A Conceptual Framework for Linked Open Islamic Knowledge

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ABSTRACT
The Linked Open Data (LOD) approach has emerged as the de facto standard for sharing and publishing the data on the web. The domain of Islamic knowledge, in particular, and religious knowledge, in general, has failed to cache upon the promised potential of the semantic web and the linked data technology; web-scale integration of these knowledge resources is currently not facilitated at a large scale. This paper presents the emerging vision and the need for Linked Open Islamic Knowledge, its requirements and foundations. The important challenges and limitations of the existing research landscape are highlighted in an attempt to analyze why it fails to meet the requirements of meeting the vision at hand. A conceptual framework that would functionally fulfill the Islamic LOD vision is presented. A brief insight is also provided to hint at the need and the role of Human Computation & Crowdsourcing (HC&C) methods and how they may facilitate the realization of the proposed vision.

Keywords: human computation, crowdsourcing, Islamic knowledge, linked open data.

1. Introduction: The Vision of Linked Open Islamic Knowledge

The emerging technologies in the recent years have greatly revolutionized the different ways to interact with knowledge. There is an increasing need to search for new ways of modeling, standardizing, aggregating, linking, publishing, visualizing and presenting knowledge for Islamic and religious knowledge providers and seekers, to engage, facilitate and educate them. So far web-scale integration of Islamic knowledge resources is not facilitated, mainly due to the lack of adoption of shared principles, datasets and schemas. This research, therefore, aims to investigate how Linked Open Data (LOD) technologies can solve the problem of information integration and provide new ways of teaching and learning Islamic knowledge.

The linked data approach has emerged as the de facto standard for sharing the data on the web. The term "linked data" refers to a set of best practices for publishing and connecting structured data on the web (Bizer et al., 2009). The linked data design issues provide guidelines on how to use standardized web technologies to set data-level links between data from different sources (Heath & Bizer, 2011). Increased interest in the LOD has been seen in various sectors e.g. Education (Dietze et al., 2013; Piedra et al., 2014), Scientific research (Attwood et al., 2010), libraries (Hannemann & Kett, 2010; Howarth, 2012), Government (Ding et al., 2011; Hendler et al., 2012; Shadbolt et al., 2012), Cultural heritage (Edelstein et al., 2013) and many others, however, the religious sector has yet to cache upon the power of the linked open data.

1.1 Motivation for an LOD Approach for Islamic Knowledge

Research in computational informatics applied to the Islamic knowledge has primarily centered around Morphological annotation of the Qur'an (Dukes et al., 2010; Dukes & Habash, 2010), Ontology modeling of the Qur'an(Al-Khalifa et al., 2010; Baqai et al., 2009; Farghaly & Shaalan, 2009; Yauri et al., 2012, 2013), and Arabic Natural language processing (Farghaly & Shaalan, 2009). The LOD take-up in the area of Islamic knowledge has been particularly extremely limited. To date only one recent study has attempted to publish a small data-set pertaining to Qur'anic knowledge (Sherif & Ngonga Ngomo, 2015). Thus, LOD opens the opportunity to address information integration and interoperability issues in the field. According to the assessment of this research, the suitability of LOD paradigm to the domain of Islamic knowledge stems from several groundings foremost of which includes a great need for standardization, common knowledge models and vocabularies in the domain of religious learning in general and Islamic knowledge in particular. In addition, there is not only great potential for generating 'links' in the distributed content that has been made available over the years with the advent of technology and the internet, there is also dire need to establish these links to better facilitate relevant and timely knowledge discovery, aggregation and efficient retrieval by knowledge seekers and educators alike. The LOD vision promotes open and interoperable access to knowledge, along with the support for multi-lingual content, both of which are highly suitable to the needs of the Islamic knowledge.

1.2 Contributions of the Paper

This paper makes the following contributions:

- It provides insights into understanding the vision, the context, the need and potential for Linked Open Islamic Knowledge; it explains the proposed Macro-structure of linked Islamic knowledge and provides the classification and the nature of links at the knowledge level (Section 2).
- It provides an understanding of the requirements for achieving this vision, and the required foundations by proposing a high-level conceptual framework that would need to be developed to achieve this vision; it also delineates upon the key challenges that are encountered in the realization of such a framework (Section 3).
- It examines the role of Human Computation and how it may be used in overcoming the key challenges associated with resolving the knowledge acquisition bottleneck in order to achieve the LOD vision for Islamic knowledge (Section 4).

2. The LOD Potential for Islamic Knowledge

The major challenge for the Islamic knowledge domain is to start adopting LOD principles and vocabularies while leveraging on existing data available on the web. However, in order to understand how and if at all the LOD paradigm is suitable to this domain, it is important to understand the structure of Islamic knowledge, some unique requirements for the knowledge providers and seekers in the domain and the nature of potential links at the knowledge level.

2.1 Understanding the Macro Structure of Islamic LOD

Figure 1 shows a broad overview of the macro structure of the Islamic knowledge landscape that has evolved since the revelation of the Qur'an. As shown in Figure 1, the Qur'an is the primary book of knowledge at the center of all Islamic knowledge. It forms the foundation for anyone wanting to learn Islam be it a Muslim or Non-Muslim. The second most important source is the books of Hadith (Narrations of the Prophet Muhammad), which are also considered as the primary source of knowledge. Together, these two are the most important sources of knowledge. The next level are the scholarly books of Qur'anic commentaries and

Exegesis, which contain interpretations and explanations to the verses in the Qur'an based on scholarly interpretation. Scholars over the years have written and compiled thousands of books on Qur'anic Exegesis. Some are more prominent than the others based on the merit of scholarly descent, caliber and the authenticity of the material cited. These books heavily rely on the books of hadiths and the Qur'an itself for explaining different aspects of the verses. At the next level are classical books, written in the early periods, which rely heavily on these commentaries, the books of hadith and the Qur'an. A detailed classification and discussion of Qur'anic explanation is provided by Philips (Philips, 2002). Although, new research, literature and educational content has continued to be generated with a high pace, and over the recent years much of it has been made available in the digital format, however it remains firmly rooted in its links to primary, secondary and tertiary sources of knowledge. Over the recent years, several structured data repositories and multimedia content in the form of audio and video lectures from contemporary scholars have also been made available which contain references to these classical and primary sources of reference. Therefore, the content is rich in 'potential links', which existing repositories and applications fail to capture.
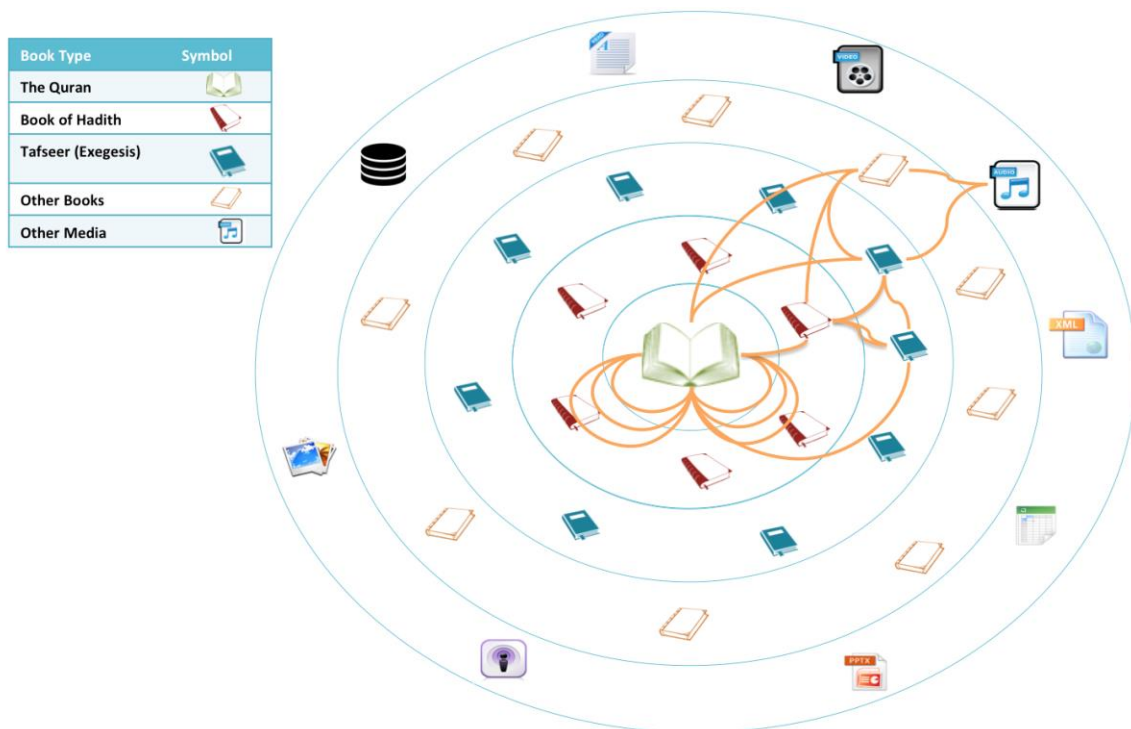

Figure 1: The Macro Structure of Linked Islamic Knowledge Landscape

Existing Islamic knowledge sources and applications are little known to be interoperable, and do not encourage automated discovery, recommendation and synthesis. As a result, teachers, students and self-learners spend too much time looking for resources or they spend too little and may end up making decisions based on incomplete information. The user experience of a knowledge seeker or an educator in Islam can be greatly improved if the system runs on a backend supported with linked open data for the representation of Islamic knowledge. In this research an effort is made to examine how the LOD can be adopted to model Islamic knowledge to address some major challenges and needs that arise for students, teachers, researchers and scholars of this domain.

2.2 The Need and Challenge for Linking Islamic Knowledge

It is important to understand why linking of relevant knowledge sources is important and particularly challenging in the domain of Islamic knowledge. The Qur'an is the primary book of knowledge. It is not possible to understand the Qur'an in isolation. Qur'anic understanding is incomplete without referring to the Hadith and books of exegesis. Cross-linking of resources will facilitate learners to cross-navigate knowledge sources at various levels of granularity to ensure a more efficient learning experience. Similarly, contemporary literature must be backed by credible primary sources; however, there is no standardized means by which this cross-linking may be made possible. Often when referring to a particular opinion, chain of narrators and scholars is important and must be traceable in order to ensure the authenticity of knowledge being quoted, however, often times this is not accurately cited in books and becomes a challenge for the learners to verify. Another level of complexity is the difference is schools of thought that make the knowledge selection and reliability difficult. While the religious practices need to be backed by primary sources, there is little or no support for cross comparison because knowledge sources are neither synthesized nor linked in such a manner. These are just some of the unique requirements for a knowledge seeker or an educator of knowledge in Islam and therefore imply the strong need for linking the relevant knowledge sources, thus making their access, retrieval and analysis easier. However, the most challenging aspect that emerges as a result is that fulfilling these needs through purely computational approaches is not an easy task. Human intelligence plays an indispensable role in capturing and modeling the knowledge in the right manner.

2.3 The Nature of Potential Links

In Figure 1, where the Macro knowledge structure is shown for the Islamic domain, the potential links may be created at various levels, depending on the level of granularity chosen for modeling the knowledge units. This research proposes the classification of these knowledge units and their respective links at two levels: Macro and Micro Level.

2.3.1 Macro-Level Links

In the proposed Islamic LOD based knowledge framework, Macro-Level Units are considered at the level of granularity that is equivalent to a Verse in the primary source i.e. the Qur'an. There may be verses in the Qur'an that link to other verses. There is also evidence in the scholarly interpretations of inter-chapter relationships. Different verses help to explain one another. In fact, the primary principle of Qur'anic Exegesis states that the Qur'an itself does the best explanation of the Qur'an (Philips, 2002). Therefore, most crucial links would tend to be the Verse-to-Verse links. Scholars over the centuries have attempted to extract these links and are captured in their commentaries. On a similar note, the next most important level of links to be captured is Verse-to-Hadith Relations. Qur'anic interpretation heavily relies on the narrations of the Prophet Muhammad, called Hadith. Modeling these formally using computational knowledge models is not a trivial task, however, if done, this would greatly facilitate Qur'anic scholarly pursuits.

It is also important to consider a Passage (Groups of Verses) as an important macro level entity, when modeling relationships between different entities at varying levels of granularity. Qur'anic verses often cannot be interpreted in isolation, and need to be closely studied in combination with the context and the surrounding verses they appear with. On a similar note, other higher-level constructs such as passages, sections and sub-sections that belong to some text may become part of some relation that is essential to capturing the link. To date, to the best of the background review that this research has undertaken, no formal knowledge model is known to have captured links and relations at this level.

2.3.2 Micro-Level Links

Since the language of the Qur'an and Hadith is Arabic, much of the classical literature is also in the Arabic language. Arabic is a rich language, with complex morphology, and semantics (Farghaly & Shaalan, 2009). There is no bound to the word-to-word relations that may exist in these texts. Different words have common roots, which appear differently with different meanings in different contexts (polysemy). Similarly, words with related meanings may not have common roots. There may be words linked due to their morphology. Related words may appear in the same verse, same surah (chapter) or across chapters. Capturing links at this level would constitute, what has been coined in this research as, Micro-level links. In addition to words and roots, often times, portions of large verses are used in literature and quoted as a significant phrase or a segment. These would also be classified as micro-level links.

2.3 Related Work towards Islamic LOD

There have been some recent works, which have attempted to create a foundation for the Islamic LOD. Amongst these, noteworthy mentions are SemanticQuran (Sherif & Ngonga Ngomo, 2015) and QuranOntology (Hakkoum & Raghay, 2015). The recent work of the authors of this research demonstrates the modeling and implementation of macro-level links namely, Verse-Hadith links in the work entitled Semantic Hadith (BasharatAbro et al., 2016). A summary of these works, the types of links they capture and the data sources they have relied on are given in Table 1.

Table 1 : Summary of Related Works towards Islamic LOD

Research Work	Types of Links in the Dataset	Original Data Source(s)
Semantic Quran *(Sherif & Ngonga Ngomo, 2015)*	**Micro-Level Links** Entity Links with DBPedia	Quran Corpus *(quran.com)* Tanzil.net
Quran Ontology *(Hakkoum & Raghay, 2015)*	**Macro-Level Links** Verse-Verse Relations Verse-Topic Relations	Quran Corpus *(quran.com)* Qurany *(Abbas, 2009)* Semantic Quran QurSim *(Sharaf & Atwell, 2012)*
Semantic Hadith *(BasharatAbro et al., 2016)*	**Macro-Level Links** Verse-Hadith Relations Hadith-Verse Relations Hadith-Hadith Relations	Sunnah.com QuranOntology *(Hakkoum & Raghay, 2015)* Semantic Quran *(Hakkoum & Raghay, 2015)*

3. A Generic, High-Level Conceptual Framework For Linked Open Islamic Knowledge

As related research in other domains suggest, linked data technologies can help to integrate the work of disperse institutions producing diverse linked data (Piedra et al., 2014). Over the years, a number of open applications and digital repositories have been made available containing a wealth of classic Islamic literature including the Qur'an, books of Hadith, Fiqh, Tafseer, Aqeedah and many others. Realizing the vision of linked Islamic knowledge requires primarily a linked data approach on Islamic knowledge repositories and establishing a framework for bringing this knowledge into a more interoperable, integrated one for sharing, connecting and discovering knowledge. Linked Open datasets need to be created by harvesting information from isolated datasets. By using semantically interoperable linked data, these materials and repositories could be cross-connected to other repositories and portals, thereby allowing a variety of information systems to disseminate knowledge across platforms. This would be crucial in facilitating students, teachers, researchers and general

knowledge seekers of Islam in particular and religion in general. Figure 2 shows the high-level conceptual framework that would need to be developed in order to achieve this vision.
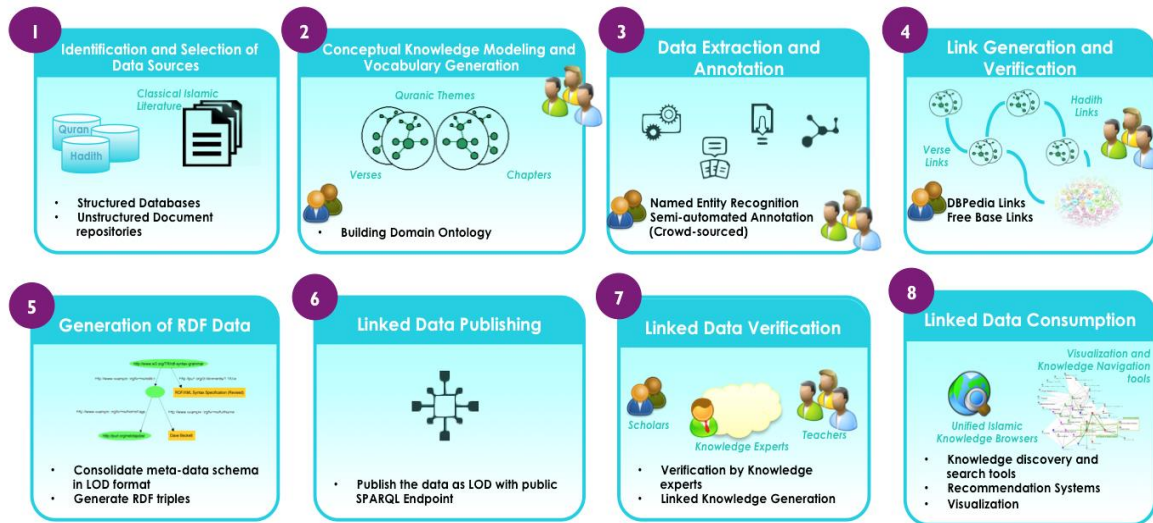

Figure 2: High level conceptual framework for Linked Islamic Knowledge Generation, Publishing and Consumption

3.1 Functional Stages of an Islamic LOD Framework

The functional aspects of this framework are briefly outlined.

Identification and Selection of Data Sources: This stage would involve the identification and selection of appropriate, heterogeneous data sources to determine the scope of the content. Data sources may be structured or unstructured. Any existing semantic models or potential reusable entities may be identified.

Conceptual Knowledge modeling and Vocabulary Generation: To accomplish this, vocabularies in the form of ontologies about the core knowledge content would need to be devised, or reused if available, as well as metadata schemas for knowledge representation appropriate for the data sources. A key research challenge will be accomplishing the creation of semantically unambiguous metadata as automatically and accurately as possible.

Data Extraction and Annotation: This would involve entities within the selected texts to be annotated and further information about these entities may be retrieved from links from existing repositories e.g. applications built using the proposed system in this research could automatically suggest further information about the entity from DBPedia or Freebase and related educational materials from other institutes.

Link Generation and Verification: By semantic data aggregation, knowledge based links will be generated e.g. Qur'anic verses would be potentially linked with other verses, related Hadith and extracts in the books of tafseer that will enable better knowledge navigation and understanding while undertaking serious study of the Qur'an.

Generation of RDF Data: This stage would be one of the key stages prior to publishing the data as linked data and would involve conversion and generation of RDF compatible data. A linked data set will convert existing knowledge into RDF Triples using pre-defined vocabularies and this can be done for Islamic knowledge at various levels. When done across various datasets, matching across RDF triples will result in linking that will become the means to offer a richer knowledge experience.

Publishing Linked Data: Linked data will be published over the LOD cloud, and linked across the existing data sets. The data will be discoverable via SPARQL query endpoints.

Link Data Verification: A crucial requirement is the verification accuracy of the published data and ensuring the authenticity and soundness of not only the knowledge itself but also the links generated. For this purpose complete reliance on automated means is not possible given the sensitivity of Islamic knowledge. Human intelligence will need to be relied upon. Means to achieve this would need to be devised such as some specialized crowd-sourcing experiments or collaborative annotation and verification.

Linked Data Consumption: The potential utilization of the generated linked data will need to be shown via some applications and visualizations. This would be crucial towards validating the success of the proposed vision of Islamic LOD.

3.2 Existing Challenges

The domain of Islamic knowledge, has failed to cache upon the promised potential of the semantic web and the linked data technology. Established research has recognized that ontology-based approaches to data organization and integration in specialized domains have produced significant successes (Niepert et al., 2009). One of the major challenges hindering such approaches from successful application to the Web at large is the so-called "knowledge acquisition bottleneck" (Eckert et al., 2010; Sabou et al., 2013), that is, the large amount of time and money needed to develop and maintain the formal ontologies. This also includes ontology population and semantic annotation using well-established vocabularies. Existing methods towards semantic annotation and linked data knowledge generation are either a) computationally driven, employing on text mining and information extraction methods or, 2) expert driven. A lack of suitable training data and gold standards make reliability and scalability of computational methods challenging. Expert driven methods involve subject specialists; however, these are often not scalable (time or cost).

4. The Need and the Role for Human Computation and Crowdsourcing

To address the challenge of knowledge acquisition bottleneck and others described earlier, researchers have recognized that the realization of the semantic and linked data technologies will require not only computation but also significant human contribution (Siorpaes & Simperl, 2010). Emerging research is advocating the use of Human Computation & Crowdsourcing (HC&C) methods to leverage human processing power to solve problems that are still difficult to solve by using solely computers and seek to harness the 'collective intelligence' and the 'wisdom of the crowds' by engaging large number of online contributors to accomplish tasks that cannot yet be automated (Howe, 2006; Von Ahn, 2009). HC&C methods are being proposed as well-suited to support the semantic web and linked open data research by providing means to efficiently create research relevant data and potentially solve the bottleneck of knowledge experts and annotators needed for the large-scale deployment of semantic web and linked data technologies (Sarasua et al., 2012).

The conceptual framework shown in Figure 1 adds and highlights the element and the need of human contribution and intelligence in few important stages such as conceptual knowledge modeling, vocabulary generation, semantic annotation, link generation and verification. Recognizing this need for human intelligence and contribution is fundamental to the motivation behind the core focus of this research i.e. human computation based knowledge engineering. The overall objective is to augment the process of automated knowledge extraction and text mining methods using a hybrid approach for combining collective

intelligence of the crowds with that of experts to facilitate activities in formalized knowledge engineering - thus overcoming the so-called knowledge acquisition bottleneck often encountered. As part of this research, it is proposed to build a hybrid methodology of ontology and linked data engineering that combines computational and human computation approaches and attempt to demonstrate the feasibility of this approach when applied to Islamic knowledge. A preliminary prototype version of a basic crowdsourcing workflow, in the context of linked data management only, has been recently published in authors' research entitled CrowdLink (Basharat et al., 2014a) , (Basharat et al., 2014b).

Follow up ongoing studies by the authors are focusing on case studies that show the amenability of crowdsourcing methods and its variations such as learnersourcing for Islamic knowledge. Some tasks that have been subject to crowdsourcing include: Thematic Disambiguation and Thematic Annotation. Tasks, which have been subject to learnersourcing, include: (1) Thematic Disambiguation, (2) Thematic Annotation, (3) Thematic Classification and (4) Relation Identification. Details may be found in (BasharatArpinar et al., 2016) and (Basharat, 2016a) respectively.

In order to facilitate the process of crowdsourcing and learnersourcing methods, a semantics drive human-machine computation framework has been proposed (Basharat, 2016b). This framework provides a workflow mechanism, which allows contributions for the above-mentioned tasks to be obtained from a range of users such as students, teachers and experts. The workflow delegates the tasks according to the difficulty level of the task and skill levels of the users. Simpler tasks are delegated to the regular users or crowd workers and their responses are analyzed. Agreement analytics are applied to filter those responses, which fail to reach a consensus. These responses are then validated by experts using the same workflow framework. Another feature of the framework is tight integration of knowledge extraction and retrieval tasks, tightly embedded in the human computation workflow, which attempt to reduce the human effort. Also, the output of the tasks which are approved, are published as ontologies and linked data. According to the authors, such a framework, which combines human and machine intelligence, is indispensable for achieving the large scale LOD vision for Islamic knowledge outlined in this paper.

5. Conclusions

This paper presented the emerging vision and the promised potential of Linked Open data for the Islamic knowledge. It has been established that the diverse and distributed body of Islamic knowledge resources present a huge potential for linking, at both macro and micro-level and then publishing this knowledge as linked open data. This would enable significant benefits to the students, teachers, researchers and all kinds of knowledge seekers and educators in general. It would pave way for new kinds of learning applications. However, achieving this vision is a mammoth task, and given the sensitivity of the knowledge at hand, it will not be possible without the intervention of humans. For a scalable approach, this research suggests integrating and automating the role and contribution of humans in knowledge engineering and linked data management processes through the use of human computation and crowdsourcing methods. While the existing research provides evidence of the promises of these methods, adding this dimension to the LOD framework will bring with itself its own set of challenges to the research. However, these very challenges will open doors to various prospective and promising research directions to be undertaken by the Islamic informatics research community at large.

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