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THE IMPACT OF INDUSTRIAL REVOLUTION 4.0 ON TELEVISION CONTENT PRODUCTION AND BROADCASTING IN MALAYSIA: CHALLENGES AND OPPORTUNITIES

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ABSTRACT

Recent developments in Industrial Revolution 4.0 – or IR 4.0 for short – are forcing broadcasters in Malaysia to either adapt or die. Archiving broadcast content and production workflow, especially, are critical to the transition to a digital broadcast environment. Obstacles to resource expansion, however, have resulted in the loss of opportunity among small- and medium-sized enterprises (SMEs), both broadcasters and vendors. Large amounts of content require metadata that follow new quality control (QC) standards compliant to recent IR 4.0 developments. The current study aims to find out (1) what IR 4.0 developments create obstacles for broadcasters, (2) the reasons why vendors face content production issues, and (3) the ways in which metadata features may facilitate the content production process. In this exploratory research, the methodology consists in face-to-face interviews with broadcasters, content providers and vendors, participant observation and content analysis at production operation centres and production houses; the combination of these research methods offers a deep understanding of the major issues. The main finding centres on the need for a set of recognisable metadata and quality control criteria – facilitated by artificial intelligence –as an additional feature of a broadcaster's media management system (MAM). These criteria will reduce the reliance on human decision-making and help overcome the obstacles that currently beset the gatekeeping process.

Keywords*: IR 4.0, machine learning, television broadcasting, broadcast content production workflow, media asset management, vendors*

INTRODUCTION

Recent developments in Industrial Revolution 4.0 – or IR 4.0 – are compelling industries to re-assess and innovate the environment in which they are used to operate. One of the major drivers of this revolution is the convergence of technologies and digitisation of processes (Schwab, 2017). Changes in operational models are creating inequality among providers, also in the broadcasting industry. Many – if not all – broadcasting processes may soon become redundant due to artificial intelligence (AI) and machine-learning.

Traditional systems and processes are barely coping with the changes brought about by IR 4.0. Typically, television content for airtime distribution comes from (1) in-house production, (2) private local productions from vendors, (3) syndicated overseas programmes from vendors, (4) looping productions or repeat programmes and (5) news and current affairs

from in-house news and partly contributed by stringers. The diversity of metadata, formats, standards, quality control (QC) criteria and workflow cycles that are involved in this are disrupting the usual operations in broadcasting production. While traditional broadcasters are coping with the new situation, small-and-medium-sized enterprises (SMEs) and vendors are lagging behind, failing to adapt to the many rapidly evolving processes.

One of the familiar workflow processes is media asset management (MAM). As a consequence of IR 4.0, worldwide, broadcasters are actively seeking ways to align themselves with the new trends in planning, controlling and coordinating assets. Following Müller (2017), the main disruption for broadcasting organisations is related to the role of audio-visual archives within their existing MAM workflow, especially as content is becoming digitised and processes are becoming more complexly networked.

Against this international background, it is timely that Malaysia has developed its National Ferberisation and Connectivity Plan (NFCP), encouraging local broadcasters to migrate from their traditional analogue systems and processes to more advanced digital equivalents. At the same time, this official push towards process digitisation is also supported by vendors in various ancillary industries as they are constantly developing new MAM process components to meet the new IR 4.0 demands. Moreover, as content management is expected to evolve in tandem, significant resources will have to be spent in the near future on re-designing and re-optimising media management systems as a whole. Under the broad umbrella of digital asset management (DAM), MAM is thus primed for managing media assets efficiently. Bancroft (2017) and Wager (2005) describe the content processing cycle of content management in terms of the following six stages: (i) ingestion, (ii) metadata creation, (iii) content archives, (iv) access, (v) re-purposing and (vi) distribution. If this cycle of content processing were to become outdated or ineffective, the archives and MAM system would become redundant, creating indefinite loss of opportunity at the re-purposing and content re-broadcasting stages.

In the context of the current pandemic and partial lockdowns across all industries in Malaysia, archives have – unexpectedly perhaps – gained in relevance: they play the crucial role of filling airtime with content from the repository at a time when the regular recording of programmes has been put on hold. To access archived content quickly for re-broadcasting purposes, broadcasting stations need to have effective and efficient systems in place around the clock. Conveniently, users of archived content do not need to re-invent content but only to re-purpose it for multimedia broadcasting (Zarwell, 2016–2017).

Archiving content – and handling increasingly larger volumes of content in multiple forms – is a never-ending function for broadcasters: it plays a critical role in safekeeping the present and past for posterity as part of the larger imperative to protect and promote national heritage (Hagedoorn & Ageterberg, 2016). Though broadcasters and society at large recognise its value, there is a shying away from systematic preservation. What seems to be lacking is a proper understanding of how IR 4.0 can support and facilitate the archiving function, especially when it comes to conceptualising a suitable model for doing so. Secondly, there is also not all that much information about the smaller-size television broadcasters and vendors and the challenges that they face. The current study aims to find out what the challenges and opportunities are and to propose a model that enhances the end-to-end MAM workflow, from archiving processes, through systematic documentation, up to on-air transmission. The availability of such a model would result in zero or minimal rejection at the technical and content quality control (QC) stages before transmission.

The promise of zero or minimal rejection is critically important for SMEs and vendors. Often, content arriving at the archiving stage does not follow in-house metadata formatting rules or use the wrong keywords for user search later. Resources and expert knowledge are too often missing from SMEs and vendors so they rarely comply fully with mainstream broadcasters' requirements. Lack of compliance entails that the programmes that the smaller players provide risk being rejected at the final transmission stage, where they are subjected to rigourous technical quality control.

In the current paper, an attempt is made to develop a new model for SMEs and vendors to address the various challenges mentioned above. In order to do so, a first step – or first research question (RQ1) – consists in identifying the main obstacles that broadcasters face due to IR 4.0. This knowledge will next help to zoom in on the content production issues that the smaller broadcasters and vendors experience (RQ2). Finally, and as a third research objective, this study will examine which quality control features can facilitate the content production workflow (RQ3), solving the content production issues and adequately remedying the disruptive effects of IR 4.0.

THEORETICAL FRAMEWORK

For a good understanding of the study, it is important to briefly present the theoretical framework within which the three research objectives have been formulated as well as define a small set of key broadcasting concepts. The main reference is Müller (2017), which is widely recognised to offer an accurate description of the broadcasting workflow process.

To capture the staged nature of the workflow, Müller (2017) proposes the so-called *Content Management System* (CMS). The benefits of the CMS workflow model are that it (1) explicitly provides for an efficient documentation stage for re-purposing archived material, (2) allows flexible adaptation to real-time situations by broadcasters and (3) articulates technical and production quality control features for producers before content enters the workflow.

Table 1: Adaptation from CMS for a scaled framework of the MAM workflow (Müller, 2017)

INGEST	MANAGE	DISTRIBUTE
indexing and creation of metadata	master control room	technical gate-keeping
embedded applications	production operations centre (POC)	content delivery and syndication to clients.
incoming content acquisition	short-term archive and storage for broadcasting call	on-ward processing for on-air broadcast

As can be seen from Table 1, the CMS workflow is made up of three main processes: (1) ingest, (2) manage and (3) distribute, which cut across two tiers. The top tier is a generic three-

step flow of ingestion, management and delivery or deployment, generally found in most broadcasting workflow models. However, the CMS workflow also – and quite uniquely – provides for the integration of incoming content, indexing of metadata and gatekeeping throughout the production workflow, which constitutes the bottom tier. What is interesting is that this second-tier workflow can be made scalable to match vendors' capacity.

LITERATURE REVIEW

Given the recency of the IR 4.0 development, the specific nature of mainstream television and radio broadcasting and the Malaysian context, there is very little in the way of prior academic or industry research for the present study to build on. The following three comments should suffice to situate the analysis and research findings and to assess their contribution to the body of knowledge.

To begin with, and following on from the preceding section, content and media asset management are intimately intertwined with the entire broadcasting production process, where – at practically every stage – broadcasters are required to handle content from multiple sources in a wide range of formats (Müller, 2017). To do so efficiently, there must be in place, first and foremost, an in-house format for metadata coding and displays to be accessed and decoded. Next, the attributive terms – words or phrases – used in storing and retrieval must be standardised so that content can be processed intelligently (Curtis &Draper, 1999). The computer processing systems must be able to interpret the metadata vocabularies correctly.

The work done to date by various industry bodies has only proposed generic metadata vocabularies (IEEE – Institute of Electrical and Electronics Engineers, 1999), largely ignoring the media-intelligent applications that are available for MAM (Rowe & Churchville, 2016). The main issue seems to be that such applications do not specifically address the needs of small producers and vendors (Bancroft, 2017). According to Lederman (2012), among others, there is yet to emerge a unified system for the organisation of content for storage and retrieval.

Secondly, in Malaysia's broadcasting industry, historically large volumes of conventional data transactions – also referred to as *metadata recognition* – are handled with human-guided computing. This approach is meant to identify relevant data linkages to help arrive at decisions at the ingestion stage and later, at the so-called play-out point at the end of the broadcasting content workflow. Such transactions, however, do not identify new flaws or frauds other than those picked up by the recognized metadata. It is in this area that broadcasters can benefit from IR 4.0, and more specifically, the introduction of machine learning (ML). ML is a branch of artificial intelligence (AI), a collection of methods that enables computers to learn new "skills" without being explicitly programmed to do so (Samuel, 1990). New data fed into computers will help improve the scope and accuracy of their data-driven programming and help make decisions at the level of (meta)data transactions that are far more accurate than what humans can do.

Even so, to enable to derive continuous benefit new transactional metadata or to recognize and adapt to emerging fraudulent metadata, broadcasters and vendors – large and small – will not only require continuous monitoring and updating of the machine-learning process but also of continuously rewriting the algorithms (SAS, n.d.). In the current IR 4.0-driven and digitised (social) media environment, large volumes of content are circulating

through multiple and converging channels 24/7. The challenge is to prevent fraud as well as to manage the fraud prevention process and the role of "blind" computers becoming more "aggressive" through machine learning; the concern is not so much preventing fraud anymore but potentially higher rates of rejecting legitimate broadcast-ready content.

This then necessitates a renewed interest in quality control, or continuous quality improvement (CQI). Against a background of fast-evolving metadata, the parameters of quality control have to evolve just as fast and in tandem with the technological and AI changes. Initiatives to overhaul and fine-tune the quality control process would facilitate real-time decision-making, ensure rapid response to change, reduce lead time and avoid potential vulnerabilities. In addition, when combined with CQI, CMS would control costs, maintain operational control and predictability with updated data, improve accuracy and finally, leverage large external network of industry information and risk indicators (Brighterion, 2017).

A third and final insight to emerge from a critical review of the literature concerns the technological choices available to broadcasters, also in Malaysia. Besides the existence of multiple archive storage formats, the search for required titles and clips of historical content is rendered problematic by the use of either too many or unrelated keywords. At the same time, similar content is also available in multiple languages (Phang & Soh, 2016-2017). One solution is Oral History Metadata Synchronizer, a back-end system which creates metadata. It allows the archivist to process content for the front-end user by linking it to a W3C's eXtensible Metadata Language (XML) file, displaying the metadata required for retrieval from the archive (Breanden, Holmes & Kroh, 2017). Note that archives with XML metadata standards resort to the index-editor or the PBCore metadata standard, for example: *eFilm_ReSources_L1 contains the L1annotation names.* L1 and L2 relate to the Level 1 and Level 2 descriptive categories in the PBCore metadata structure (Zarwell, 2016-2017). Another solution that has been suggested for digital asset management (DAM) is automatic image cataloguing (Digital Asset Management, 2014). This method allows uploading and retrieval processes to take place seamlessly, enabling clients "at will" location and tracking of archived content, even though there is scepticism among some content providers. Under DAM conditions, archiving existing and new content begins at the ingest stage, followed by embedding metadata and file formats. A reader or a photo-editing application to extract embedded data is required for editing and re-purposing for further use (Curtis & Draper, 1999).

This brief review of the relevant literature shows that within the IR 4.0 context and the more general societal changes in the volume, value and validity of broadcast content, SMEs and vendors are likely to struggle and studies like the current one are necessary to help design new business models so as to ensure their future viability.

RESEARCH METHODS

The research design is situated within the qualitative research paradigm (Denzin & Lincoln, 2000), which is most suited for examining the research questions listed at the end of the introductory section. Three interrelated methods were selected to arrive at a thick description and substantial comprehension of the challenges facing broadcasters and vendors. The main method consisted in conducting in-depth face-to-face interviews with subject matter experts (broadcasters, business owners and vendors). It is typical of this kind of localised and highly practical research to opt for convenience sampling. By snowballing from one informant to the next within the Klang Valley but also Kelantan and Kuching, a total of 22 expert interviewees

could be brought together: 12 subject matter experts from four mainstream broadcasters and 10 broadcasting content vendors. All interviews were recorded, transcribed verbatim and analysed using NVivo software.

The second and third methods are participant observation (DeWalt & DeWalt, 2002) and broadcasting content analysis thanks to the generous access that the interviewees provided to their production operation centres (POCs), vendors' production processes, television editing tables, and most usefully, their archives. More particularly, supplementary data could thus be collected regarding (1) the trajectory of programme input into the archives, (2) the workflow at the newsroom archives and (3) the MAM processes at the POC, the QC unit and the on-air playout centre.

For reasons of space and to avoid unnecessary detail, it was decided to combine the primary and secondary data, using recursive inductive reasoning, and to report generalisations and central tendencies in purely qualitative terms rather than through quantification; after all, the number of interviewees is small, which is typical of this kind of exploratory research.

FINDINGS AND DISCUSSION

Three research objectives and their accompanying research questions guided the present study. For each of them, careful analysis allows the following findings to be reported.

RQ1: What are the main obstacles that broadcasters face due to IR 4.0?

There is near general agreement among the subject experts that within IR 4.0, machine learning stands out as the major change agent. For all broadcasters, ML is steadily pushing the traditional production process flow towards automated metadata-driven content programming and playout. The interviewees highlight two main obstacles to this much needed transformation.

On the one hand, there is a diversity of different practices among Malaysia's broadcasters, putting up barriers, especially at the end of production workflow. The main obstacle here is perceived to be the lack of technical compliance on the part of content providers and vendors, that is, compliance with technical standards and requirements, all the way through from production to transmission to archiving or in the case of re-purposing, from archiving to transmission; however, without technical compliance and technical standardisation, the transition to a new future-oriented digital broadcasting reality may be slowed down, or worse, never materialise.

The second major obstacle encountered during the production process is the large volume of content that undergoes evaluation. The process of evaluating content and taking decisions takes up too many resources. Performing this task manually entails human fatigue causing human error. Results show how machine learning can facilitate decision making in the MAM workflow for multimedia content providers. Conversely, machines do what they are programmed to do leaving zero tolerance for human consideration.

Content evaluation plays a critical role in (1) archiving, (2) brand quality control and (3) technical gatekeeping.

Analysis shows that while intelligent machine learning and recognition is an option relevant to the processing of large *archives*, as also observed by Zarwell (2016-2017), archivists have continuously been coding large volumes of data manually for transactions at the front end of the MAM process.

As for *broadcasting content quality control*, interviewees emphasize that this is generally managed at source by producers and editors, namely, before ingestion. Television stations are delegated to manage self-censorship owing to the volume of programmes they produce and broadcast 24/7 but censorable content can always slip away. Content censorship is guided by (1) the guidelines found in the *Film Censorship Act 2002* (LPF – Lembaga Penapis Filem, 2018) and (2) *The Malaysian Communication and Multimedia Content Code*, also with its specific broadcasting guidelines (CMCF – The Communications and Multimedia Content Forum of Malaysia, 2004).

Note that the QC criteria in place are also meant to support and reinforce the intangible brand of the television station, its look and feel, so that anything that is alien to or incompatible with the branding will be recommended for correction. Examples include political affiliation, racial and religious sensitivities and overall programming content.

Finally, when it comes to *technical gatekeeping*, the legacy system of checking manually is no longer an option. It is now the embedded algorithm that carries out the evaluation of technical QC criteria at this stage. The machine reads and interprets the expected range of technical compliance, including the parameters that the content should match. One such parameter, for example, is chrominance on colour. There are two standards: 75% and 100%. The Asia-Pacific Broadcasting Union (ABU) standard that Malaysia uses is 75%; only the United States and Japan use 100% chrominance level. Similar technical criteria exist for luminance and audio. The main thing is that non-compliant programmes will be returned to source for corrections.

RQ2: What content production issues do the smaller broadcasters and vendors experience?

Owing to the challenges presented by IR 4.0, broadcasters – also in Malaysia – have been forced to review their traditional television production systems and processes, migrating to more capital-intensive and technological methods. The decision by especially SMEs and vendors to engage in this extensive, revolutionary and systemic migration is expected to create numerous opportunities for continued high-quality television production. However, the interviews, participant observation sessions, and to a lesser extent, the content analyses that were conducted all point to three serious issues facing the smaller producers and vendors. The most frequently mentioned ones are technical and other quality standards followed by resource limitations and content evaluation.

Technical standards

As for the first one, IR 4.0 developments have led to an almost never-ending cycle of fast-evolving standards, a situation that causes disruption, uncertainty and confusion. Smaller broadcasters and vendors are not always able to comply with the new standards or fall short of full compliance; this jeopardises playout at the end of the content production workflow.

An observation made time and again among the interviewees is that the lack of compliance undermines the integration of Malaysia's creative industry with mainstream television broadcasting. There are no fewer than 1,300 registered part-timers, stringers and vendors, contributing a vital 40%–60% of airtime to the local television industry but many of them experience difficulties adapting to the new quality parameters. However, failure to comply will lead eventually to a shortage of relevant broadcast content, especially in markets where the legacy broadcasters are less active.

To give an example, when supplying content, broadcasting SMEs and vendors need to follow what are called inherent station formats. The two content submission formats (or codec options) that vendors have are XDCAM 422 and Apple Processor 422. Vendors should send in their content in either of these two recommended file-based formats. Content that still exists in formats that are obsolete such as films need to be converted first. The problem is that inherent station formats may differ from one another. The DAM/MAM production process unique to stations is usually made known through a producer/vendor content supply policy document. The station format is important for the system to convert content from the archives into programmes that are recognisable by their respective machine-learning algorithms. The system will automatically track and upload the required content and provide essential data for users. When fields are empty, however, the metadata entry has to be researched and the information entered manually.

Limited resources

Secondly, and perhaps not surprisingly, the already struggling SME and vendor sector is characterised by a lack of financial and material resources and may not always succeed either in attracting the expertise that is so urgently needed now. SMEs and vendors do recognise the significance of evolving metadata indexing, QC standards that comply with mainstream machine-learning processes and the continuous rewriting of new algorithms.

Yet, few of them are ready for these far-reaching changes as it requires hefty capital investment in a new production chain. By contrast, the more established and larger-size broadcasters are well endowed with resources to manage compliance by means of, among other things, infrastructure with machine-learning features. SMEs and vendors are aware that machine-learning features will harmonise with mainstream broadcasters' QC requirements and will prevent rejection of otherwise legitimately approved programmes. However, due to their limited resources, they have to be more cautious in taking up the challenge.

Content evaluation

As discussed at the end of the previous section, capital expenditure for compliance purposes will also have to address the more general issue of content evaluation. Here again, as different broadcasters demand different submission formats, Malaysia's SMEs and vendors will be faced with dilemmas as to which formats to adopt and which QC parameters to work with. Barriers are created by the use of non-standard equipment at production. However, as production processes need to adhere to strict technical QC parameters, producers need to change their chain of equipment used for production, incurring additional cost.

RQ3: Which quality control features can facilitate the content production workflow?

To survive and thrive in the new IR 4.0 era, local television content production has to adapt. Careful analysis of the primary and secondary data underlying this study brings out that this adaptation will likely take the form of *reconceptualising* and *optimising* the content production workflow in light of the new technological capabilities. Müller's (2017) will help summarise the main suggestions more systematically.

Indexing and ingesting

At this stage, proper indexing or metadata entry is required for incoming content by the producers and/or the archivists who use a standard field for machine recognition throughout the production workflow. The vocabulary used now is inconsistent or incomprehensible. The playback machines used are pieces of legacy equipment that do not work efficiently. Compounding these obstacles is content which arrives in multiple formats. Improper and wrong entry are not the only challenges. Correct metadata information lies with unknown sources and at indistinguishable locations. Therefore, some required metadata fields are left empty making machine recognition difficult. Restoration of torn, scratched and defaced films is expensive and is often difficult to justify.

Management

Several short-term archiving strategies and storage for broadcasting call at the POC have to be managed as ingestion of content into the online storage starts four days before transmission. The MAM system operates under the broader umbrella of Digital Asset Management. MAM is responsible for transmission, where files are stored in formats called 'OP1' and 'OPATEM', which are different. In MAM, content appended audio and video, one file comes with audio, video and the header. In DAM, it comes with video and four audios or eight audios separately. When content specific title is required for transmission, it is compressed and retrieved from the archive.

Distribution

One problematic area is the gatekeeping that has to take place just before actual transmission or distribution and the signal leaves the station. The initial gatekeeping happens at the level of the newsroom, the second gatekeeping is for station branding, and finally, there is technical gatekeeping for onward processing. When final processing is done, content is ingested into the system and two copies are made while the master copy is printed into the XDCAM format (without re-rendering) and sent straight to the deep archive. At the distribution stage in the production process, programmes are blocked into several parts called segmentation for commercial insertion. The system automatically inserts the predetermined commercials at the designated locations during on-air transmission. When the program is returned to the archives, it will not contain the commercial that went on-air.

Based on the above discussion, a proposal can be formulated with minimally the following three suggestions. First, SMEs need to monitor and update their machine-learning process and engage in a continuous rewriting of existing algorithms. As the QC standards evolve, their machine-learning features too must evolve in tandem with these changes to enable real-time decision-making. While machine-learning processes have partly reduced reliance on human intervention, the accuracy of some metadata entries – as in the indexing,

branding of programme content QC and technical QC – still require "eyes and hands". There have been grievances among the technical community that jobs are becoming redundant. However, the sheer volume of content turnover is making many operations like content evaluation unmanageable, and thus, it is inevitable for machines to be used to optimise the production workflow. Secondly, SMEs should endeavour to harmonise their branding, content QC and technical QC parameters for a flawless production process workflow; this can only be achieved by strictly adhering to the metadata-recognition systems used by the mainstream broadcasters. Finally, a seamless MAM-enabled production workflow will improve efficiency and quality for *all* broadcasters and vendors. As a first step, however, SMEs must endeavour to achieve zero or minimal rejection at transmission. Despite the strict regimes imposed by mainstream broadcasters, SMEs should think through their strategic response to the new reality and try and achieve perfect content and technical compliance.

CONCLUDING REMARKS

IR 4.0, artificial intelligence and machine learning are disrupting traditional ways of manufacturing, distribution, retailing and many other business practices across industries and sectors. Malaysia's television broadcasting industry is no exception, presenting both challenges and opportunities. The current study was primarily interested in identifying the obstacles in the content production workflow from the viewpoint of SMEs and vendors. It was argued that much can be expected from introducing intelligent processes centred on recognisable metadata. Only properly indexed metadata fields will provide seamless facilitation for both the broadcasting stations, their content providers/vendors and their clients. Within the CMS model, this calls for a full-scale migration to a 100% digitised MAM workflow process.

One of the main and novel insights to emerge from the study is that this migration has to begin with the archiving function. This is critically important for indexing and gatekeeping. Judging by the interview data, two kinds of digitised content in storage are considered necessary: deep archive and online storage. The new digitised system would then be able to search any indexed material in the deep archive and restore it to the online storage after use. As soon as this is in place, managing the workflow can be simplified but also optimised, right through to the technical gatekeeping at the distribution or playout stage. Ultimately, the present study has brought into sharp relief the interdependence of various stakeholders in ensuring quality and suitable mechanisms for quality control, both in terms of programme content and technical compatibility.

The role of metadata tracking in the production workflow requires further research, especially in the Malaysian broadcasting landscape, with its reliance on many SMEs and vendors. Smaller broadcasters need to adopt basic metadata field requirements that are compatible with the formats used by the local television stations. A file-based format is recommended for this metadata tracking function, especially for vendors. It in this context that the archive metadata field is an essential tool for producers/vendors data entry and retrieval functions.

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