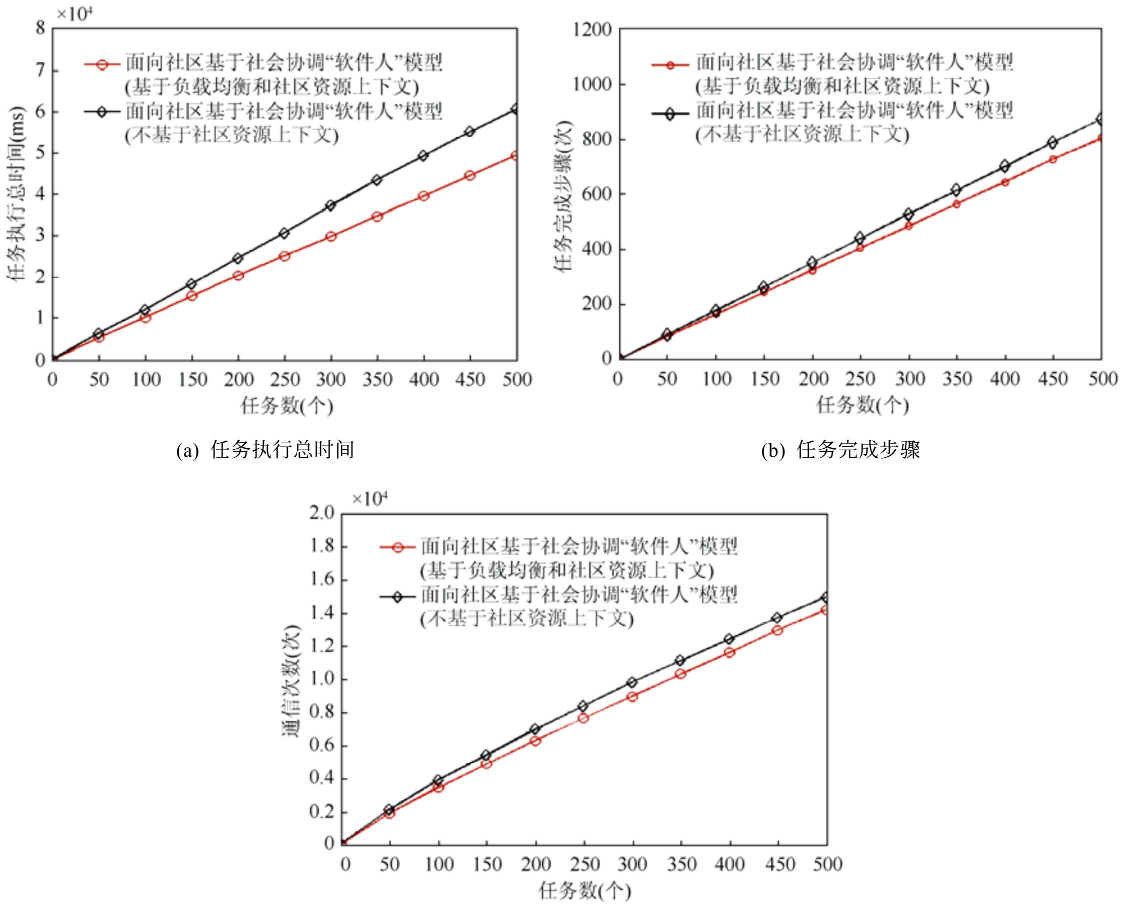
由图 10 和图 11 可以看出,社区内采用基于上下文的任务再分配机制时,降低了任务执行总时间、完成步骤和通信次数,提高了模型的分配性能.这是由于,当社区执行任务失败时,其在社区内部采用基于上下文的任务再分配机制可省去任务管理方对该任务再次招投标的时间和通信开销,也避免了任务管理方再次招投标时将任务分配给不诚信社区、不诚信社区执行任务失败的情况发生.

4.4 模型鲁棒性

因面向社区基于协调“软件人”任务分配模型和直接面向“软件人”任务分配模型在面向实体方面的截然不同,这部分将测试此两种模型在诚信社区动态变化环境下的鲁棒性,并对实验结果进行对比、分析.诚信社区动态变化是指社会中的诚信社区将发生变化,即原本不诚信的社区会变为诚信社区,原本诚信的社区中会有一部分变为不诚信社区.



(a) 任务执行总时间

(b) 任务完成步骤

(c) 通信次数

Fig.11 Model performance comparison of using and not using the redistribution mechanism based on context when allocating robot community type tasks

图 11 分配机器人社区类型任务采用与不采用基于上下文的任务再分配机制的性能对比

随机产生 100 个面向“软件人”社区的任务,这 100 个任务将被重复分配 30 轮,每轮每个社区固定分配 10 个任务.第 1 轮任务分配前,将从 10 个社区中选择 3 个社区作为不诚信社区;在第 11 轮任务分配开始时,这 3 个社区将动态地变为诚信社区,而在原先诚信社区中将随机挑选 3 个变为不诚信社区.实验重复进行 50 次,得出每

轮任务的平均执行总时间和平均完成步骤,实验结果如图 12 所示.

随机产生 100 个面向机器人社区的任务,这 100 个任务将被重复分配并执行 30 次(轮),每轮每个社区固定分配 10 个任务.第 1 轮任务分配前,将从 5 个拥有机器人的社区中选择 2 个社区作为不诚信社区,社会中其余社区为诚信社区;在第 11 轮任务分配开始时,这两个社区将动态变为诚信社区,而原先拥有机器人的 3 个诚信社区中的其中 2 个将变为不诚信社区.实验重复进行 50 次,得出每轮任务的平均执行总时间和平均完成步骤,实验结果如图 13 所示.

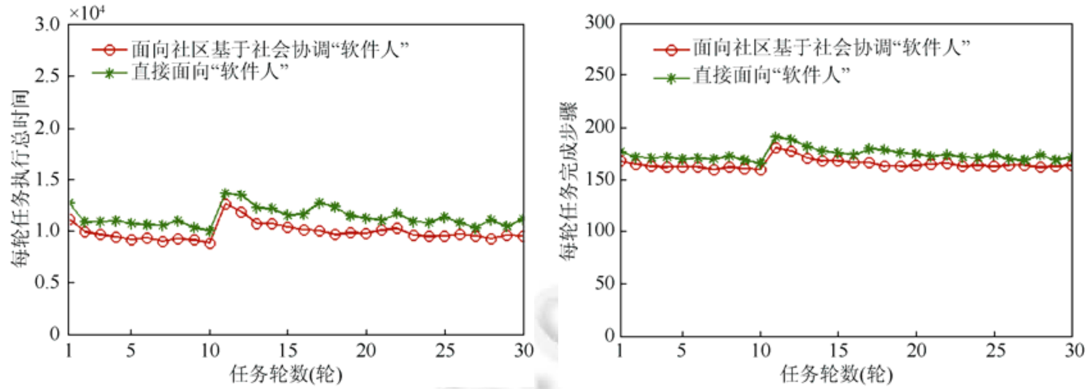


Fig.12 The experimental results of using two allocation models allocating SoftMan community type tasks under the social circumstance of the honest communities changing dynamicly

图 12 诚信社区动态变化时,分配“软件人”社区类型任务两种模型的实验结果

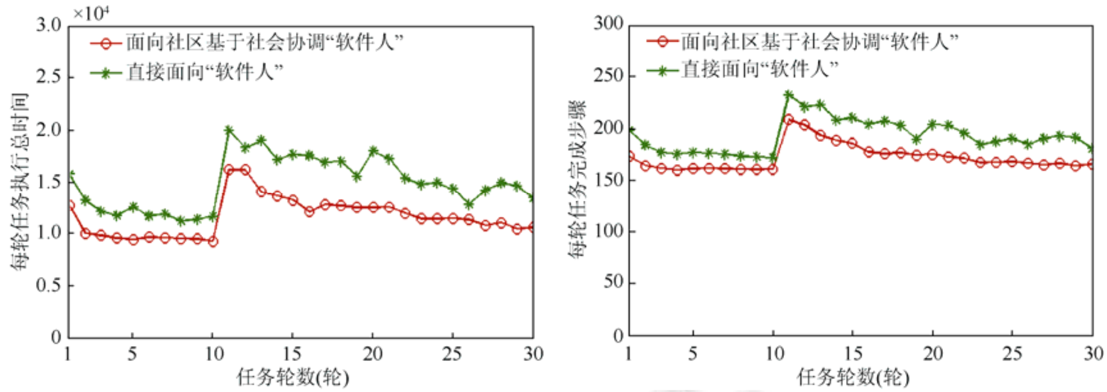


Fig.13 The experimental results of using two allocation models allocating robot community type tasks under the social circumstance of the honest communities changing dynamicly

图 13 诚信社区动态变化时,分配机器人社区类型任务两种模型的实验结果

由图 12 和图 13 可以看出,在第 1 轮~第 10 轮任务,随着轮次的增加,两种模型每轮任务的平均执行总时间和平均完成步骤逐渐下降,说明这两种模型都有自学习功能;随着分配经验的累积,性能越来越优,最后趋于稳定,说明了模型中针对社区或“软件人”的信任度评估机制以及基于信任度的社区节点或“软件人”选择策略的有效性.在第 11 轮,诚信社区发生变化,面向社区基于社会协调“软件人”的任务分配模型和直接面向“软件人”的任务分配模型在每轮任务执行总时间和完成步骤上有一个大幅度的升高.这是由于,诚信社区发生变化,第 1 轮~第 10 轮积累下来的社区信任度不再适用.此后,随着任务轮次的增加,执行总时间和完成步骤总体为下降趋势,但在下降过程中,面向社区基于社会协调“软件人”的任务分配模型下降趋势稳定,波动较小,且较直接面向“软

件人”的任务分配模型恢复性能快;而直接面向“软件人”的任务分配模型在性能恢复过程中每轮任务的执行总时间和完成步骤波动较大,且恢复性能较慢.这是由于动态变化的是社区的诚信度,但直接面向“软件人”的任务分配模型面对的是“软件人”个体.每次任务执行后任务管理方只能修正对一个“软件人”的信任度,当社区变为不诚信社区(或变为诚信社区)后,如社区中的另一“软件人”投标任务时,其仍以之前对该“软件人”形成的信任度历史进行分配,而不能顾及该“软件人”所在社区的诚信度已发生变化、一个“软件人”是否诚信的决策是由社区管理“软件人”决定的实际情况,因此性能恢复较慢,且波动性较大.总的来说,两种模型都具有鲁棒性,但面向社区基于社会协调“软件人”分配模型的鲁棒性比直接面向“软件人”的分配模型要强,且稳定性要好.

5 结 论

在合一系统中,“软件人”之间的协作很大程度上受组织模型结构的影响,本文所研究的任务分配作为协作的重要一环,首先即设计了合理的基于“软件人”群协作组织模型.

任务分配的主要目标是最大化系统的整体效能并且尽可能快地完成任务.最大化系统的整体效能即充分利用系统资源;尽可能快地完成任务即最小化每个任务的执行时间.每个任务的执行时间应包括 4 个部分:分配任务时与其他社区的协商时间、在非管理“软件人”中的等待时间、执行过程中任务管理社区与任务承包社区间的通信时间以及任务在非管理“软件人”中的处理时间.因此,在不可靠的合一系统社会应用背景下,为达到任务分配的目标,分配模型在社区间进行任务分配时采取了借助社会协调“软件人”的协商机制、基于直接信任度和社区声誉的社区信任度评估机制和基于社区信任度的社区节点选择机制;在社区内进行任务分配时采取了基于负载均衡的分配机制和基于上下文资源的任务再分配策略.实验结果表明,基于社会协调“软件人”面向社区的任务分配模型与直接面向“软件人”的任务分配模型和基于资源的任务分配模型相比,任务执行总时间最短,满足了不可靠社会网络中的任务分配优化目标.此外,所提出的模型对动态的社会环境具有鲁棒性和自适应性,可适应除合一系统社会外的多种现实应用.

本文提出的任务分配模型是基于固定的合一系统社会组织模型设计的,社会协调“软件人”的通信压力较大,因此下一步的工作将研究如何使每个社区基于自身任务分配的历史经验,建立自己的社会上下文环境,即熟人社会关系,以扩充任务分配的路径,缓解社会协调“软件人”的通信压力,降低社会网络中的通信密度.此外,对于模型中的权重参数,实验时是通过设置多个参数组合,每一个组合经过多次实验,根据最小化任务执行时间的任务分配目标取最优设置值.但这种参数取值方法较为传统,工作量也较大,因组合设置有限,最终参数取值也较难很近似地接近最优.此外,当社区诚信动态变化时也不能及时调整.因此下一步工作我们将专门研究参数取值及在实时分配过程中的自适应调节问题.

References:

[1] Kim JH, Yang W, Sincak P, Xu P. Robot Intelligence Technology and Applications 3. Springer Int’l Publishing, 2015.

[2] Tan M, Wang S. Research progress on robotics. Acta Automatica Sinica, 2013,39(7):963−972 (in Chinese with English abstract). [doi: 10.3724/SP.J.1004.2013.00963]

[3] Navaravong L, Zhen K, Shea J M, Dixon WE. Formation reconfiguration for mobile robots with network connectivity constraints. Network IEEE, 2012,26(4):18−24. [doi: 10.1109/MNET.2012.6246748]

[4] Nigl F, Li S, Blum J E, Lipson H. Structure-Reconfiguring robots: Autonomous truss reconfiguration and manipulation. IEEE Robotics & Automation Magazine, 2013,20(3):60−71. [doi: 10.1109/MRA.2012.2201579]

[5] Zeng GP, Tu XY, Wang HB. SoftMan Research and Applications. Beijing: Science Press, 2007 (in Chinese).

[6] Wilensky U, Rand W. An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo. MIT Press, 2015. [doi: 10.1063/PT.3.2884]

[7] Liu DY, Yang K, Chen JZ. The research status and development trend of agent. Ruan Jian Xue Bao/Journal of Software, 2000,11(3):315−321 (in Chinese with English abstract). http://www.jos.org.cn/ch/reader/create_pdf.aspx?file_no=20000305&journal_id=jos

[8] Lu Q, Zeng G, Zhang W, Tu X. SoftMan and agent. In: Proc. of the 2005 IEEE Networking, Sensing and Control. 2005. 904−907. [doi: 10.1109/ICNSC.2005.1461313]

[9] Wu DF, Zeng GP, Xiao CE, Zhang QC. Open robot agent: Construction of host SoftMan. Journal of Computer Applications, 2015,35(6):1766−1772 (in Chinese with English abstract). [doi: 10.11772/j.issn.1001-9081.2015.06.1766]

[10] Wu DF, Zhang QC, Zhang X, Xiao C. Research on appendage SoftMan based on machine cogmatics. Open Automation and Control Systems Journal, 2014,6:1480−1490. [doi: 10.2174/1874444301406011480]

[11] Weerdt MMD, Zhang Y, Klos T. Multiagent task allocation in social networks. Autonomous Agents and Multi-Agent Systems, 2012,25(1):46−86. [doi: 10.1007/s10458-011-9168-3]

[12] Ohtsuki H, Hauert C, Lieberman E, Nowak MA. A simple rule for the evolution of cooperation on graphs and social networks. Nature, 2006,441(7092):502−505. [doi:10.1038/nature04605]

[13] Jiang Y, Zhou Y, Wang W. Task allocation for undependable multiagent systems in social networks. IEEE Trans. on Parallel & Distributed Systems, 2013,24(8):1671−1681. [doi: 10.1109/TPDS.2012.249]

[14] Tu XY, Z. Wang Z and Y. Guo YH. Large Scale Systems Control Theory. Beijing: Beijing University of Posts and Telecommunications Press, 2005 (in Chinese).

[15] TU XY. Generalized model, intelligent simulation, Soft-Man. Computer Simulation, 2011,28(7):224−228 (in Chinese with English abstract). [doi: 10.3969/j.issn.1006-9348.2011.07.056]

[16] Aref A, Tran T. FTE: A fuzzy logic based trust establishment model for intelligent agents. In: Proc. of the 2015 IEEE/WIC/ACM Int'l Conf. on Web Intelligence and Intelligent Agent Technology (WI-IAT). IEEE, 2015. 133−138. [doi 10.1109/WI-IAT.2015.105]

[17] Huynh TD. Trust and reputation in open multi agent systems [Ph.D. Thesis]. Southampton: Electronics and Computer Science, University of Southampton, 2006.

[18] He LJ, Huang HK, Zhang Wei. A survey of trust and reputation systems in multiagent systems. Journal of Computer Research and Development, 2013,39(7):963−972 (in Chinese with English abstract).

[19] Hendrikx F, Bubendorfer K, Chard R. Reputation systems: A survey and taxonomy. Journal of Parallel & Distributed Computing, 2014,75:184−197. [doi: 10.1016/j.jpdc.2014.08.004]

[20] Zacharia G, Moukas A, Maes P. Collaborative reputation mechanisms for electronic marketplaces. Decision Support Systems, 2000,29(4):371−388. [doi: 10.1016/S0167-9236(00)00084-1]

[21] Sabater J, Sierra C. Social ReGreT, a reputation model based on social relations. ACM SIGECOM Exchanges, 2002,3(1):44−56. [doi: 10.1145/844331.844337]

[22] Mui L, Mohtashemi M, Halberstadt A. Notions of reputation in multi-agents systems: A review. In: Proc. of the 2002 Int'l Conf. on Trust, Reputation, and Security: Theories and Practice. Springer-Verlag, 2002. 280−287. [doi: 10.1145/544741.544807]

[23] Amazon. 2016-06-03. http://www.amazon.com/

[24] Taobao. 2016-06-03. https://www.taobao.com/

[25] Geetha G, Jayakumar C. Implementation of trust and reputation management for free-roaming mobile agent security. IEEE Systems Journal, 2015,9:1−11. [doi: 10.1109/JSYST.2013.2292192]

[26] Jiang Y, Zhou Y, Li Y. Reliable task allocation with load balancing in multiplex networks. ACM Trans. on Autonomous & Adaptive Systems, 2015,10(1):1−32. [doi: 10.1145/2700327]

[27] Khosravifar B, Bentahar J, Gomrokchi M, Alam R. CRM: An efficient trust and reputation model for agent computing. Knowledge-Based Systems, 2012,30(2):1−16. [doi: 10.1016/j.knosys.2011.01.004]

[28] Basheer GS, Ahmad MS, Tang AYC, Graf S. Certainty, trust and evidence: Towards an integrative model of confidence in multi-agent systems. Computers in Human Behavior, 2015,45:307−315. [doi: 10.1016/j.chb.2014.12.030]

[29] Ntemos K, Kalouptsidis N, Kolokotronis N. Managing trust in diffusion adaptive networks with malicious agents. In: Proc. of the Signal Processing Conf. (EUSIPCO), the 23rd European. IEEE, 2015. [doi: 10.1109/EUSIPCO.2015.7362351]

[30] Jiang Y, Li Z. Locality-Sensitive task allocation and load balancing in networked multiagent systems: Talent versus centrality. Journal of Parallel & Distributed Computing, 2011,71(6):822−836. [doi: 10.1016/j.jpdc.2011.01.006]

[31] Jiang Y, Jiang J. Contextual resource negotiation-based task allocation and load balancing in complex software systems. IEEE Trans. on Parallel & Distributed Systems, 2009,20(5):641−653. [doi: 10.1109/TPDS.2008.133]

[32] Hunt S, Meng Q, Hinde C, Huan g T. A consensus-based grouping algorithm for multi-agent cooperative task allocation with complex requirements. Cognitive Computation, 2014,6(3):338−350. [doi: 10.1007/s12559-014-9265-0]

[33] Su Z, Jiang J, Liang C, Zhang G. A distributed algorithm for parallel multi-task allocation based on profit sharing learning. Acta Automatica Sinaca, 2011,37(7):865−872. [doi: 10.1016/S1874-1029(11)60212-7]

[34] Abdallah S, Lesser V. Modeling task allocation using a decision theoretic model. In: Proc. of the 4th Int'l Joint Conf. on Autonomous Agents and Multiagent Systems. ACM, 2005. 719−726. [doi: 10.1145/1082473.1082583]

[35] Xu H, Mandal S, Pattipati KR, Kleinman DL, Mishra M. An optimization-based distributed planning algorithm: A blackboard-based collaborative framework. IEEE Trans. on Systems Man & Cybernetics Systems, 2014,44(6):673−686. [doi: 10.1109/TSMC.2013.2276392]

[36] Kota R, Gibbins N, Jennings N. Decentralised approaches for self-adaptation in agent organisations. ACM Trans. on Autonomous & Adaptive Systems, 2012,7:1−28. [doi: 10.1145/2168260.2168261]

[37] Val ED, Rebollo M, Vasirani M, Fernández A. Utility-Based mechanism for structural self-organization in service-oriented MAS. ACM Trans. on Autonomous & Adaptive Systems, 2014,9(3):1−24. [doi: 10.1145/2651423]

[38] Wang W, Jiang Y. Multiagent-Based allocation of complex tasks in social networks. IEEE Trans. on Emerging Topics in Computing, 2015,1−12. [doi: 10.1109/TETC.2015.2403200]

[39] Kinnebrew JS, Biswas G. Efficient allocation of hierarchically-decomposable tasks in a sensor Web contract net. In: Proc. of the 2009 IEEE/WIC/ACM Int'l Conf. on Web Intelligence and Intelligent Agent Technology. IEEE Computer Society, 2009. 225−232. [doi: 10.1109/WI-IAT.2009.154]

[40] Qiu HP, Qin Y, Hu R, Guan L. Study on the task allocate based on improved contract net in multi-agent system. Computer Science, 2012,39(6A):279−282 (in Chinese with English abstract).

[41] Rahimzadeh F, Khanli L M, Mahan F. High reliable and efficient task allocation in networked multi-agent systems. Autonomous Agents and Multi-Agent Systems, 2015,29(6):1−18. [doi: 10.1007/s10458-014-9273-1]

[42] Wang W, Jiang Y. Community-Aware task allocation for social networked multiagent systems. IEEE Trans. on Cybernetics, 2014,44(9):1529−1543. [doi: 10.1109/TCYB.2013.2289327]

[43] Jiang Y, Huang Z. The rich get richer: Preferential attachment in the task allocation of cooperative networked multiagent systems with resource caching. IEEE Trans. on Systems Man & Cybernetics Part A Systems & Humans, 2012,42(5):1040−1052. [doi: 10.1109/TSMCA.2012.2186439]

附中文参考文献:

[2] 谭民,王硕.机器人技术研究进展.自动化学报,2013,39(7):963−972. [doi: 10.3724/SP.J.1004.2013.00963]

[3] 曾广平,涂序彦,王洪伯."软件人"研究与应用.北京:科学出版社,2007.

[7] 刘大有,杨鲲,陈建中.Agent 研究现状与发展趋势.软件学报,2000,11(3):315−321. http://www.jos.org.cn/ch/reader/create_pdf.aspx?file_no=20000305&journal_id=jos

[9] 武丹凤,曾广平,张青川,肖超恩.开放式机器人智体——宿主"软件人"的构建.计算机应用,2015,35(6):1766−1772. [doi: 10.11772/j.issn.1001-9081.2015.06.1766]

[14] 涂序彦,王枞,郭燕慧.大系统控制论.北京:北京邮电大学出版社,2005.

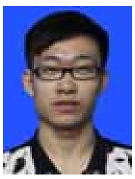
[15] 涂序彦.广义模型智能仿真软件人.计算机仿真,2011,28(7):224−228. [doi: 10.3969/j.issn.1006-9348.2011.07.056]

[18] 贺利坚,黄厚宽,张伟.多 Agent 系统中信任和信誉系统研究综述.计算机研究与发展,2008,45(7):1151−1160.

[40] 裘杭萍,覃垚,胡汭,管留.多 Agent 系统中基于改进合同网模型的任务分配研究.计算机科学,2012,39(6A):279−282.

武丹凤(1982－),女,山西清徐人,博士生,讲师,CCF 专业会员,主要研究领域为智能机器人,"软件人"技术,社会计算,分布式计算.

张绳昱(1995－),男,本科生,主要研究领域为网络工程,分布式计算.



于思淼(1994－),男,学士,主要研究领域为高性能并行计算,软件工程.

张锐文(1996－),男,本科生,主要研究领域为网络工程,复杂系统建模.