# *Promoting better financial inclusion through web page transformation—a systematic literature review*

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ORIGINAL PAPER

# Promoting better financial inclusion through web page transformation—a systematic literature review

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**Abstract**
Most financial institutions, NGOs, and self help groups (SHG) are now using web technology to create outreach. However, for non-mainstream users, like those in rural India, the web application's non vernacular language, unfamiliar terminology, complex financial models, and user's own poor digital exposure, together creates a mistrust in the web applications, which tends to result in poor adoption. This inhibits financial literacy initiatives and slows down Financial Inclusion, which is a Millennium Goal. We treat this as a web accessibility problem, and look for prior work on transforming published web content for making it suitable for easy consumption by non-mainstream users. To this end we present a systematic literature review, which forages through 1068 records related to page transformation, to RQ1) uncover existing motivators for transforming an existing web page, RQ2) surface the approaches taken, and RQ3) study their implementation techniques. Our stringent paper selection criteria resulted in a final corpus of n = 72 papers on which we pose 17 sub-questions. Results indicate 21% of them transcoding a structure, layout, flow and presentation; 46% augmenting the content or its meta data; and 11% annotating the content. Results indicate that it is feasible to transform existing web content, on the client side, by 3rd party volunteers. We conclude with the hope that by transforming already published financial content to better suit the vernacular and socio-cultural expectations of various divergent groups of non-mainstream users, we could indeed positively contribute to the larger goals of financial literacy and inclusion.

**Keywords** Systematic review · Web page transformation · Web accessibility · Web technologies · Web tools · Browser plugins

## 1 Introduction

Financial inclusion (FI) to alleviate poverty and thereby develop nations is a major cross-cutting concern of Millennium Development Goals. According to World Bank[1] FI not only helps individuals in improving their quality of life, but it also helps nations reduce poverty and boost prosperity. This may be the reason why over 60 countries, including the G20, see FI as a key enabler for multiple sustainable development Goals[1]. Proliferation of Banking, Financial Services and Insurance (BFSI) services through web enabled Internet and Mobile Banking have contributed to substantial access to financial services. Nations have also created policy and pressure to promote better outreach. For example, a government initiated program in India—called Pradhan Mantri Jan Dhan Yojana (PMJDY)—went on a mission and contributed to the creation of a phenomenal 335 million new accounts,

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[1] https://www.worldbank.org/en/topic/financialinclusion/overview

with 60% coming from rural India[2]. While access is facilitated and accounts are opened, it is the Usage of services that appears to be stunted.

For Pakistan, poor adoption of banking technology [3] seems to be due to several factors like lack of digital literacy, poor net speed, unfriendly Website design, fear of government tracking etc. In the case of Nigeria, an appraisal [76] explains how banks are now dealers of "information" and information storage devices like cheques, credit cards and online payments, instead of them being the handlers of the more tangible physical cash. Similarly, a study of Internet banking in Zimbabwe [81] highlights "security concerns" contributing to relatively low usage levels. In general, it appears that for non-mainstream users, lack of familiarity with either technology or the financial jargon; mistrust with systems, actors or institutions; 'incongruence' with local socio-cultural aspects; language barrier may all be cumulatively inhibiting the non-mainstream users from utilizing any web based technologies [39]. We identify these barriers to usage of financial services' web content as a general Web Accessibility problem.

Upon exploration we found that under this "Accessibility" banner, web communities have come forward with focused groups [91], refined policies [90], guidelines [70], tools [80], evaluations [1, 87] etc. From a tools point of view, there are screen readers for the blind, zoom and magnifier type[3] access technologies for the aged, and Ghotit type tools for the cognitively impaired[4]. Interestingly, however, most of the work is focused on the disabled human user. Whether it is a political initiative impacting a country's policy and law [25, 44], or a technology oriented Web Content Accessibility Guidelines (WCAG) initiative [70] impacting web development, the key thrust of these efforts has been "to make the Web accessible to people with disabilities" [89].

In [67] we argue for a more broader definition to the word "accessibility". We suggest that language-barriers, socio-cultural challenges, unfamiliarity with technical jargon should also be considered as Web Accessibility problems, because they too forbid access to web content for some non-mainstream users. Web accessibility in general, or its related categories like web augmentation, web personalization, web localization, typically use some sort of web page transformation techniques to make the original source content suitable to its target audience.

For example, to make a visually rich web page more accessible to a visually challenged user, the web accessibility researchers suggest that we transform the visual material into an aural mode for delivery [61]. Or, substitute text with braille. In some cases, to facilitate audio by screen reading software, they propose transforming the page by injecting text into $< alt - text >$ tags [8]. For geriatric users, they suggest a transformation of increase in font-size [34]. Similarly, web personalization researchers gear up for customized experiences by modifying the user interface (UI) [83]. To reach non-native English readers, the web localization community focuses on substituting the typical mainstream english presentation in web sites with its vernacular equivalent [71]. From a web augmentation community's point of view, reader confusion on a site is eliminated by adding useful instructions as tool tips [83], or by create filters to de-clutter existing information [41].

Typically, a web page is designed to cater to the needs of a majority of its users. To make that particular page more inclusive, one needs to also accommodate the needs of the otherwise neglected set of non-mainstream users as well. For Banking, Financial Services and Insurance (BFSI) web content and services, we presume that web page transformations that allow for language changes into vernacular, narrative changes to better reflect the socio-cultural financial models of a community, terminology variations to reflect more colloquial preferences etc. could lead to more trust and adoption of these web services. This could subsequently lead to more FI.

In this paper we present a systematic literature review (SLR) on the topic of web page transformations. We choose this review approach because an SLR is known to be (1) rigorous, (2) methodical, and (3) structured [48]. We felt that by employing an SLR over a broad spectrum of literature, we could effectively collate, categorize and document the extensive amount of prior work that may have gone into this space of web content accessibility to help future researchers working in this space. The literature review questions we are seeking to answer in this SLR include: In earlier works, did researchers seek ways to modify already published web content to create an alternate narrative? If yes, what has motivated such work? And, what means and methods did they use to create such variants? We feel that if there are ways and means to modify published pages, then such methods can now be applied to increasing financial literacy, which in turn, impacts financial inclusion, and even poverty alleviation.

## 2 Research goal and methodology

The goal of the SLR is realized through 3 main research questions (RQs):

RQ1: What are some of the inherent accessibility challenges in the current published web content?

[2] https://www.business-standard.com/article/economy-policy/nearly-23-3-of-total-jan-dhan-accounts-lay-inoperative-in-2018-shows-data-119010300053_1.html

[3] http://www.blacksunsoftware.com/screenmagnifier.html

[4] http://www.ghotit.com/

**Table 1** List of sub questions for first research question (RQ1)

| SNo. | Sub-questions for RQ1 | Measures |
|---|---|---|
| RQ1.1 | Is there a problem in presenting existing source content in its already published form? | Yes, No |
| RQ1.2 | When does the problem or the challenge manifest? | When using a Small screen device; when a disabled user uses it; Or, even when a conventional user uses it; Or, when a conventional user uses it in a different context. |
| RQ1.3 | How does the challenge manifest? | Can't see all the information of interest; What is shown is *insufficient*; There is an information overload; The presentation appears to be cluttered |

**Table 2** List of sub questions for second research question (RQ2)

| SNo. | Sub-questions for RQ2 | Measures |
|---|---|---|
| RQ2.1 | What do they suggest needs to be done to overcome their challenge? | Annotate, augment, personalize, transcode, modify |
| RQ2.2 | What basic operation is being conducted? | Actions on the source page could be: Add, Del, Modify |
| RQ2.3 | What material on the source page is being acted upon? | *Markup, script, content-text, content-image*, or, something *Outside* the page |
| RQ2.4 | What rendered outcome is being influenced? | Flow or *order* of presented material; look or *aesthetic* of the rendering; the *control* of UI; or the *notification* aspect of UI; *content-text; Content-image*; it could be to *overcome an accessibility barrier* |

**Table 3** List of sub questions for third research question (RQ3)

| SNo. | Sub-questions for RQ3 | Measures |
|---|---|---|
| RQ3.1 | What technologies do they support? | *HTML, XML, RDF, DOM, CSS, PDF etc.* |
| RQ3.2 | Are they using any custom tools? | *Yes*, some customization required for this solution; *No*, generally available tools can be used |
| RQ3.3 | Who is controlling the transformation? | *System, End user* |
| RQ3.4 | Is the transformed outcome fixed or flexible enough to be influenced by end user? | *Predetermined, EndUserInfluence* |
| RQ3 3.5 | When is the transformation action executed? | At *presentation* time; *cached* before for subsequent rendering |
| RQ3.6 | What method is being used? | *Browser extension, Server side changes, StyleSheets, Scripts* |
| RQ3.7 | What components are used in the solution? | A-AppServer, P-proxy, C-cloud, B-browser; *APCB* |
| RQ3.8a | Does the transformed result persist? | *Yes, No* |
| RQ3.8b | Is persisted content standardized or application specific? | *Std, AppSpecific* |
| RQ3.8c | Where is the persisted data stored? | *ClientSide, AppServerSide, Cloud etc.* |

RQ2: What is the scope and focus of the modifications and transformation methods that are proposed to overcome the identified accessibility barriers?

RQ3: How are the proposed transformation methods implemented?

These 3 research questions are further subdivided into 17 other sub-questions which are given in Tables 1, 2 and 3 respectively. The methodology for this SLR is in keeping with the guidelines proposed by [45] and is also informed by Database of Abstracts of Reviews of Effects (DARE)[5] criteria for SLR. The reporting follows the format set by [48]. The research effort for SLR started in Nov, 2016, and lasted till end of Feb, 2017.

[5] https://www.ncbi.nlm.nih.gov/pubmedhealth/about/DARE/

**Table 4** List of general search criteria that helped us formulate more detailed search strings for each database

| SNo. | Search string | Restrictions |
|---|---|---|
| S1 | ("web page" OR "web content") AND (transformation OR augmentation OR modification OR transcoding OR reorganization) | Title, Abstract, Keyword searches; filters barring books, non-English, patents, 0 citations records |
| S2 | (stylesheet OR "style sheet") AND (transformation OR modification OR change) | Title, Abstract, Keyword searches; filters barring books, non-English, patents, 0 citations records |
| S3 | ("client side" OR browser) AND (coding OR programming OR scripting OR plugin OR "plug in" OR addon OR "add on") | Title, Abstract, Keyword searches; filters barring books, non-English, patents, 0 citations records; timeline for 2010-Feb'17 |

**Table 5** Resources used for manual search

| SNo. | Category | Choices | Comments |
|---|---|---|---|
| 1 | Conferences | W4A, WWW, ASSETS, CHI, ISWC, ESWC | Searched 2010–2016; Full papers; no workshops |
| 2 | Journals | TACCESS, HCI Series, Semantic Web, Journal of Web Semantics | Searched 2010–2016 |
| 3 | Authors | Simon Harper, Jeffrey P. Bigham, Richard E. Ladner, Hironobu Takagi, Chieko Asakawa | Full papers; Journal Articles; Searched 2010–2016 |

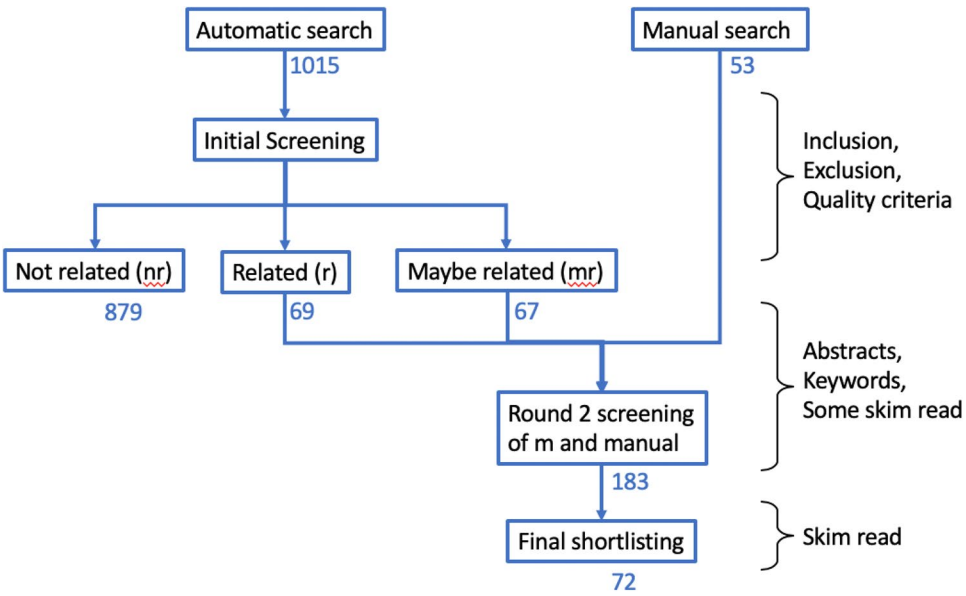


**Fig. 1** Screening process that we followed for this SLR

## 2.1 Search strategy

A string based search was conducted in these six repositories: (1) ACM Digital Library, (2) IEEE Xplore, (3) Science Direct, (4) SpringerLink, (5) Wiley Inter Science and (6) Google Scholar. A refined search string for each of these databases was derived from the higher level set of three search strings, given in Table 4. In addition, we also manually foraged through conference proceedings, journals, and popular authors—see Table 5—related to the goals and objectives set forth for this SLR.

The completeness of the results from both the automated and the manual search process were determined by subjective and collective evaluation of the review teams of this SLR.

## 2.2 Paper selection

We employed various inclusion, exclusion and quality criteria for shortlisting our original corpus. See Fig. 1. The inclusion criteria consisted of english-only documents that were peer reviewed, primary studies, that were published on the topic of web page transformation and / or web accessibility, web

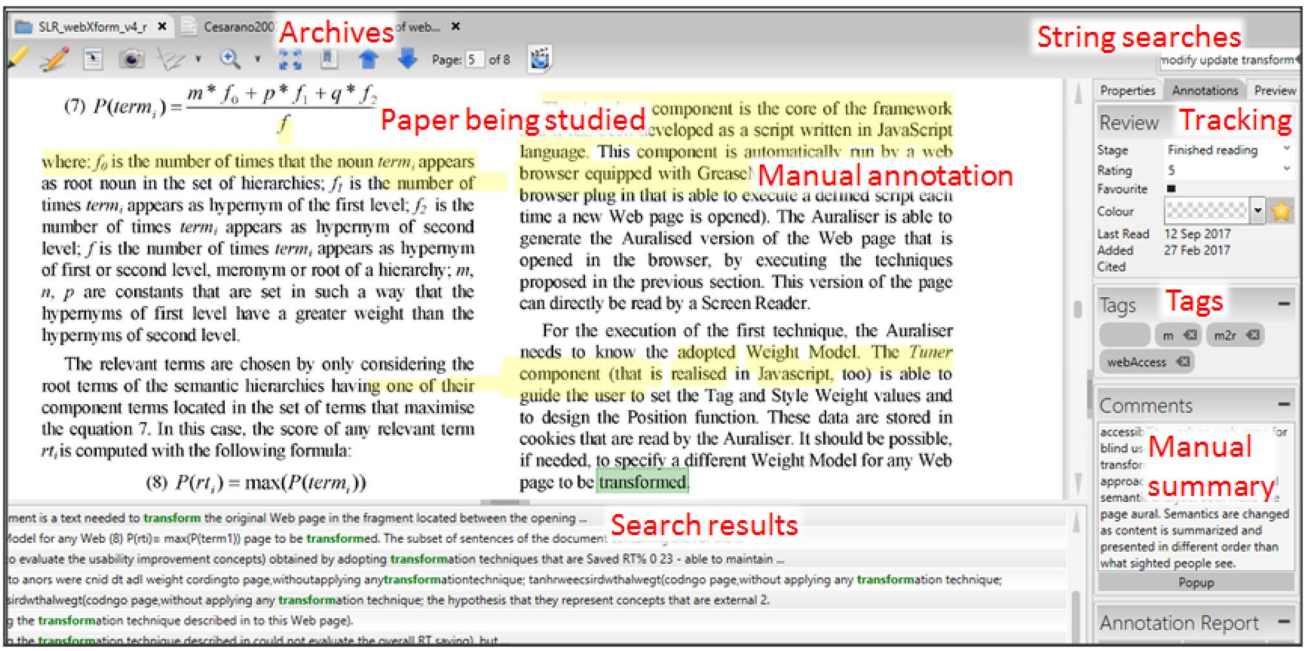


**Fig. 2** Highlighting the various tools and techniques being used for extraction of data from our shortlisted documents

augmentation, web personalization, web localization, style sheets etc.

Our exclusion criteria filtered out any non-computer-science oriented content. Within computer science, records on peripheral topics like cognition, eye-tracking, marketing, specific mobile devices, databases, mining, data extraction etc. were also filtered out. In addition, records that mainly featured a review, an evaluation or a specification were also removed.

As part of quality criteria, we sought records that had citations, had four or more pages and did not exclude Masters or PhD thesis, or any detailed technical reports. It, however, excluded patents, books and book-chapters.

### 2.3 Data extraction

The data to be extracted from the shortlisted papers is given in Tables 1, 2 and 3. The code words we used for tabulating the collected data is shown in italics. Some of the questions can be observed to be open-ended and subjective. These questions were iteratively framed after some skim reading of related papers. Words such as *other, unclear* and *unknown* were assumed to be available for all sub questions of RQ1-3. See Fig. 2 for a depiction of how various tools and techniques were used for data collection.

## 3 Execution of the SLR

This SLR study involved an elaborate paper selection process, which is depicted in Fig. 1. The initial set of records (n = 1068) were from multiple reputed conferences and journals. Tables 10, 11 enumerates the yearly distribution and the topic distribution for the final corpus. The corpus also contained several PhD thesis and included chapters from reputed scholarly books. The records ranged in years from 1920s to 2017, and covered topics in web technologies, document engineering, conceptual modeling, databases, information sciences, digital document processing, security etc. Figure 3 depicts the yearly distribution and Fig. 4 depicts the

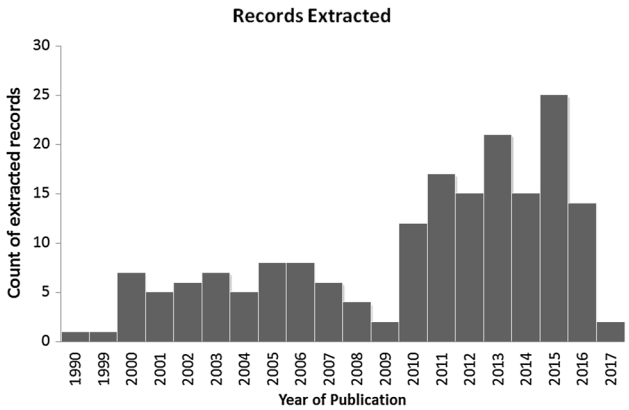


**Fig. 3** Year-wise distribution of extracted records

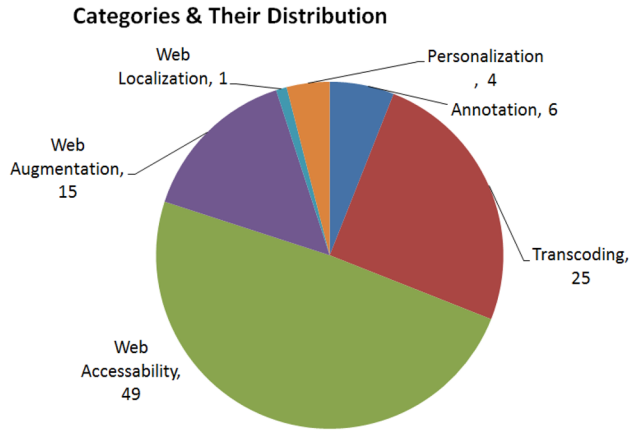


**Fig. 4** Distribution of topics

topic distribution for the larger set of records. Geographically, the articles were from Africa, Australia, China, Korea, Japan, Russia, Scandinavia, France and both Americas.

The original raw set of 1068 records were initially managed in MS Excel worksheets. Here we were able to spot 17 duplicates, 213 with less than 4 pages and 650 records that were focused on unrelated topics. Of the 53 records that were manually obtained, only 1 was a duplicate, 3 were not accessible and 35 turned out to be not directly related to our topic. In general, applying our other inclusion, exclusion and quality criteria helped us eliminate a bulk (883) of the initial corpus. This left us with 185 potentially relevant records, of which 183 were Qiqqa uploadable PDFs which were non-duplicate documents. On Qiqqa tool[6], the keywords and abstracts of the 183 earmarked records were studied. Some of the papers which had ambiguous summaries were also skim read. Finally, after filtering, we were left with 72 shortlisted set of documents.

This reduced set of records were published from years 1990s to 2017. They represented conferences like W4A, WWW, ISWC, CHI, ASSETS etc. Topics related to user interface design, Semantic Web, Multimedia were included. Journals consisted of TACCESS, Digital Libraries, Web Semantics etc. Documents were also ensured to be from various prominent geographies of the world. Established authors from Accessibility research community were also checked to be adequately represented. And, the domains that were represented included web accessibility, content transcoding, web augmentation, web localization, web personalization, web annotation etc. See Figs. 3 and 4.

[6] http://www.qiqqa.com/

### 3.1 Threats to validity

During paper screening, to minimize human error and bias, the corpus was arbitrarily divided and redistributed to other reviewers for their confirmation and agreement. This was done in chunks of 80 with 20 overlapping records each. Any discrepancies between reviewers was further resolved in our weekly face-to-face meetings.

Despite our stringent paper selection process, we had few papers that deviated from our stated protocol. For example, we had papers that were below 4 pages [12, 13, 53]. In addition, we also encountered documents that did not detail out implementation of a transformation [8], or had only some partial information on the implementation [10], or focused more on the algorithm and not the implementation [23, 51]. After careful scrutiny of each document, the records were later retained because they did sufficiently meet many of our other requirements for data collection and the review.

Finally, during data extraction, some of the qualitative points were subjectively assigned codes. For example, the notion of web page transformation had been associated with multiple terms like content modification, page mutation, adaptation, augmentation etc. In some cases the sought information was not explicitly articulated (e.g. is the data persisted?) or ambiguous (e.g. is it in the application server or another server?) in the document. In all such cases of ambiguity, the reviewers inferred the intent and coded the data into terms that reasonably fit the intent. Also, when the codes were not mutually exclusive, we did not use percentages, but used actual numbers instead.

## 4 Results of SLR

### 4.1 Results of RQ1 sub-questions

Results from RQ1 1.1 revealed that there were two primary motivating factors behind web page transformations: one was the challenges of accessibility, and the other was the opportunity to enhance existing functionality. According to gathered results, 51% that is, 37 of the 72 were reporting accessibility challenges. The other 49% or the other 35 of the 72 saw an opportunity to enhance existing content in novel ways.

RQ1.2 sought to understand who was bound to face the accessibility challenge and why. See Graph (a) of Fig. 5. Results revealed that 32% focused on the needs of disabled users, 17% cited the constraints imposed by smaller rendering devices, and a majority, or 51% cited the potential opportunities in re-presenting the same source content to end users, but now in a different environment or context.

Example papers on disabled users include [9, 79, 86] which were catering to blind users; [34] focused on the

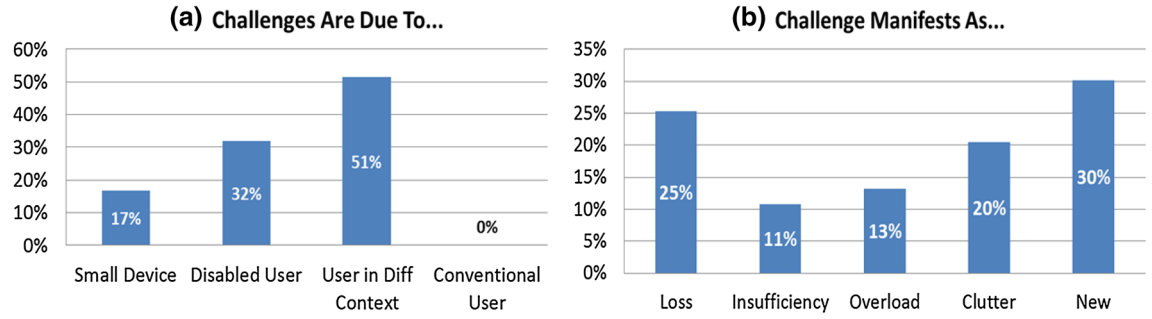


**Fig. 5** **a** Highlights the reasons behind web page transformation in our corpus. **b** Highlights the implications of this challenge

special needs of the elderly; and, [65] focused on the WCAG guidelines. Example challenges on smaller rendering devices include transcoding color for low power LED displays [7, 23], adjusting image [49] and content [6, 77, 92] for smaller screen size etc. Examples of user in a different context include [93] which assists users to learn Japanese while browsing, [41] to provide filtering abilities on tabularized content, or [24] which assists user to write reviews etc.

RQ1.3 explores the implication or the consequence of the accessibility challenge for the end user. See Graph (b) of Fig. 5. Here the results indicate that 25% cite a loss of information, 11% report an insufficiency in what is presented, 13% think that there maybe an overload of information, 20% report clutter of content, 30% see an opportunity to augment new content onto an old page. While these implications are not always mutually exclusive, we find that missing content, clutter of content or opportunity to add new content seem to be the three main thrusts for carrying out a web page transformation.

In summary, for RQ1, we found that there were indeed strong motivations for web page transformations. As we expected Web Accessibility is indeed a challenge. However, constraints of a smaller rendering device or user trying to reuse content in a new context also motivated the researchers to modify existing content either by de-cluttering it [24], re-formatting [6] it or by adding new content [93].

## 4.2 Results of RQ2 sub-questions

RQ2 concentrates on the focus and scope of the employed approach. RQ2.1 focuses on the method employed by the studies. We found that, 33 out of 72, that is, 46% augmented content, 21% used transcoding as a strategy, 11% annotated and augmented the content, 8% personalized content, 7% claimed modifications. 4% or, 3 of the 72, claimed to just annotate content [22, 67, 94]. There were 1 each of a mix strategy which used annotation, augmentation and either personalization [18] or transcoding [59].

Transcoding approach involved using external parameters—like device details—to make changes to rendered images [49], content [6, 77] or layout [40, 92]; Some have even throttled delivery to ensure proper use of network bandwidth [17]. Annotation based approach had to do with adding tags [93, 94], adding meta-data [79] etc. A personalization approach had to do with creating new content aggregations based on user preferences [18, 19]; changing text font, luminance, contrasts [26] based on who is viewing; maintaining fluency of browsing between devices for a particular user [29] etc. Augmentation involved adding new scripting power to give user more processing capability [21], adding hypermedia functionality [10], new code for filtering [41], adding voice support [78], control for security [68] etc.

RQ2.2, RQ2.3 and RQ2.4 are related in that, the RQ2.2 seeks to understand the operation being performed, RQ2.3 tries to identify the item being mutated in the source, and RQ2.4 links it to the transformed outcome being rendered in the target page. Our findings for RQ2.2 are given in Table 6. From all the 72 documents we could detect 73 operations. Some were unclear and others had double operations, thus the count over 72. Of this 73, 33 or nearly 45% of the operations were indeed modifying the content (or markup) that was already available through the source page. In addition, 38 documents, or 52% of those detected were actually adding or enhancing existing web content (or markup) of the source. None of our 72 studied documents reported deleting existing content. There were two documents whose actions leading to transformation were ambiguous for us. These two papers had to do with gathering analytics and reporting it

**Table 6** Material in the source page that is getting modified

| Area | Add | Modify | Del | Unclear |
|---|---|---|---|---|
| Markup | 9 | 5 | 0 | 1 |
| Script | 16 | 9 | 0 | 0 |
| User interface | 7 | 8 | 0 | 1 |
| Text | 3 | 2 | 0 | 0 |
| Images | 0 | 3 | 0 | 0 |
| Outside browser | 14 | 19 | 0 | 1 |

**Table 7** Aspect of the target page that is getting influenced

| Area | Flow | Aesthetic | UI control | UI notify | Access | Image | Text |
|---|---|---|---|---|---|---|---|
| Markup | 0 | 1 | 5 | 5 | 5 | 0 | 1 |
| Script | 1 | 2 | 16 | 9 | 4 | 0 | 2 |
| Text | 1 | 0 | 1 | 1 | 0 | 2 | 3 |
| Images | 0 | 0 | 0 | 0 | 0 | 3 | 2 |
| Outside browser | 5 | 3 | 7 | 7 | 13 | 2 | 1 |

elsewhere [88], and processing of information graphics on another server [57].

Results of RQ2.3 indicate that there were 15 cases of changes to markup and 25 cases of changes to script. 5 documents worked with text or content and 3 focused on images. Moreover, there were 33 that worked with the source page either outside the browser (in some proxy or server elsewhere), or they involved content or significant functionality from the outside. This was nearly for 41% of the 81 total cases we observed. For example, [31] provided a multimedia learning environment for users which included source plus additional audio and other media works. [32] uses HTTP header information to do proxy based XSLT transformation. [26] uses machine learning to study browsing patterns to personalize the viewing experience of the current page.

Examples of text enhancements include [35] which augments source web page's embedded or displayed code with micro explanations (fetched from outside), and [19] which brings in fragments from source page to create a consolidated new page. Examples of script enhancements include [30] which ensures session fluency between a user's experience on different devices, or [86] which enables speech access to the current content, or [21] which enables more web augmentation, or [41] which enables filtering etc.

Results of RQ2.4 indicate that 7 papers are impacting the flow and order of presentation [19, 58], 5 are impacting the aesthetic (look and feel), 26 are keen on providing more control to the user [63, 72], 19 are enhancing the source to notify more information to the end-user [36, 78], 21 are specifically focusing on the accessibility barriers and are focused on eradicating them [17, 65], 6 are impacting text [19, 71] and 5 are impacting the visuals (images) [14]. Table 7 shows the relationship between the source which is being mutated and the target which is being impacted.

### 4.3 Results of RQ3 sub-questions

RQ3.1 results indicate that 61 papers support HTML, 16 support XML/XSLT or XHMTL technologies, 3 support RDF [47], 2 support OWL [4] and 2 SVG [31]. Some have also supported ePub [36, 94], Flash [36, 37] as well.

RQ3.2 seeks to understand how many of the studied papers actually have used some specialized software which makes the work harder to replicate. We identified 26 such papers, which included 3 which support or are Adobe Flash oriented works [36, 37, 58]. Other papers which work with specialized software include [82] which has its own set of tools for *Yeomen, Grunt*, and editing; [27] which uses a *dot net* based experimental platform; and [42] which extends a *Web Alchemist* tool etc.

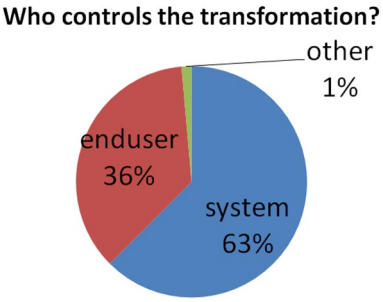


**Fig. 6** Distribution of the entity controlling the web page transformation

**Table 8** An indication of who is controlling and how nimble the transformed outcome is

| Outcome | System | End user | Other |
|---|---|---|---|
| Fixed | 40 | 2 | 1 |
| Flexible | 5 | 24 | 0 |

RQ3.3 sought to surface the control point or agent behind the web page transformations. The results indicate that 63% of the web page transformation in our corpus has been controlled by system. These include transcoding works which are triggered either by the structure of the HTML content [42] or by the image within the content [14], or by the details of the device [32] which is rendering the content. [17] throttles bandwidth base on network conditions. [75] automatically makes the SVG charts more interactive. For RQ3.3, the remaining 36% of papers are triggered by explicit actions of the end user. See Fig. 6.

In RQ3.4 we sought to understand if the outcome of transformation was fixed or flexible. See Table 8. Our results indicate that 60% of the papers had a predetermined transformation (or output). These include works like [23] which handles color correction and [30] which maintains

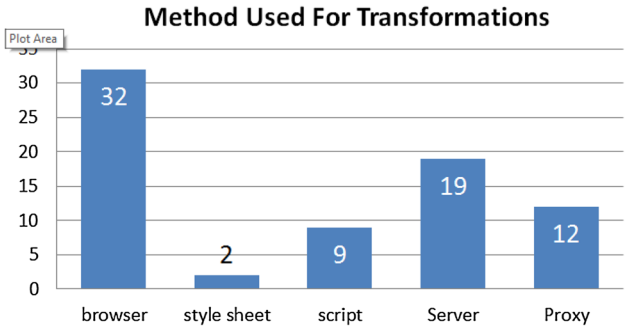


**Fig. 7** Variation of methods used to control the web page transformation

fluency of the web session between devices. Results of RQ3.4 show that only 40% of the web page transformations had a nimble or flexible output. For example, [22, 67] transform a source page with annotations that are defined by a user and not the system.

RQ3.5 focuses on when the transformation is actually happening. Results tell us that 65 of the papers report that transformation is happening at the time of presentation. Whereas 7 have some sort of cached content. For example [19] works with stored profiles for creating new content, or [14] works with image transcoding for which device properties are stored, [94] works with the editing phase which carries over to the transformation of the rendered ebook page.

RQ3.6 sought to understand which method was being used to implement the transformation. Results, which are shown in Fig. 7, indicate that 2 papers utilized style sheet as an approach [6, 52], 32 used browser extensions [60, 84], 12 used proxies and 19 used server side changes.

RQ3.7 explored the components used for implementing the transformations highlighted in our shortlisted papers. See Tables 9, 10 and 11, and for the volume and variety of implementations that were surfaced in our survey. In the notation, A stands for Application Server, C stands for cloud, P for proxy and B for browser. AxxB notation suggests that a solution was proposed which had an application server and also some client side code in the browser.

The data shows that 30 of the 72, that is 42% of the solutions were browser based. For example, [10, 79] have used a browser plugin. Mostly application server based solutions were 14. Some of the transcoding applications that did reconfiguration of web pages before presenting it to browsers [6, 40] were following this application server based strategy. Transformation implementations with proxy centric strategy were 10. Examples include [14, 34] which were also transcoding oriented. There were no pure cloud based solutions. Most popular combination in the collection was to have a application server work with some supportive client side code.

RQ3.8a-c are related in that they focus on persistence. Results of 3.8a tell us that only 22%, that is 16 papers, are persisting transformation related information. According to 3.8b, of this only 6 are storing that information in some standardized format [10, 37, 59, 79, 83] (e.g. RDF [47]), but there are other 10 which have made their own application specific recommendation. And, finally according to 3.8c, only 1 is storing it on the client side [8], 4 are storing it on the cloud [22, 37, 67, 83], and 11 are having their own application specific storage [18, 47].

## 5 Discussion and analysis

In this section we intend to do two things: one, synthesize results under each of our 3 SLR questions, and two, connect the insights gained from the SLR to the BFSI related web content.

### 5.1 Synthesis of RQ1 results

The intention behind RQ1 was to explore the various motivating factors for prior researchers that compelled them to carry out a web page transformation.

While we were initially guessing Web Accessibility to be the primary motivating factor, we found that it accounted for only half ( 51%) of the reasons for modifying a web page. The other motivating factor, or the other half of the story, was about enhancement to the web page. That accounted for nearly 35 of the 72 documents (i.e. 49%) of the documents. The enhancements were either about reformatted the content [6], de-cluttered it [24], or augmenting it with new material [93]. Our initial intuition was that a user's challenge or a user's need for enhanced functionality—which we called accessibility—would be driving the web page transformation. The results show that it is not just a human user, a device too can motivate a transformation. That is, transcoding of source to fit the display sizes [92] and power requirements [7, 23] of small screen devices also motivated enhancements to current web content. And, finally, a third party user wanting to reuse content [84] or curate the existing information [19, 36] was also another driver for web page transformation.

#### 5.1.1 Web page transformation for BFSI sites

In our earlier work [66, 67], we have used the term "**Renarration**" to mean the target output of a web page transformation. RQ1 results of the SLR inform us that BFSI related web pages too can be transformed or renarrated into a variant of the original. For example, an English site can now be presented in vernacular to suit the non-native English users. Similarly, a complex financial explanation can now be

simplified in its presentation by substituting images for text, or tips for instructions. Beyond language changes, a BFSI related site may also be renarrated to create a de-clutterd, or tool-tip augmented variant. In general, for BFSI sites, the renarrations may include: partial or full language translations; addition or deletion of additional explanatory text, instructions or images; inclusion of helpful multiple media material etc. So, while the original BFSI source page continues to cater to the mainstream, these customized renarrations can now cater to the otherwise neglected non-mainstream communities; thus contributing to more financial literacy and inclusion.

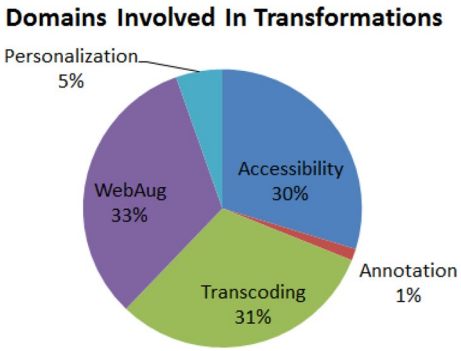


**Fig. 8** Distribution of the domains involved in web page transformation

## 5.2 Synthesis of RQ2 results

RQ2 and its sub-questions were intended to surface the approaches and the methods being proposed by the various studies. Results indicated that adding new scripts, tags to markup and links to external content was the chief way of augmenting existing content. Other techniques included annotating the existing markup with either meta information [8, 79] or adding missing information [35], and, transcoding the content before it reached the browser.

We fused results from RQ2.2 and 2.3—see Table 6—to surface the trends in our studies. We intuited that enhancements to web pages would mean adding new content (as in new text or images) to the existing source. Results indicate the opposite. We observe that adding new text or images has been minimally used for enhancing web pages. The table shows that enhancements are typically at the script level and outside the browser. This would mean that markup and code behind the content is getting modified; it appears that the system is getting better notified with new and additional information. The outcome of this turns out to better user control, notification and access to the information. See Table 7. Reordering of content, or improving of aesthetics, or changes to the internals of a paragraph of text or the visuals of an image—i.e. things that would impact a human user—seemed to be at a minimum.

### 5.2.1 Implications of RQ2 to BFSI content

RQ2 insights indicate that it is not just content but also backend tag structures, business logic and scripts that can be transformed. That is, for a BFSI web site or application, renarrations of tags can be used to mark-up and convert complex and unfamiliar words like "retail banking", "NRO account", credit/debit etc. to something a banking transaction-illiterate person can understand. For instance, a Internet Banking application web page could now be scripted such that a variant exists for savings holders which is simpler to use. Or, have another variant for credit card transactions only. Tagging and related scripting can be injected to allow on-page changes of debit/credit terms to either show +/− symbol or show red/green color. Similarly, scripts can be injected which renarrate numbers with commas instead of dots, or uses a Indian terminology of "lakhs" and "crores" instead of the more American notation of "millions". Even the presentation of the number itself can now be renarrated into an Arabic or a Indian numeral.

## 5.3 Synthesis of RQ3 results

RQ3 and its sub-questions were intended to surface any latent patterns in implementation of a web page transformation. Results of RQ3.4 and 3.3 indicate that 60% of the outcome of a transformation seems to be predetermined. And, that the trigger for the transformation appears to be the system (at 63%) and not the end user. For example, there are transformations that collect user info for some backend purpose [5, 27], or work in the backend to maintain security [68], or deal with fluency by synchronizing sessions [30, 85]. See Table 9. This also explains why adding script and markup appears to be predominant in RQ2. While XML offered ways to transform pages, the need to transform HTML did not fade. Nearly 61 of the 72 studied papers supported HTML. And, the results of RQ3.5-3.7 indicate that work is predominantly at the client side, implemented as browser side scripting and extensions. And, set of the RQ3.8a-c sub-questions suggest that persistence does not seem to be of high interest in the shortlisted documents. The domains involved in transformation include are given in Fig. 8. And the methods used in transformation are given in Fig. 9.

### 5.3.1 Implications of RQ3 to BFSI content

Insights from RQ3 inform us that a rendered web page transformations need not persist. And, that transformations can be carried out, on the client side, either automatically, manually or semi-automatically. For financial applications and

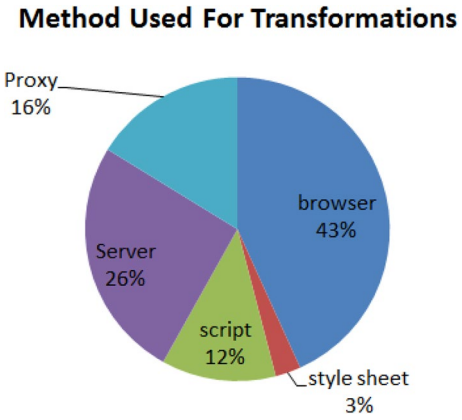


**Fig. 9** Distribution of the methods used for web page transformation

**Table 9** Components used in the web page transformation strategy

| Components | Quantity | % |
|---|---|---|
| Appserver | 26 | 36 |
| Browser | 43 | 60 |
| Proxy | 14 | 19 |
| Cloud | 4 | 6 |
| Combination | 15 | 21 |

websites, templates can be devised to facilitate automatic transformation. Or, 3rd party volunteers or intermediaries can now be equipped with editing tools to help them enhance a previously published BFSI website. When multiple transformations exist, democracy prevails: i.e. end-users will have choice and they will get to select (or 'upvote') only those that are meaningful to them. This also creates a opportunity to crowd-source the renarrator's work in transforming a site or an app.

## 6 Value for BFSI community

As with any other sector, BFSI too has promoted the use of web sites and applications on smart phones for its own business benefits. And, like any other community BFSI community has also chiefly targeted only the mainstream user. But, to create more FI impact, BFSI can leverage web page transformations as a mechanism to meet the heterogeneous needs of its diverse B2C-driven user community.

There are already some existing WCAG [70] type guidelines and tools in place to help content accessibility. This can be done at the site authoring level. Also, special access technologies and links with accessibility software—like screen readers—can be setup to ensure wider inclusion of minority users.

One of the insights of this SLR activity is that, while web page transformations are nothing new and have been in place for a while, the BFSI community now has an additional possibility to use independent, 3rd party volunteers—who have no concern with the author or publisher—to also be able to make web page transformations happen at the client side. Such web page transformations have already been labelled as renarrations, and those volunteers as renarrators. Here are some benefits of using this particular technique for BFSI community for creating more FI:

1. There can be more than one web page transformation for a given web site or web app that can co-exist. Each of these narratives can be specialized and cater to a different minority group.
2. A given web page transformation of the original web app narrative, can either be focused on a particular aspect (e.g. transforming just the currency in an app), or on the entirety of the app (as in making the entire app accessible to a set of blind users). Additionally, they could either happen in the backend (i.e. on the cloud, or on the server side) or at the browser on the client side.
3. These transformations need not be timed with the publishing date of the mainstream site or app. Because volunteers or sponsored workers are involved, and because the web transformation activity is decoupled from app publishing, this may be undertaken at any time and at the renarrator's convenience. That is, new transformed versions of an app - like the Hindi renarration, or a decluttered icon-based renarration of the app - can be released at different dates than the publishing dates of the original financial app.
4. The impact of having a poorly done renarration is not significant because, there can simultaneously co-exist other variants that would meet the needs of the user community. It is the end-user who democratically chooses.
5. Because the transformation of a web page happens to be on the client side, there need not be any backend cost or bandwidth burden to the stakeholders.

## 7 Areas for further research

In our SLR study, we found gaps in prior work, which could be taken up as future research opportunities in web page transformations.

1. *A system for managing transformations* A web page transformation can be seen as a renarrated outcome of a source page. Going forward, a single source page may inspire multiple renarrated target pages. How is a end-user kept informed of the availability of various renarrated pages? Here multiple research opportunities exists to link current published pages with their renarrated

**Table 10** listing and summary of all the studies used in this SLR—Part 1 of 2

| ID-cite | Year | Implementation | Method | Domain | Approach |
|---|---|---|---|---|---|
| S1- [4] | 2012 | xxxB | Browser Extension | | Annotation |
| S2- [5] | 2013 | Axxx | Server Side | WebAccess | |
| S3- [6] | 2005 | Axxx | stySht (CSS prepProcessor) | | Transcoding, Stylesheet |
| S4- [7] | 2012 | xPxx | Network Side (Proxy Server) | | Transcoding |
| S5- [9] | 2007 | xPxB | Client Side coding brExt; scrpt | WebAccess, WebAug | |
| S6- [8] | 2006 | xPxx | Network Side (Proxy Server) | WebAccess | |
| S7- [10] | 2002 | xxxB | Browser Plugin (JS ) | | Annotation |
| S8- [12] | 2010 | xxxB | Browser Extension | WebAccess | |
| S9- [11] | 2013 | xxxB | Browser Extension | WebAccess | |
| S10- [14] | 2006 | xPxx | Proxy Server | | Transcoding |
| S11- [16] | 2007 | xxxB | Client Side coding | WebAccess | |
| S12- [17] | 2000 | Axxx | Server Side | | Transcoding |
| S13- [19] | 2004 | Axxx | Network Side coding Application Server (scripts) | WebPersn | Transcoding |
| S14- [18] | 2007 | Axxx | web app specific to this | WebPersn | Transcoding |
| S15- [21] | 2013 | xxxB | Browser Extension (Sticklet on top of JS ) | WebAug | |
| S16- [22] | 2012 | AxxB | Browser Extension | WebAccess | |
| S17- [23] | 2012 | AxxB | Browser Extension (modified Fennec) | | Transcoding |
| S18- [24] | 2012 | xxxB | Browser Extension (Chrome plug) | | |
| S19- [26] | 2016 | xxxB | Browser Extension | WebPersn | |
| S20- [27] | 2011 | xxxB | Browser Extension | WebPersn | |
| S21- [28] | 2012 | xxxB | Browser Extension + Network Side (Application Server) | WebAccess | |
| S22- [30] | 2015 | APxx | JS injection and synching with migration serv | | |
| S23- [29] | 2016 | xPxx | Network Side (Proxy Server) | | Mashup |
| S24- [31] | 2016 | unclear | Browser Extension | WebAccess | |
| S25- [32] | 2006 | xPxx | Proxy Server | | Transcoding |
| S26- [34] | 2001 | xPxx | Network Side (Proxy Server) | WebAccess | |
| S27- [35] | 2015 | xxxB | Browser Extension | | |
| S28- [36] | 2010 | xxxB | Browser Extension | WebAug | |
| S29- [37] | 2013 | unclear | Client Side coding | WebAug | |
| S30- [38] | 2000 | xPxx | Proxy Server (programable Proxy Server by IBM) | | Annotation, Transcoding |
| S31- [40] | 2000 | Axxx | Web Intermediary server plug In; PatML used for transcoding | WebAccess | Transcoding |
| S32- [41] | 2006 | xxxB | Browser Plugin(JS for DOM manipulation) | WebAug | |
| S33- [42] | 2003 | Axxx | Application Server (Web Alchemist) | | Transcoding |
| S34- [43] | 2012 | AxxB | Browser Extension | WebAccess | |
| S35- [13] | 2016 | AxxB | Browser Extension | WebAccess | |
| S36- [46] | 2016 | Axxx | Application Server + Browser Extension | | |
| S37- [47] | 2004 | Axxx | Browser Extension + Network Side (Application Servers) | | |
| S38- [49] | 2003 | xPxB | Network Side (Application Server + Proxy Server) | | Transcoding |
| S39- [50] | 2010 | xxxB | Browser Extension | WebAug | Mashup |
| S40- [51] | 2005 | Axxx | Network Side (Application Server) | | Transcoding |
| S41- [52] | 2008 | xxxB | StySht | | Transcoding, Stylesheet |
| S42- [53] | 2011 | xxxB | Browser Extension | WebAccess | |
| S43- [55] | 2011 | xxxB | Browser Extension | WebAccess, WebAug | Transcoding |
| S44- [56] | 2001 | xPxx | Network Side (Proxy Server) with cooperation from Application Server | | Transcoding |
| S45- [57] | 2014 | xxCB | Browser Extension | WebAccess | |

**Table 11** listing and summary of all the studies used in this SLR - Part 2 of 2

| ID-cite | Year | Impl | Method | Domain | Approach |
|---|---|---|---|---|---|
| S46- [58] | 2006 | AxxB | Network Side (Application Server) | | |
| S47- [59] | 2001 | Axxx | Server Side changes | | Annotation, Transcoding |
| S48- [60] | 2013 | xxxB | Browser Extension | WebAug | |
| S49- [61] | 2010 | Axxx | Network Side (web app) | WebAccess | Transcoding |
| S50- [62] | 2002 | xxxB | ? | | Stylesheet |
| ID-cite | Year | Impl | Method | Domain | Approach |
| S51- [63] | 2013 | xxxB | Browser BookMarklet | WebAug | |
| S52- [64] | 2012 | xxxB | Browser BookMarklet | WebAug | |
| S53- [65] | 2005 | xPxx | Proxy Server | WebAccess | Transcoding |
| S54- [67] | 2014 | AxxB | Browser Extension | WebAccess | |
| S55- [68] | 2015 | xxxB | Client Side coding | | |
| S56- [71] | 2015 | xxxB | Browser Extension | | |
| S57- [72] | 2001 | unclear | guessing Network Side | | |
| S58- [74] | 2007 | xxxB | Browser Extension | WebAug | |
| S59- [75] | 2009 | xxxB | Browser Extension (JS ) | | |
| S60- [77] | 2002 | Axxx | Network Side (Application Server) | | Transcoding |
| S61- [78] | 2003 | xPxx | Network Side (Proxy Server) tagging (could be automatic) which is facilitated thru voice browser | | Annotation, Transcoding |
| S62- [79] | 2008 | xxxB | Browser Plugin (Client Side codingscrpt) | WebAccess | |
| S63- [82] | 2016 | xxxB | Browser Extension | WebAug | |
| S64- [83] | 2011 | xxxB | Browser Extension | WebAug | |
| S65- [84] | 2011 | AxxB | Browser Extension | WebAug | |
| S66- [85] | 2011 | AxxB | Browser Extension + Network Side (Application Server) | | |
| S67- [86] | 2013 | AxxB | Server Side modifications (to figure out the flow / transactional goal) | WebAccess | |
| S68- [88] | 2013 | xxxB | Browser Extension | WebAccess | |
| S69- [92] | 2004 | APxx | Application Server (could be Proxy Server) | | Transcoding |
| S70- [93] | 2015 | AxxB | Client Side coding scrpt | | Annotation |
| S71- [94] | 2016 | Axxx | Server Side + DOM handler on client | | Tagging |
| S72- [95] | 2010 | xxxB | Browser Extension | WebAccess | |

outcomes; to group multiple renarrated pages; to setup a recommender system etc. From a BFSI perspective, while renarration of an existing page into vernacular assures us better outreach, the question still remains, how does a new reader to an existing, published English page get to know that there is indeed a local language renarration available for a site? Also, if there are multiple narratives, which one is to be recommended to the end-user? And, when should such a recommendation be made? That is, should the user run into a problem before a recommendation be made, or should the vernacular site be shown upon initial visit, or only upon request? These are the areas that one could contribute with new research.

2. *Semantic transformation* In our SLR study, we noticed that most of the web page transformations focused on either structural or syntactical level transformations. Going forward there is an opportunity to deal with human semantics. How does one maintain semantic equivalence between a source and its renarrated target? What is the implication on trust and also on intellectual property (IP) when a semantics of an original page is changed by a non-author? what is the implication to the original presentation, when a volunteer is allowed to drastically change the semantics? Exploring Semantic Transformation to a Internet Banking context, we find that the word loan in a Telugu language can be presented either as “runam”, “appu” or “baaki”. Usage of any of the three words is appropriate for a Telugu translation. However, for some sub-communities of Telugu speaking users, the word “runam” may be more meaningful than “appu” or “baaki”. This preference may change for yet another sub-community. So, how does one choose which translation to apply to which user? How does one decide if any of the three choices are semantically equivalent to the original source? Are all three words (or corresponding renarrations of the original source) equal in their semantics?

3. *Automatic transformations* Studies in discourse analysis suggest that there could be a structure to a narrative [54]. Could such structures be setup in such a way that a source is automatically and systematically transformed from a source to a target? Can such templates be setup and coded by users? For example, in a Internet Banking application, there could be different renarration templates for Telugu speaking, credit card report generation users; yet another one for Mandarin speaking travellers who are wanting to do forex transactions on the go.
4. *Need for a common framework* There appears to be no single, common, reusable, open framework to enable annotation or augmentation of content. Although new efforts on the part of W3C for annotation[7] are now emerging, there is still room for creating a common, reusable framework for annotation and augmentation of content, markup and script. Such frameworks need not be generic. A BFSI related system with its own set of tools could also expedite better FI.
5. *Juxtaposing multiple semantic structures on a given page* Current focus on adding or modifying the markup and scripts on a source page seems to emphasize the need and opportunity we have to structure the content for further processing by the back-end systems. This appears to be yet another research opportunity. That is, the ability to juxtapose multiple semantic structures on a given page; the ability to simultaneously create, manage, maintain such structures is missing. This sort of co-existence and multiplicity of various semantic structures on a source web page could then be subsequently leveraged for downstream processing. The idea that a web page has one meaning and one interpretation can be eliminated. Fragmenting the page with semantic structures to facilitate new ways to re-assemble, re-narrate, re-package and re-deliver the content for new interpretations could be yet another new direction of research.
6. *Compute content* In the existing works, textual content has not been significantly modified. Few works complemented the current text with foreign phrases (to help in language learning) [84], or semantically linked the content to external resources (to help the user have more inter-connectivity with to other web resources) [4]. Going forward, there can be an opportunity to compute the content as well. If we can semantically structure portions of the existing content then we can process those fragments as well. For instance, dates can be modified to suit different cultural calendars (e.g. Arabic, Buddhist, Islamic etc); or, for travellers, forex conversions can be shown automatically. With respect to language, earmarked textual content can also be processed for pronunciation, for language translations, for phonetics, for aural links etc.
7. *Adoption* Finally, there is already existing research on adoption of new technologies [33], adoption of innovation, and, more specifically, adoption of innovation in banking and also mobile banking [15, 69]. These are based on fundamentally sound theories of Diffusion of Innovation (DOI) [73], Theory of Planned Behaviour (TPB) [2] and Technology Acceptance Model (TAM) [20]. Similar adoption studies can then be conducted to rate the uptake of any of our proposed new web transformation technique for the benefit of FI.

## 8 Conclusion

FI is indeed on the global agenda. Governments have created policy and pressure to drive inclusion. Like other verticals, BFSI too leveraged web technology to create better outreach. But, availability of BFSI services has not resulted in usage by the rural masses, nor by the financially illiterate, nor by the digitally challenged. The adoption of such web based content and services may also have been stunted for other socio-cultural reasons [39]. In our work, we sought to address this challenge by looking at web page transformations. In the past, content transformations have been used as treatment for Web Accessibility, Web Personalization, Web Augmentation and Web Localization problems. To this end, we conducted a systematic review to survey prior web page transformation efforts, in order to understand their motivation and approaches.

Through this SLR we learn that the existing, already published content is not fixed and immutable. On the contrary, an apparently infinite number of web page transformations—which we have called renarraions—can now be created to suit the needs of various target groups. Current transformation patterns indicate that changes are happening to either de-clutter [77], reformat [92] or maximize control [82] on existing content. From this we inferred that, for the inclusion of non-mainstream users, finance related sites and applications can also be transformed at the presentation level. Localizing the information, use of vernacular, aligning the financial matter to more culturally valued trust models could help drive up more financial literacy and usage [39]. Telecommunications Standards Development Society, India (TSDSI)[8], a standards body for Indian ICT, cites a 10% increase in vernacular newspaper subscriptions,

[7] Open Annotation model and recommendations have been proposed by World Wide Web Consortium (W3C). See: https://www.w3.org/annotation/

[8] https://tsdsi.in/event/workshop-on-indian-languages-and-information-centric-networkingicn/

and an abundance of (i.e. 550) vernacular television channels in India. This they credit to use of vernacular support. Ultimately, however, what specific changes to a published page increases trust, or, what specific transformations to an existing page can create more human semantic can be the seed for further research.

An additional insight we draw from this SLR is that the author-publisher is not the only one capable of controlling what is published on the Web. Intermediaries, third-party volunteers and end-user champions can now transform content to bring in more value-addition to the end-user. Like in social networking, multiple re-narratives of an existing page can result in choice and true democratization of the content. The results of this SLR suggest new research opportunities for measuring quality, trust and credibility related issues in a given crowd-sourced environment.

Web is indeed prolific with tremendous amount of BFSI related content. From a Computer Science point of view, web page transformation has already been used to make existing content accessible. Now, we can apply the same techniques and technologies to drive up adoption and usage in BFSI related web content. We believe that by engaging 3rd party volunteers, who formulate community specific web page transformations, we can create trust, drive up financial literacy and ultimately contribute to an improved state of FI.

## Shortlisted records used in SLR

All the 72 shortlisted records are cited, summarized and collated here in Tables 10, 11. Where the material is unavailable or unclear in the source, we have left it blank. Legend used is: Axxx = Application Server; xPxx = Proxy Server; xxCx = Cloud based solution; xxxB = Browser based solution; Impl = Implementation;

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