Software Architecture Design for Gesture Interaction: Components, Layers, or Graphs?

Jean Vanderdonckt
Louvain Research Institute in Management and Organizations
Université catholique de Louvain
Louvain-la-Neuve, Belgium
jean.vanderdonckt@uclouvain.be

***Abstract*—Gesture-based interaction performed in real-time imposes several constraints on the software architecture of interactive systems to balance the performance of the system, such as its accuracy, with the preference of end-users, such as their subjective satisfaction and fast response time. To reach this balance and to support software quality properties of these systems, such as flexibility, maintainability, and efficiency, various software architectures need to be designed depending on the context of use in which the system will be deployed. To address these properties, we present and compare software architecture designs for three scenarios of gesture interaction: a component-based design for radar-based hand gesture interaction in a smart meeting room, a layered design for full-body gesture interaction in extended reality, and a graph-based design for multimodal interaction with multiple devices.**

Keywords—gesture interaction, software architecture, quality properties, radar-based gestures, extended reality

I. Extended Abstract

Gesture-based interaction [9] performed in real-time imposes several constraints on the software architecture of interactive systems to balance the performance of the system, such as its accuracy (the degree to which a gesture recognizer produces a correct answer, e.g. >95%), and the preference of end-users, such as their subjective satisfaction (the degree to which end-users prefer to issue a certain gesture over others, e.g., >80%), and the response time (the duration needed by the system to react to a gesture input, e.g., <10 msec). To reach this balance and to support quality properties of the system, such as flexibility [1], maintainability, and efficiency, various software architectures need to be designed depending on the context of use in which the system will be deployed. To address these properties, we present and compare software architecture designs for three scenarios of gesture interaction: a component-based design [5] for radar-based hand gesture interaction in a smart meeting room [7], a layered design for full-body gesture interaction in extended reality [4], and a graph-based design for multimodal interaction [8] with multiple devices in a way that is compliant with the principles of model-driven engineering [2] and universal design of user interfaces [3] in multiple contexts of use [8]. We also discuss the advantages of event-driven software architectures [6].

II. Speaker Biography

Jean Vanderdonckt is a Full Professor of Computer Science at Universite catholique de Louvain (UCLouvain, Belgium) where he is Emeritus President of Louvain Research Institute in Management and Organizations (LouRIM) and Director of the Louvain Interaction Laboratory (LiLab) since its creation in 1998. He holds a master and an aggregation in mathematics, a master in computer science and a PhD in Sciences from University of Namur. He has been Visiting Associate Professor at Stanford University (2000), invited professor at Univ. of Fortaleza (2001), and permanent invited prof. at Polytechnic Univ. of Valencia. He has over 30 years of experience in research and development. Being ACM member since 1987, he is currently ACM and IEEE Senior Member, and member of ACM SIGCHI. He received several awards (e.g., the IBM Belgium Award in 1998, the ACM Service Award for Contributions to ACM in 2004, 2006, and 2010, the Brian Shackel Award in 2007, the ITEA Research Excellence Award in 2013) and fellowships (e.g., Fulbright-Hayes fellowship in 2000, NATO Advanced Fellowship in 2001). He is co-editor-in-chief of Springer HCI Series.

Acknowledgment

The authors acknowledge support by the EU European Innovation Council Pathfinder-Awareness Inside Challenge "Symbiotik" project under Grant no. 101071147 and by the Fonds de la Recherche Scientifique (FNRS) under Grant n°T.0407.26, Agreement no. 40035986 COSMIC project.

References

[1] N. Aquino, J. Vanderdonckt, and O. Pastor, "Transformation templates: adding flexibility to model-driven engineering of user interfaces," in Proc. of the ACM Symposium on applied computing, SAC '10, pp. 1195–1202. https://doi.org/10.1145/1774088.177434

[2] N. Aquino, J. Vanderdonckt, N. Condori-Fernández, Ó. Dieste, Ó. Pastor, "Usability evaluation of multi-device/platform user interfaces generated by model-driven engineering, " in Proc. of the ACM-IEEE International Symposium on Empirical Software Engineering and Measurement, ESEM '10. https://doi.org/10.1145/1852786.1852826

[3] E. Furtado, J.J.V Furtado, W.B. Silva, D.W.T. Rodrigues, L.S. Taddeo, Q. Limbopurg, and J. Vanderdonckt, "An ontology-based method for universal design of user interfaces," in Proc. of Workshop on Multiple User Interfaces over the Internet: Engineering and Applications Trend, MUI '01. https://www.academia.edu/download/96742796/10-01-13_FE_Kiosk_Accessibility_Paper3.pdf

[4] J.-Y. Lionel Lawson, J. Vanderdonckt, and R.-D. Vatavu, "Mass-Computer Interaction for Thousands of Users and Beyond," in Proc. of ACM Conf. on Human Factors in Computing Systems, CHI '18, Extended Asbtracts, Paper LBW032, pp. 1–6, 2018. New York, NY: Association for Comp. Mach. https://doi.org/10.1145/3170427.31884

[5] J.-Y. Lionel Lawson, A.-A. Al-Akkad, J. Vanderdonckt, and B Macq, "An open source workbench for prototyping multimodal interactions based on off-the-shelf heterogeneous components," in Proc. of ACM Symposium on Engineering Interactive Computing Systems, EICS '09, pp. 245-254, 2009. https://doi.org/10.1145/1570433.1570480

[6] O.-A. Schipor, R.-D. Vatavu, and J. Vanderdonckt, "Euphoria: A Scalable, event-driven architecture for designing interactions across heterogeneous devices in smart environments," Inf. Softw. Technol. 109, pp. 43-59, 2019. https://doi.org/10.1016/j.infsof.2019.01.006

[7] A. Sluÿters, S. Lambot, J. Vanderdonckt, and R.-D. Vatavu, "RadarSense: Accurate Recognition of Mid-air Hand Gestures with Radar Sensing and Few Training Examples," ACM Trans. Interact. Intell. Syst. 13(3), pp. 1-45, 2023. https://doi.org/10.1145/3589645

[8] J. Vanderdonckt, G. Calvary, J. Coutaz, and A. Stanciulescu, "Multimodality for Plastic User Interfaces: Models, Methods, and Principles," in Tzovaras, D. (ed.), Multimodal User Interfaces. Signals and Commmunication Technologies. Springer, Berlin, Heidelberg, 2008. https://doi.org/10.1007/978-3-540-78345-9_4

[9] R.-D. Vatavu, "Gesture-based Interaction," in J. Vanderdonckt, P. Palanque, M. Winckler, M. (Eds.), Handbook of Human Computer Interaction. Springer, Cham, pp. 1-47, 2023. https://doi.org/10.1007/978-3-319-27648-9_20-1

979-8-3315-8386-6/26/$31.00 ©2026 IEEE