

The Suitcase: Using C4, Semantics, and NoSQL for Managing Motion Picture Data

By Nancy Silver, Kaki Ettinger, Joshua Kolden, Michael Malgeri, and Erik Weaver

Abstract

Today's television and motion picture production workflows make it incredibly challenging to preserve and manage data throughout the production lifecycle. The Entertainment Technology Center (ETC) at the University of Southern California addresses this data dilemma through The Suitcase project. The Suitcase is a short film created by Abi Damaris Corbin with a technical test led by the ETC Production in the Cloud Working Group. This paper examines the process of upstream authoritative metadata extraction so that it does not have to be recreated downstream, as well as processes for creating and enhancing metadata further downstream when necessary. This paper discusses how to effectively use the C4 framework—Cinema Content Creation Cloud, semantics, and NoSQL technologies—to manage motion picture content by tagging metadata so that it can be leveraged for software applications.

Keywords

C4 (Cinema Content Creation Cloud), data integration, metadata, NoSQL, production in the cloud, semantics

Introduction

Today's television and motion picture production workflows make it incredibly challenging to preserve and manage data throughout the production lifecycle. Some of these challenges pertain to technical aspects of integrating data from various software tools, while other challenges pertain to the nature of the production process. Examples of the latter include the following:

- Contract labor that production companies are not incentivized to train
- Production companies not yet convinced of the value of collecting production metadata and standardizing processes
- Creative focus prioritized over standard process and tool focus

The specific objectives of this effort target various organizations that often compete to work on a common goal toward developing an interoperable cloud framework and cloud-based workflows.

The Entertainment Technology Center (ETC) at the University of Southern California (USC) addresses these challenges in managing production metadata through *The Suitcase* project. *The Suitcase* is a short film created by Abi Damaris Corbin with a technical test led by the ETC Production in the Cloud Working Group. One of the key components of this project is to examine the process of collecting production authoritative metadata upstream so that it does not have to be recreated downstream in the production process, or worse yet, in distribution (**Fig. 1**).

ETC@USC is a think tank and research center that brings together senior executives, innovators, and thought leaders from the entertainment, consumer electronics, technology, and service industries along with the academic resources of USC to explore and to act upon topics and issues related to the creation, distribution, and consumption of entertainment content. Project Cloud is one of the ETC's initiatives that advises a core group of key media and cloud-resource leaders on developing guidelines for accelerating innovation and adoption of next-generation cloud-based content creation and production tools and processes. The specific objectives of this effort target various organizations that often compete to work on a common goal toward developing an interoperable cloud framework and cloud-based workflows.¹

About The Suitcase Project

As part of the ETC Project Cloud initiative, *The Suitcase* project evaluated network-based workflows with a focus on descriptive metadata automation for motion pictures. The mission of the project was to explore emerging production technologies for a studio project. For the components of *The Suitcase* project that focused on managing production metadata, the key participants



FIGURE 1. Mojean Aria (actor) is pictured with Jon Keng (cinematographer) during the production of *The Suitcase*.

were Disney—ABC Television Group, Avalanche, and MarkLogic. Disney—ABC Television Group led the overall vision, management, and data design for the project. Avalanche directed the implementation of C4 and the post-production workflows of *The Suitcase*. MarkLogic oversaw the database platform that managed the descriptive metadata and also created the software application with Disney—ABC Television Group for viewing *The Suitcase* movie and related descriptive metadata.

One of the primary goals of *The Suitcase* project was to provide upstream metadata extraction and automated metadata generation. A secondary goal involved developing an application using the extracted metadata to demonstrate the validity of the end-to-end workflow and achieve learnings about product development use cases for this information.

The initiative targeted extracting authoritative structured metadata from the production process so that it does not have to be recreated downstream. Richer metadata lives upstream (pre-production/production) but is subject to change. Data extracted toward the end of the post-production workflow is more authoritative, but not always as robust. For this undertaking, the emphasis is on descriptive metadata (information about what is going on screen as opposed to technical or operational metadata). Examples of the type of metadata that is captured and managed are characters, locations, on-screen actions, storylines, and scene breaks.²

There are many benefits to extracting upstream production metadata instead of recreating it downstream. Richer descriptive metadata, such as the director and cinematographer's intent, make for better search capabilities when building software applications for managing motion picture and television content. This type of metadata also enriches downstream consumer applications. Wouldn't it be ideal to know what the director was thinking when a particular scene was shot? This type of metadata can greatly enable and enhance target user experiences.

Capturing upstream descriptive metadata from the production also helps eliminate production metadata loss that often happens because the data is coming from multiple systems and changes hands throughout the production, and metadata is often recreated downstream after the production occurs. Automating the capture of descriptive metadata during the production eliminates the need to recreate it later, thus saving time, money, and reducing overall risk.

Overview of the Descriptive Metadata Extraction Workflow for *The Suitcase* Project

The Suitcase project required automated metadata solutions for motion picture production that would extract the descriptive metadata, create and manage the authoritative metadata, and create relationships among the metadata that could be easily leveraged for building agile software applications. This new metadata management production workflow is implemented through the use of the Cinema Content Creation Cloud (C4) framework, and through the use of the MarkLogic Enterprise NoSQL multimodel database platform (**Fig. 2**).

About C4

C4 is an open-source framework created and governed by ETC for content creation using remote resources. The C4 framework is composed of modular components that address common problems of cloud-based production. Given the distributed nature of film and media production, these tools are also very useful for production in general. C4 enables authoritative, consistent, and cross-organization identification of data that is created throughout the production, from inception through archive. C4 is an open-source software initiative with growing adoption throughout the motion picture industry. The source code for C4 is available at Github under "etcenter/c4."

One of the key components of C4 is the ID system. It provides an unambiguous, universally unique ID for any file or block of data. In other words, if one has a copy of a digital asset, they can use the C4 software to get the C4 ID of that digital asset and compare that ID with the expected ID. This use of C4 IDs is incredibly helpful for version control of data. As files change, C4 IDs and copies of the files are retained as versions.³ C4 supports JavaScript Object Notation (JSON), a lightweight data-interchange format. JSON is easy for humans to read and write, easy for machines to parse and generate, and is based on a subset of the JavaScript Programming Language. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers. These properties make JSON an ideal data-interchange language.⁴

C4 Framework and *The Suitcase* Project

The C4 framework test cases for *The Suitcase* project consist of C4 ID management, data authority,

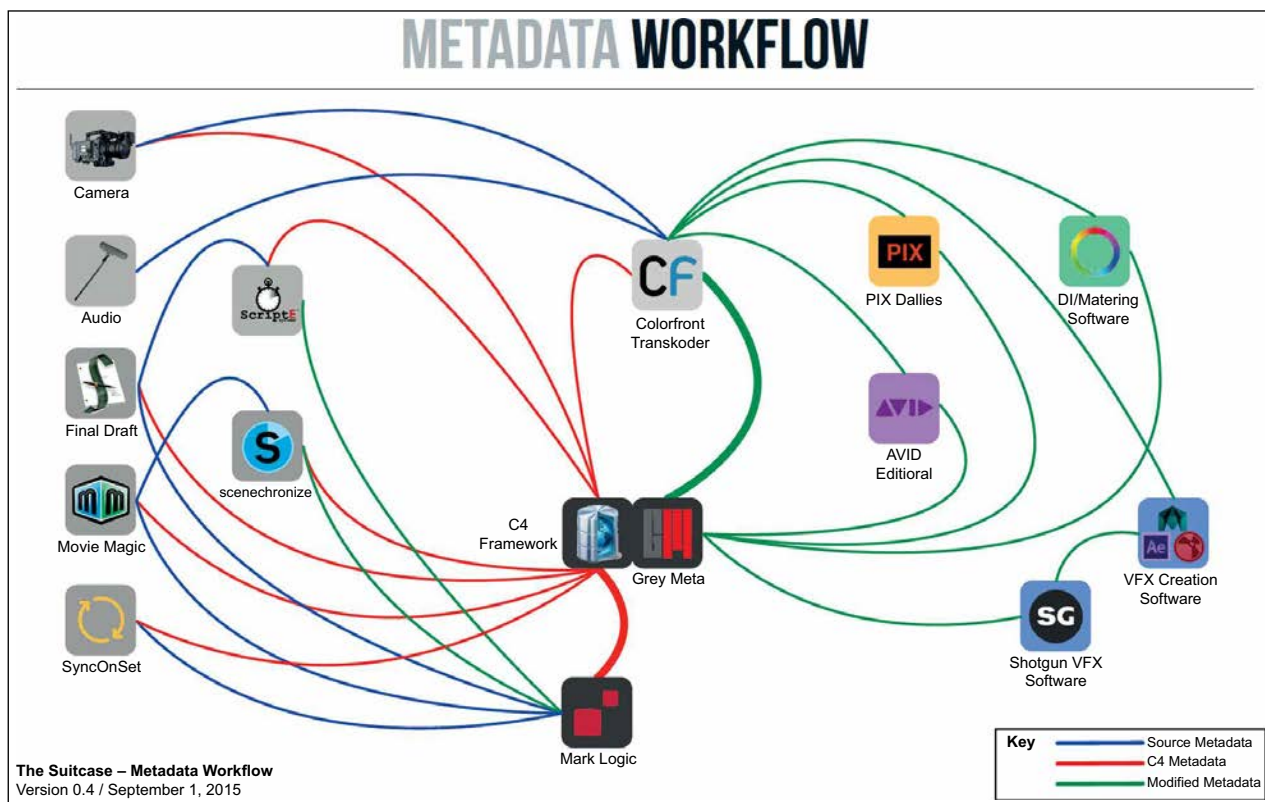


FIGURE 2. Metadata workflow.

synchronization, and integration. Using the C4 ID system during a motion picture production provides the ability to track digital assets across the production ecosystem of vendors and tools. C4 applies a unique automated ID for both the asset and the metadata associated with that asset. The ID manages all data and it is human readable and self-discoverable.

Authoritative descriptive metadata, such as characters, locations, and events, are extracted from production software, such as Movie Magic, a popular movie-scheduling software application that was used in the production of *The Suitcase* and endorsed by the appropriate authority such as the producer. This data, in JSON format, is first identified by getting its C4 ID for future reference and validation and then delivered to the metadata management team to quality check and normalize before they implement semantic data modeling using linked data and temporal tagging.

Benefits of Using the C4 Framework for Managing The Suitcase Production Metadata

The C4 framework provides guidelines for integrating and gluing together services from multiple data sources throughout a typical production. By standardizing on JSON RESTful APIs and using the C4 ID system to establish a universal identifier, the framework simplifies the consistent and reliable communication of data among systems. This process minimizes the effort required to connect production software applications and services within the C4 framework because all parties will

independently agree on the C4 ID of any given block of data. C4 encourages the integration and communication of the various disparate software systems throughout the production ecosystem, which in turn provides data authority and accuracy. The integration and automation of metadata management using C4 greatly improves the efficiencies of verifying authoritative descriptive metadata, which currently is a manual process that often can be wrong due to human error and miscommunication.

C4 also reduces storage costs through the use of data deduplication and archiving. By unambiguously identifying files based on the content of the files themselves, C4 IDs readily reveal which files are identical copies of each other so that unneeded copies can be removed. The storage recovered by that process can be significant, delivering immediate real value to the enterprise. C4 also improves network efficiency—as with data deduplication; C4 IDs can reduce transmission costs across a network. By keeping a record of C4 IDs for all files on remote and local systems and transmitting only the differences, one can improve speed and reliability when synchronizing data. This record keeping is helpful because it eliminates transmission errors and inconsistencies by reconfirming IDs after transmission.

Within the C4 framework, every modification of a file is considered a different file and will result in a unique C4 ID. This provides a perfect mechanism for version tracking, and the basis of a version control system that can accurately manage any type of file,

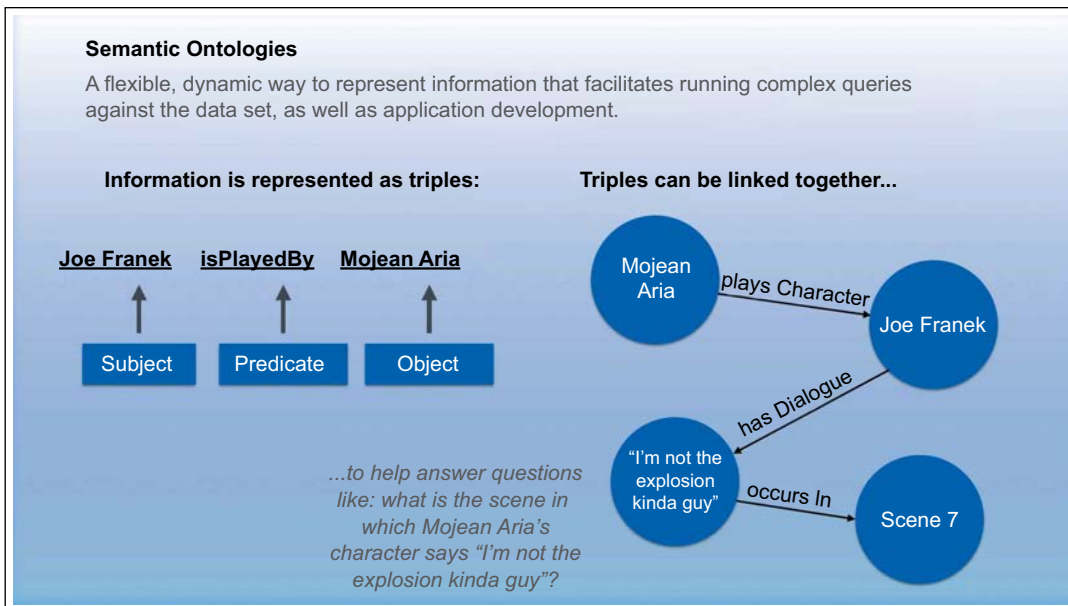


FIGURE 3. Example of the semantic data modeling for *The Suitcase*.

or even sets of files within file systems of arbitrary. It is important to note that, while the use of C4 IDs focuses on individual asset identification, a C4 ID does not carry any meaning, for example, what project the asset is for. The Entertainment Identifier Registry initiative was designed for this purpose, and its use in the production process is synergistic, not in contention, with the C4 ID system.

Implementing Semantic Data Modeling: Using Linked Data for Managing Motion Picture Content

After the authoritative JSON file of metadata was created, the Disney team needed to normalize the metadata, primarily because the original file was created while the production was still taking place. They verified an authoritative set of characters, locations, and storylines for the movie. These vocabularies were then ingested, alongside the finished video asset, into an internal, web-based video annotation platform. This platform enabled a trained workforce to efficiently index the authoritative metadata vocabularies to the film's time codes, including implementing a robust quality control process. Instance data was created (the final cut of *The Suitcase* is "tagged"). The annotation platform also enabled the generation of scene boundaries for the video asset through a combination of automated and manual processes. Together, the instance data and scene boundaries provided a finished data set that captured metadata in every scene, describing who was on screen, what locations were featured, and what storyline was a part of the scene.⁵ The use of semantic data modeling and ontologies to manage motion picture content creates linked data. Linked data is a method of publishing structured data so that it can be interlinked and become more useful through semantic queries.

The ontology defines the relationships between the attributes of interest. By linking the data together, we

are able to describe who was on-screen, the locations, and what storyline was a part of the scene. An example of this is creating the linkage between the character and when they appear in a scene (Fig. 3). The ontologies are then ingested into the MarkLogic Enterprise NoSQL multimodel database and queries are constructed to answer interesting questions. Semantic ontologies provide for a flexible dynamic way to represent information that facilitates the ability to run complex queries against the data set as well as increase rapid software application development.

For purposes of *The Suitcase* technical test, the descriptive authoritative metadata focused only on characters, locations, and storylines. However, this data modeling and metadata extraction workflow (Fig. 4) could also be applied to additional categories of descriptive metadata as well as other forms of metadata such as technical (camera metadata), administrative (rights management), structural metadata (data about the containers that hold metadata), and preservation metadata (data that supports the preservation of digital assets).

Leveraging Semantic Data to Create Unique Software Applications

A tremendous benefit of creating and managing descriptive metadata with semantics or linked data is it allows for rapid agile software development. For *The Suitcase*, a search application was created that leverages the tagged motion picture data. Users of the application can view the movie and the corresponding descriptive metadata at the same time. This sets the stage for custom information delivery by matching descriptive metadata with user appetites for information, such as funniest one-liners, scenes with specific actors/actresses, scenes depicting certain wardrobe styles, and certain action type scenes, such as car chases or battle scenes. It also allows

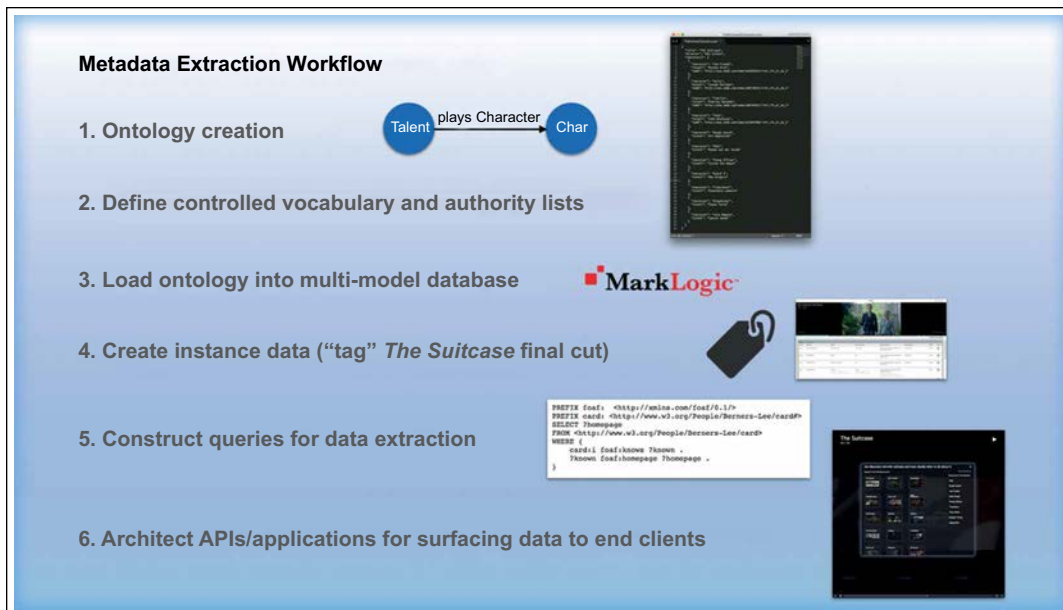


FIGURE 4. Metadata extraction workflow for *The Suitcase* project.

the user to optionally embark on a personal, nonlinear journey through the content (**Fig. 5**).

The Suitcase software application took less than three weeks to build, including user interface (UI) design and development, management of the triples data, and creation of the SPARQL queries. The app is built on MarkLogic 8 using RDF triples exclusively, and an Apache ProxyPass as the middle tier. The app makes use of Angular JS for data-driven UI components. Transitions between areas of the application are purely CSS, as there are no actual "routes" besides the default in Angular. The open-source library VideoJS is used to expose API elements of the video player itself. Watch events are used to trigger various data updates within the

Angular application. Each navigational event in the app sends a request to a MarkLogic custom REST extension. These extensions utilize SPARQL to retrieve the data requested. For example, when pausing the video, the pause time is sent to a REST request for characters at that particular millisecond. Data queries for the app were created using the pause time and scene start/end times as variable constraints (**Fig. 6**).

Potential Software Applications that Can Be Created Leveraging Semantic Data

Being able to manage your data in one place and implementing semantics (linked data) opens the door to many different use cases that can be implemented as follows:

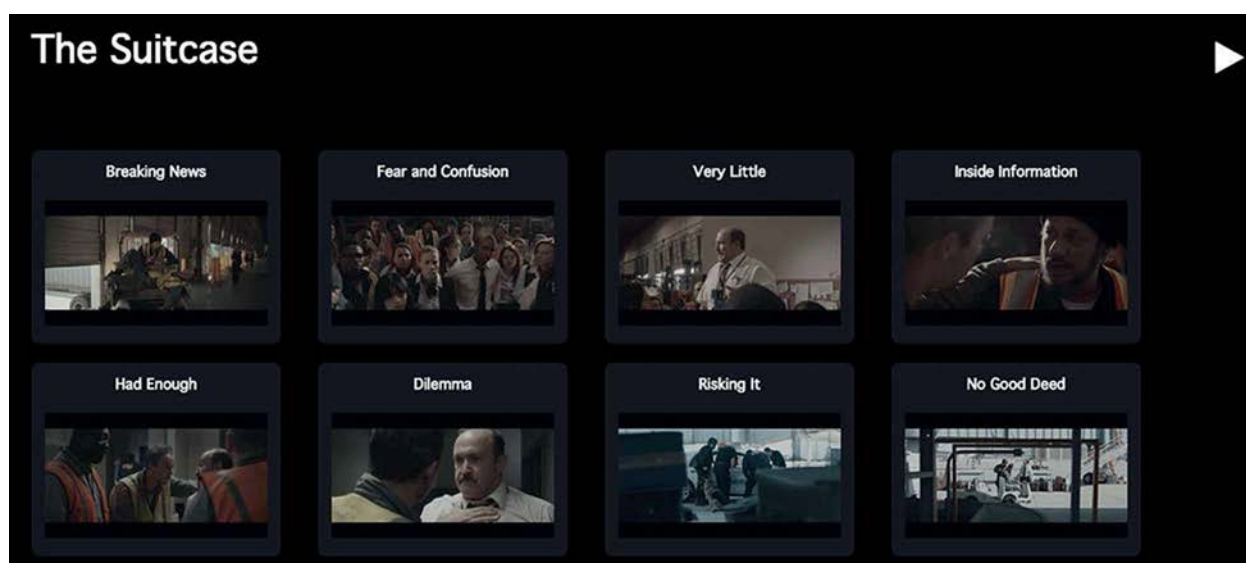


FIGURE 5. *The Suitcase* application allows users to view descriptive production metadata by scene.

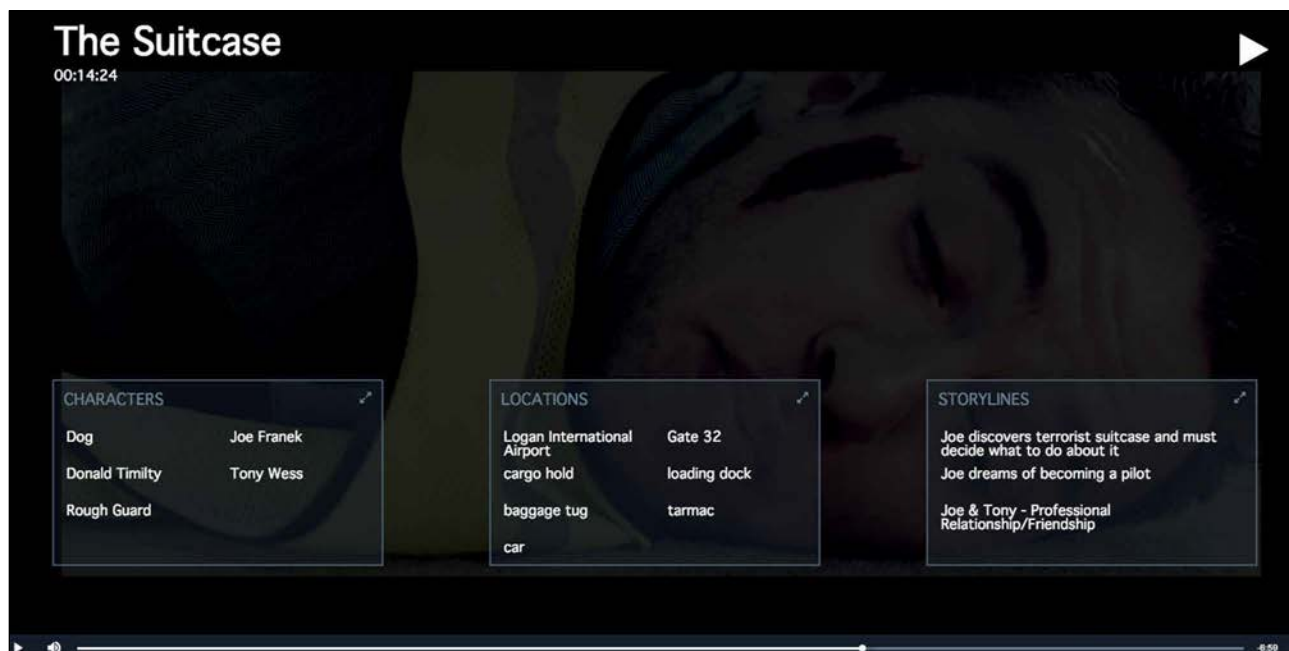


FIGURE 6. Users can explore the movie metadata by characters, locations, and storylines of *The Suitcase*.

- **Search/Research**—Search on granular facts and metadata fields to generate clips based on descriptive metadata for various purposes, such as marketing materials/promos, and actors (for reels).
- **Content Personalization**—Drive massively customized, individually targeted user experiences for increased engagement and loyalty.
- **Content Monetization**—Leverage assets in unique ways for content monetization. An example of this is identifying and selling products seen throughout the movie. The use of linked data allows for the ability to build software applications that sync a movie to display and sell products seen on-screen.
- **Analytics**—Surface patterns in the content that are not intuitive. An example of this would be the ability to capture facial recognition data for tracking accurate reporting for actor residuals.
- **Recommender Systems**—Support creation of information-filtering applications that seek to predict the “rating” or “preference” that a user would give to an item.

Benefits of NoSQL for Data Management

NoSQL has become a popular alternative to traditional relational databases because of the ability to manage both structured and unstructured data and adapt to environments that are increasingly dynamic. Relational databases require a consistent structure and a fixed schema for managing data. This is incredibly challenging for today’s applications that require the ability to utilize data from multiple systems and silos and pivot with changing business conditions.

According to “The NoSQL Generation: Embracing the Document Model,” the term “NoSQL” is a broad descriptor covering a wide range of new databases, generally broken down into four main categories: document, key-value, column-family, and graph databases. Among these categories, document databases are the best general-purpose databases, because they are flexible and easy to use, with a more logical human approach to modeling data. The term “NoSQL” has been in use since 2009 and was initially chosen as a Twitter hashtag to promote a meetup group to discuss new database technologies in San Francisco. The term was meant to have only a short lifespan, but it quickly caught on with the emergence of other databases, such as Cassandra, MongoDB, CouchDB, Google Bigtable, and Amazon Dynamo.⁶ A big misconception is that the term NoSQL means “No SQL,” and that NoSQL databases do not use structured query language (SQL) as a query language. However, many NoSQL databases do use SQL as one option among many supported query languages. For example, MarkLogic supports Java, JavaScript, .NET, SQL, XQuery, and SPARQL. For this reason, NoSQL is now generally referred to as “Not Only SQL.” The term is still useful for describing a broad class of databases ideally suited for the data problems we deal with today.⁷

MarkLogic and The Suitcase Project

The ETC Working Group selected the MarkLogic Enterprise NoSQL database platform for *The Suitcase* project for several reasons as follows.

Integration of Multimodel Data

Managing the descriptive metadata that was captured during the production required a multimodel platform that would support both documents (JSON) and semantics (RDF). The working group wanted the ability to test and use linked motion picture data so that a software application for viewing the movie and related metadata could be built on top of that platform. MarkLogic is optimized for both structured and unstructured data—characteristic of today’s television and motion picture data coming in various formats and types—allowing users to manage, query, and search across JSON, XML, RDF, geospatial data, text, and large binaries.⁶

MarkLogic has the capability to manage and integrate multiple silos of production data sources from systems such as Final Draft, Movie Magic, Scenechronize, ScriptE, SynchOnSet, and Avid.

Built-in Search

Another reason MarkLogic was selected was the need to deliver enhanced search and rich user experiences by delivering relevant targeted content. This, along with the information about the user (profile info and interaction behavior), allows for content personalization as well as monetization. The built-in search capabilities of MarkLogic, including its “Ask Anything Universal Index,” meant that project developers did not need to integrate a separate search engine tool.

Enterprise Features

It is imperative to keep data secure, consistent, and durable throughout the lifecycle of motion picture production. Element-level security allows for granular user permissions for data access. ACID compliance ensures data are reliable and transactions are consistent. These features are necessary to manage and preserve production metadata in the long term.⁶ MarkLogic differentiates itself as an “Enterprise NoSQL” database because in addition to qualifying as a NoSQL database, it has all of the critical features that enterprises need to run mission-critical applications such as security and ACID transactions.

Previous Experience

The MarkLogic database platform has been successfully used at major motion picture and television studios and is highly regarded throughout various industries globally for its unique enterprise features for data integration.

Conclusion

Metadata Extraction Learnings

When collecting descriptive metadata during a motion picture production, it is vital to understand the business logic about the production and who has the knowledge and authority to confirm and endorse data validity when it is created, updated,

and finalized. There is also a need to automate this authorization chain of data. To improve reliability and reduce human error in this process, technologies such as C4 are looking to incorporate endorsement and chain of authority mechanisms into the framework’s security model.

It is also important to understand the constraint inputs during the production and the controlled vocabularies of locations from the script that are used during the budgeting process, as they will help with the verification of the authoritative descriptive metadata. Active communication with the production team along with cooperation and alignment between the creative teams and those using the data downstream is a key requirement.

Using Semantic Data Accelerates Rapid Agile Software Development

Another key takeaway from the project was how fast and easy it was to build an app to leverage the linked tagged movie metadata. A major deliverable of the project was to create a search application that uses the linked descriptive metadata. *The Suitcase* software application development took less than three weeks to build, including UI design and development, management of the triples data, and creation of the SPARQL queries. Only one part-time developer from MarkLogic worked on the project, performing both the software development and the UI design.

New Jobs and Business Opportunities Emerge in Motion Picture Production

The automation of production metadata with C4, NoSQL, and semantics is creating a new technology disruption focusing on improving the business processes around content generation. All said, these new technology advances in motion picture content management will make for greater career opportunities for those with savvy, creative, technical, and business skills. This technology will also expose tremendous opportunities, in the areas of cost reduction and revenue generation, for companies that embrace rather than resist these changes.

Centralized Repositories for Production Metadata Management Are Necessary

Today more than ever, making motion picture content fast and easy to find is critical to the success of content creators, distributors, and the ecosystem as a whole.

The challenging production workflows and disparate systems necessitate the need for centralized repositories for data management and curation. Through the use of technologies, such as C4, NoSQL, and semantics, motion picture productions are able to implement on-set data curation so that the creation, collection, and governance of data does not have to be replicated downstream. This new automation of data is not only a cost saving in labor, but it also saves time and allows for

rapid software development by leveraging data collected throughout the production instead of trying to reconstruct it long after the production is complete.

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- Dean Allemang, Ontologist
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- Kenneth Williams, Executive Director & CEO

Avalanche

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MarkLogic

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- Alicia Saia, Director of Solutions Marketing
- Frank Sanders, Director of Sales Engineering, North American Commercial
- Nancy Silver, Media and Entertainment Industry Solutions Architect
- Matt Turner, CTO Media and Entertainment

Universal Pictures

- Daniel De La Rosa, Director of Film Production Technologies

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About the Authors



Nancy Silver is a principal solutions architect for MarkLogic. Her work focuses on providing strategic and technical leadership to MarkLogic’s Media and Entertainment practice in the areas of content strategy, next-generation content and metadata workflows, data management, and governance. Prior to MarkLogic,

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Kaki Ettinger has been with Disney—ABC Television Group’s R&D team for three years, focusing on exploration, prototyping, and technology transfer of disruptive innovations in the TV space. Prior to Disney, she worked in product management and producing, including leading early stage development and production for

a sports media start-up (Whistle Sports). She is passionate about creative industries, digital media, and building things. She earned her undergraduate degree at Yale and an MBA from Harvard Business School.



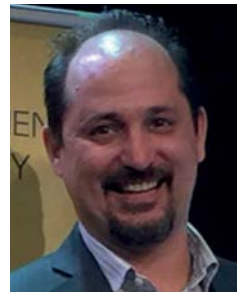
Joshua Kolden is a pioneer of entertainment technology in Hollywood. A visual effects professional for more than 20 years, Kolden has credits in some of the most successful films of all times. In 1999, Kolden led a team of artists at Digital Domain to produce the world's first digital human face replacement—a technique

later popularized with projects such as *The Curious Case of Benjamin Button*. In 2002, he started Crack Creative to apply leading-edge realtime technologies to the filmmaking process. The most well-known of Crack Creative's innovations is the "Virtual Production" process originally created for James Cameron's *Avatar* in 2005. In 2013, Kolden launched Studio Pyxis, a production studio specifically designed to employ the latest filmmaking technologies. Currently, Kolden is a production technology consultant and the architect of C4, an open-source framework designed specifically for media production that harnesses distributed resources to provide scalable storage and computing, and remote collaboration.



Michael Malgeri is a principal technologist with MarkLogic, where he works with companies to match their business requirements with MarkLogic's enterprise NoSQL database and semantic features. He also helps organizations reduce costs, automate processes, find new opportunities, and create applications

that bring high value to businesses and their customers. He focuses on the media and entertainment industry, where content providers, distributors, and related companies are seeking to leverage the power of data, in order to capture new opportunities driven by expanding global information consumption. He holds master's degrees in computer science, business, and mechanical engineering. He also volunteers with the local Boy Scout troop.



Erik Weaver is a specialist focused on the intersection of cloud and the media and entertainment industry, who is currently running "Production in the Cloud" for ETC. The project unites senior leaders from the six major studios to develop next-generation cloud standards, support Hollywood organizations and

major cloud vendors, and produce proof of concepts. The group encompasses many aspects of the cloud, including transport, security, metadata, long-term storage, and formation of an agnostic framework that unites key vendors and studios. Previously, Weaver was the chief executive officer at Digital Ribbon, Inc., an early pioneer in the field of cloud-based computing.

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