deployment in a way that provides more flexibility and ease of use without sacrificing data security as compared to the conventional technology/tools available on the market today.

In one such embodiment, the server **18** depicted in FIG. **1** is configured as a cloud-based computing platform comprising hardware and software components (e.g., business process management software) that are used by users **11** from one or more tenant organizations over the internet (e.g., network **16**) to develop, test and/or deploy their enterprise applications. Such shared use of resources among multiple tenant organizations on a cloud-based server (e.g., **18**) allows each respective tenant to quickly develop, test and deploy their applications while avoiding the cost and complexity of buying the underlying hardware and software components and hosting them in their own data centers.

Despite its many benefits, the multi-tenant architecture have traditionally presented significant challenges related to data security and integration between cloud-based application(s) and the legacy systems/resources located within each of the respective tenants' data centers. These challenges are exacerbated by the business need of many of the tenant organizations who want to take the hybrid approach of leveraging a cloud-based platform (e.g., server **18**) to develop/test their application(s) and eventually migrating them for deployment within the respective data centers, and vice versa. Given the prior state of the technology, one major drawback of this hybrid approach is that the integration configuration of the tenant application(s) with respect to other applications and/or systems (e.g., data bases) has to be updated each time the tenant application is migrated in/out of the tenant data center.

Thus, for example, enterprise software applications are typically developed and tested by tenants on a server by creating and/or modifying a plurality rules that may be stored in a rules base present on the server. These rules can define all aspects of such tenant applications including their integration with other applications and/or systems, some of which may be located behind tenant firewalls in the tenant's data center. Thus, in order to enable communication between a tenant application on server and other applications, systems and/or functionality located behind tenant firewalls (hereinafter collectively referred to as "tenant legacy systems"), the integration rules for the tenant applications might attempt to obviate the obstacles presented by the firewalls, e.g., by opening multiple ports in the tenant firewall depending upon, e.g., the integration method (e.g., SOAP, .NET, JAVA, EJB etc.) and/or the type of tenant legacy system (e.g., SQL database, web service etc.) that is being linked to the tenant application. If that same tenant application is then subsequently deployed within the tenant's data center (i.e., within the tenant firewalls), the integration rules for that application must be reconfigured to establish the direct link between the tenant application and the tenant legacy systems without any intermediate firewall.

Similarly, a tenant may develop and test its application within its data center before migrating it outside its firewall for deployment on a cloud-server. At run-time of the application, a rules engine on the server might execute one or more of the plurality of rules that define the application in response to requests/events received by server e.g., from users within a tenant data center. The data processed during run-time by such rules could potentially either be stored in the database local to the server or it may be stored in remote tenant data bases that may not be accessible to server (e.g., due to firewalls) to effect the desired processing. In such a system, the conventional prior art approach would require that the integration rules of the tenant application be reconfigured upon migration of the tenant application to the cloud-based server in order to avoid any errors/interruptions during execution of such tenant applications on cloud-based servers due to inaccessibility of the required data and/or other resources.

Systems and techniques described herein overcome these drawbacks, for example, when configured as described below, by allowing tenant organizations to simulate their data center environment on an external cloud-based infrastructure (e.g., server **18**), thus obviating the need to reconfigure the integration framework of the tenant application(s) upon migration.

This and other benefits of the systems and techniques described herein become apparent in embodiments of the type illustrated FIG. **1** which are configured such that digital data processor **18** operates as a server on a "cloud" platform, e.g., of the type commercially available from Amazon, SalesForce, Google, or other cloud-computing providers. In such embodiments, digital data processors **12** and **14** can be, for example, different "tenant" digital data processors that are in communication with the server **18** over network(s) to access resources (e.g., rules, applications, modules, database, rules bases, data, code, scripts, hardware etc.) that may be either "generic" (i.e., available to users/systems associated with all tenants that are able to connect to the server **18**) or "tenant-specific" (i.e., only accessible to users/systems associated with a particular tenant).

As a departure from the conventional approach mentioned above, embodiments of the invention configured as described herein allow tenant organizations to build seamless integration between their enterprise application(s) and the tenant legacy systems without having to reconfigure the application(s) multiple times depending upon where the application(s) is developed, tested and/or deployed. This is accomplished by establishing communication between coordination modules that are installed on the cloud-based server (or wherever the application is developed, tested and/or deployed outside the tenant firewall) as well as within each tenant's data center.

Accordingly, for example, the first time a user **11** signals/sends a request (e.g., HTTP request or otherwise) using digital data processor (e.g., **12**, **14**, **11***a*) to access any of the resources that are located on the server **18**, any of the coordination module **18***d* and engine **18***a* first authenticate the user by e.g., matching parameters or other indicators of user identification in the request with data related to authorized tenant users previously stored in any of the local data bases (e.g., **18***b*, **18***c*), registries, files and elsewhere. If the user is authenticated/verified as an authorized user who is able to access resources on server **18** on behalf of a tenant organization, a coordination module (e.g., **12***d*, **14***d*) can be transmitted back in response to their initial request. The coordination module that is transmitted back (e.g., **12***d*, **14***d*) may be installed on any digital data processor (e.g., **12**, **14**, **11***a*) located behind/protected by the firewall of the tenant organization that the user is associated with. In one embodiment, the coordination module transmitted back to the authorized tenant user may be installed in the web browser of the digital data processor being used by the tenant user to communicate with server **18**. Upon installation, the coordination module (e.g., **12***d*, **14***d*) may prompt the user to provide information related to the tenant legacy systems that may need to be integrated with the tenant application(s) on server **18**. This information is then be transmitted to server **18** where it is stored in any of the local data bases (e.g., **18***b*, **18***c*), registries, files and elsewhere.

Thus, when an authorized user starts to develop and test applications on server **18** on behalf of tenant organizations and stores the legacy system information for that tenant on the server **18**, any of the authorized developers associated with that tenant organization can configure integration rules for tenant application(s) on server **18** in exactly the same way as if they were developing the integration rules on a digital data processor located within that tenant's data center. Similarly, even if the integration rules were first built within that tenant's data center and then later migrated to server **18**, the legacy system information on server **18** coupled with the communication between coordination module **18***d* and the coordination module located within the tenant's data center (e.g., **12***d*, **14***d*) obviate the need to reconfigure the integration rules to maintain the integration links that are defined by such rules.

FIG. **3** illustrates operation of an embodiment of the invention and particularly, for example, operation of module **18***d* on digital data processor **18** at run-time within a multi-tenant cloud-based environment as described above. In one such embodiment, the module **18***d* can be configured to omit a few steps and simplify its operation as compared to the illustrated embodiment in FIG. **2**. Namely steps **20**, **24**, **34**, **36** and **44** of the operation depicted in FIG. **2** are omitted in here FIG. **3** for various reasons. For example, the platform-as-a-service business model by its very nature typically requires that the service provider (e.g., salesforce.com, Google etc.) provision all required hardware and software components to its tenants. Thus, the coordination module may not need to verify the local presence of all required portions of rules engine **18***a* in step **24**. In fact, all requests by users for rule execution on behalf of the tenants at run-time may initially be signaled to and/or received by engine **18***a*. After the authentication/verification process (as described above) for the user making the request, the rules engine **18***a* may also verify the availability of the requested rule before working with module **18***d* to access the required data in step **22**. Therefore, even though rules engine **18***a* may employ the same techniques as step **20** illustrated in FIG. **2** to verify the local presence of the requested rule, that step **20** can be omitted from the simplified operation of module **18***d* in the illustrated embodiment.

Once the verification process related to user authentication and local rule presence is completed, coordination module **18***d* will respond to requests for data access in substantially the same way as described previously in connection with FIG. **2**. That is, the module **18***d* will verify the local presence of the required data on server **18** using the techniques discussed previously. If locally present, the module will typically defer to the local engine **18***a* for local execution the rule on the required data through steps **26-30**. On the other hand, if the required data and/or database are not locally present, the coordination module **18***d* will attempt to identify the location of the required data in step **32** by checking any of the tenant information, user information, parameters and other indicators of data presence e.g., in the request signaled to the engine **18***a* and/or the module **18***d*. In addition or instead, the module **18***d* may also check integration rules (if any) that may be referenced by or otherwise related to the requested rule and/or the tenant legacy system information that may be found in a registry, data base or elsewhere on the digital data processor **18**. Once the appropriate tenant location of the required data is identified in step **32**, the coordination module **18***d* may retrieve the data for local execution of the requested rule(s) and/or transfer the requested rule(s) to the identified tenant location for execution, all as previously discussed in connection with steps **26**-**30** and **40**, **42** and **46** depicted FIG. **2**.

It will be appreciated that while effecting any of notifications, transfers and retrieval of data and/or rules in step **40** of the illustrated embodiment, the coordination module **18***d* may only open a single port in the tenant firewall. That is a more secure approach than opening multiple ports (e.g., based on integration methods etc.) as required by the conventional approach described above.

It will be appreciated that steps **34**, **36** and **44** from the operation depicted in FIG. **2** are also omitted from the illustrated embodiment in FIG. **3** for the sake of simplicity. It is entirely possible, for example, that the identified tenant location (e.g., digital data processor **12**) in step **32** may not have the required resources (e.g., computing power and/or rules engine) for the requested rule(s) execution. In that case, the coordination module **18***d* may work with the local coordination module (e.g., **12***d*) at the appropriate tenant data center to identify one or more other digital data processors with the necessary resources within that data center for the execution of the requested rules(s).

Described above are systems and methods meeting the foregoing objects. It will be appreciated that the embodiment illustrated and described herein are merely examples of the invention and other embodiments incorporating changes thereto fall within the scope thereof.

In view thereof, what is claimed is:

**1**. A distributed processing system comprising:

a server digital data processor coupled to a rules base that stores a plurality of rules that define an application, wherein the server digital data processor operates on a cloud platform,

an integration link used for communication of one or more data between the application and a tenant legacy system during execution of the application, wherein at least one integration rule among the plurality of rules defines the integration link, and wherein the tenant legacy system comprises at least one of a database and a web service that is communicatively coupled to the server digital data processor,

one or more coordination modules associated with a respective one of the server digital data processor and the tenant legacy system that facilitate the communication between the tenant legacy system and the application in accordance with the integration rule and other tenant legacy system information accessible to the server digital data processor, and

a firewall that is coupled to the one or more networks and that interrupts the integration link between the application and the tenant legacy system, absent intervention of the one or more coordination modules and the other tenant legacy system information accessible to the server digital data processor,

wherein a tenant data center environment is simulated such that the one or more coordination modules and the tenant legacy system information accessible to the server digital data processor obviate a need to reconfigure the integration rule, so as to maintain the integration link regardless of execution of the application on the server digital data processor or a tenant digital data processor, and wherein the tenant legacy system is directly accessible to the tenant digital processor without the firewall preventing such access.

**2**. The system of claim **1**, wherein the one or more coordination modules facilitate the communication between the tenant legacy system and the application by making available the tenant legacy information to the server digital data processor in response to a request from a rules engine executing on at least one of the server digital data processor and the tenant digital data processor.

**3**. The system of claim **2**, wherein the one or more coordination modules make available the tenant legacy information to the server digital data processor by opening one or more communications ports on the firewall.

**4**. The system of claim **3**, wherein the one or more coordination modules make available the tenant legacy information to the tenant digital data processor by opening a single communications port on the firewall and obviate a need to open a plurality of communications ports on the firewall.

**5**. The system of claim **1**, wherein the one or more coordination modules retrieve the tenant legacy information for use in execution of one or more selected rules from the rules base coupled to the server digital data processor.

**6**. The system of claim **1**, wherein the one or more coordination modules transfer one or more selected rules from the rules base coupled to the server digital data processor for execution on the tenant digital data processor.

**7**. The system of claim **1**, wherein the at least one integration rule defines the integration link according to at least one of a Simple Object Access Protocol (SOAP) integration method, a .NET integration method, a Java integration method, and an Enterprise Java Beans (EJB) integration method.

**8**. The system of claim **1**, wherein the server digital data processor transmits the one or more coordination modules to the tenant digital data processor in response to a request to access one or more resources available to the server digital data processor.

**9**. The system of claim **8**, wherein the server digital data processor installs the one or more transmitted coordination modules in a web browser executing on the tenant digital data processor.

**10**. A method of distributed rules processing, the method comprising:

coupling a server digital data processor to a rules base that stores a plurality of rules that define an application, wherein the server digital data processor operates on a cloud platform,

defining an integration link for communication of one or more data between the application and a tenant legacy system during execution of the application, wherein at least one integration rule among the plurality of rules defines the integration link, and wherein the tenant legacy system comprises at least one of a database and a web service that is communicatively coupled to the server digital data processor,

facilitating the communication between the tenant legacy system and the application, via one or more coordination modules associated with a respective one of the server digital data processor and the tenant legacy system, in accordance with the integration rule and other tenant legacy system information accessible to the server digital data processor, and simulating a tenant data center environment such that the one or more coordination modules and the tenant legacy system information accessible to the server digital data processor obviate a need to reconfigure the integration rule, so as to maintain the integration link regardless of execution of the application on the server digital data processor or a tenant digital data processor, wherein the tenant legacy system is directly accessible to the tenant digital processor without a firewall preventing such access, and

wherein the firewall is coupled to the one or more networks and interrupts the integration link between the application and the tenant legacy system, absent intervention of the one or more coordination modules and the other tenant legacy system information accessible to the server digital data processor.

**11**. The method of claim **10**, wherein the facilitating the communication between the tenant legacy system and the application comprises making available, via the one or more communication modules, the tenant legacy information to the server digital data processor in response to a request from a rules engine executing on at least one of the server digital data processor and the tenant digital data processor.

**12**. The method of claim **11**, wherein the making available the tenant legacy information to the server digital data processor comprises opening one or more communications ports on the firewall.

**13**. The method of claim **12**, wherein the making available the tenant legacy information to the tenant digital data processor comprises opening a single communications port on the firewall so as to obviate a need to open a plurality of communications ports on the firewall.

**14**. The method of claim **10**, further comprising retrieving the tenant legacy information, via the one or more coordination modules, for use in execution of one or more selected rules from the rules base coupled to the server digital data processor.

**15**. The method of claim **10**, further comprising transferring one or more selected rules from the rules base coupled to the server digital data processor, via the one or more coordination modules, for execution on the tenant digital data processor.

**16**. The method of claim **10**, wherein the at least one integration rule defines the integration link according to at least one of a Simple Object Access Protocol (SOAP) integration method, a .NET integration method, a Java integration method, and an Enterprise Java Beans (EJB) integration method.

**17**. The method of claim **10**, further comprising transmitting the one or more coordination modules from the server digital data processor to the tenant digital data processor, in response to a request to access one or more resources available to the server digital data processor.

**18**. The method of claim **17**, further comprising installing the one or more transmitted coordination modules, via the server digital data processor, in a web browser executing on the tenant digital data processor.

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