Rada Hussein
Dr. sc. hum.

**Integrating the Healthcare Enterprise (IHE):**
**Generic tools for workflow engineering and international adaptation**

Geboren am 23.10.1970 in Kairo
Abitur am 09.08.1988 in Kairo
Studiengang der Fachrichtung Medizinische Informatik vom WS 1988 bis SS 1993
Vordiplom am 01.10.1995 an der Universität Kairo
Diplom am 30.11.1998 an der Universität Kairo

Promotionsfach: Medizinische Informatik
Doktorvater: Prof. Dr. H.-P. Meinzer

In today's healthcare enterprises, data from many resources are needed to make optimal healthcare decisions. However, the healthcare communication standards are insufficient alone to solve the real-world integration problems. Therefore, the Integrating the Healthcare Enterprise (IHE) concept was emerged in 1997 to fill the gaps between these standards.

The main problems of implementing a healthcare application in accordance with the IHE technical framework arise from the fact that IHE addresses the most problematic and challengeable parts of the Digital Imaging and Communication in Medicine (DICOM) standard in implementation, such as the DICOM Structured Reporting (SR). Moreover, the DICOM standard defers to the other industry standards in remaining silent regarding the SR presentation. Therefore, the biggest challenge in DICOM implementation is to consider the different customization aspects to provide the end users with user-friendly toolkits while handling the complicated DICOM objects transparently.

In addition, the practical experiences also showed the essential need for having localized, true cross-platform healthcare applications that can be easily adapted to the local policies and traditions of care. Otherwise, it will be meaningless to integrate information systems that could not understand, or at least accept, the data stored in each other. In this case, there will be a massive data loss of useful information. The main problem of internationalizing the healthcare applications is the restricted internationalization areas supported by the IHE underlying standards.

The work reported in this thesis has solved these problems to be able to improve the Picture Archiving and Communication System (PACS) workstations interoperability among the other information systems, and bridge the traditional gap between imaging and information systems. Based on that, a multistage plan for implementing a full-featured PACS solution in accordance to the IHE technical framework was created at first. Then, the author has developed the DICOM-based modules according to this IHE-compliance plan, e.g., DICOM structured reporting and presentation state, as well as the required complementary tools for workflow engineering and international adaptations utilizing new software concepts and technologies. To evaluate and demonstrate the effectiveness of these new methods and approaches in a pragmatic setting before the public use and utilization, the developed modules and toolkits have been integrated and successfully tested in a real PACS workstation (CHILI).

As a result of this work, the PACS viewer and reporting workstations are IHE compliant. The main advantage gained to the reporting workstation is the ability to link clinical documents with the referenced images for simultaneous retrieval and display at the same workstations. This satisfies the PACS users who need an effective tool that covers a variety of clinical

contexts. In addition, this enables the computer search and analysis for various purposes, such as the scientific research, education, training, clinical trials, performance evaluation, and finally integrating with data mining applications. On the other hand, the viewing workstation has been enabled to have consistent presentation of images through a cost effective solution to insure that the image quality is maintained across different monitors and film producing devices in terms of intensity and geometry.

The results of applying the developed tools for workflow engineering and international adaptations have shown that the new generic approaches and tools of internationalization, localization, customization, and true cross-platform support on the PACS workstations has enabled the PACS applications to handle the different internationalization and localization aspects transparently, such as supporting complex languages, e.g., Arabic, switching between different languages at runtime, and supporting multilingual clinical reports. In addition, the generic design approaches created by the author have facilitated the implementation of a highly configurable application that can be easily customized. Moreover, they have provided a true cross-platform application that can run on many different operating systems, e.g., Windows and Linux. This approach can be also used and easily applied to any other PACS workstation.

Finally, this work is a model of incorporating the IHE concepts as well as the required localization capability for other healthcare specialties. This model can be used as a blueprint for the other healthcare developers to solve the described problems of implementing the DICOM standards in accordance to IHE with the specified localization and cross-platform features in their own systems. As a result, healthcare applications can be adapted to fulfill the requirements and specific needs of different environments (including different languages, cultures, operating systems, etc.), clinical workflow, and users in order to provide a better health service.