Non-linear Interactive Media Productions

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ABSTRACT
Creating non-linear interactive media is a challenging task. In this paper we summarise our findings with non-linear, interactive movie productions. We carry out this discussion based on experiences gathered during the development and evaluation of an authoring suite enabling the creation and testing of non-linear narratives. The paper shows how our workflow can be understood in terms of the canonical model of media production.

Categories and Subject Descriptors
H.1 [**Models and Principles**]: General; I.7.2 [**Document Preparation**]: Multi/mixed media, Hypertext/hypermedia

General Terms
Design, Human Factors, Standardisation

Keywords
Non-linear media, Interaction, Delivery, Broadband

1. INTRODUCTION
In traditional TV media productions, the writer or director creates a storyline as a linear sequence of the available material. Through the manual application of implicit rules it is ensured that the story is appealing and consistent. However, the chosen storyline is often only one of many possibilities. On the other hand, non-linear stories enable the material to be more extensively exploited through alternative story-angles.

Creating non-linear, interactive media [1, 2, 3] is a challenging task. Not only does the story world itself need to be non-linear so that the story can evolve based on the user's interaction, but also the workflow to create such media productions is iterative and contains interdependencies.

Works in the realm of authoring non-linear media productions are well known, mainly discussing—both from a academic as well as a commercial point of view—narrativity and interaction [4, 5, 6].

In this paper we summarise our findings with non-linear, interactive movie productions. We carry out this discussion based on experiences gathered during the development and evaluation of an authoring suite that enables the creation and testing of non-linear narratives. The paper describes our approach and shows how this dynamic workflow can be understood in terms of the canonical process of media production [7].

So far a toolkit has been created that was already used by several productions in different genres and is now being made available to a larger community[1]. The toolkit was used to author and successfully deliver a black comedy on a major public-broadcast TV channel in Finland, as well as an interactive news production (Sweden) and a drama based on a previous BBC production (UK). The projects our experiences stem from focus on manually authored broadband media productions. However, the results are likely to be applicable to other productions, such as gaming. This is due to the end-user exploring the story-world, hence shaping the story through her interaction.

This article is organised as follows. In section 2 we introduce the non-linear movie production system developed in the realm of an EU project in the years 2004 to 2007, along with the authoring and discuss exemplary productions. The central part is presented in section 3, where we describe the non-linear movie production process in terms of the canonical process. We summarise and discuss the mapping effort in section 4.

2. NM2: A NON-LINEAR MEDIA PRODUCTION ENVIRONMENT
"New Media for a New Millennium" (NM2), an Integrated Project under the European Union's 6th Framework Programme, aims at developing tools for the media industry enabling the efficient production of non-linear, interactive media. To provide non-linearity, NM2 productions are not final edited pieces of media. The productions rather consist of a pool of media assets to be recombined at run-time based on a logical description of the story world and the end-users' interaction.

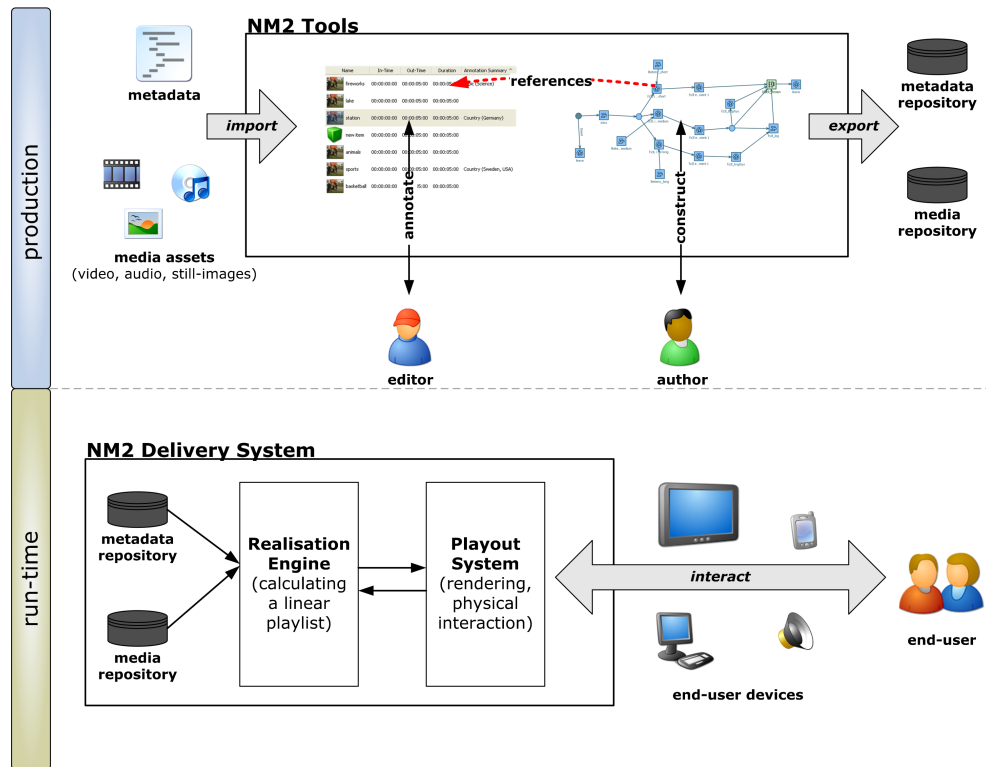[1]Note that the tools will be publicly available for download at http://www.shapeshift.tv/.

Figure 1: The NM2 workflow.

The NM2 toolkit can be divided into the following main parts:

- The *NM2 Tools* support the creation of non-linear stories. They cover the ingestion of essence, the description of video clips, as well as the authoring of possible stories. These tools aim at integrating seamlessly into existing production environments, such as Apple's Final Cut Pro[2].

- The NM2 Delivery System comprises the *Realisation Engine* and the *Playout System*. It presents the output to the end-users and interacts with them. The Realisation Engine is responsible for dynamically creating a (linear) playlist, based on the author-defined story world, and the interaction of a particular user. The Playout System takes care of rendering the actual playlist on a client device and handles the physical interaction.

    Previewing in the NM2 Tools is implemented using an instance of the Realisation Engine along with a generic interaction client.

- The *Media Repository* and the *Metadata Repository* manage the media assets along with the metadata. The Metadata Repository contains the low-level metadata (MPEG-7, annotations), the production ontology (domain specific entities), and the formal description of the story world.

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[2]http://www.apple.com/finalcutpro/

Fig. 1 depicts the overall workflow in NM2: in the upper half of the figure the production workflow is shown. People with different roles (such as editors annotating material or authors creating a story) work in a collaborative fashion with the NM2 Tools in order to create and manage the repositories. While the generic story itself is constructed on the logical level using a graph-based tool, it references the media items either directly or via a logical expression.

In the lower half of Fig. 1 the actual run-time setup of the NM2 system is illustrated. The repositories produced during earlier production stages are used by the NM2 Delivery System to create an actual output based on the logical description of the story world and the interaction of the end-users through the end-user devices.

For a detailed overview of the NM2 project objectives, system capabilities and the productions, the reader is referred to [8, 9].

2.1 Authoring Of Non-linear Stories

Following Bulterman and Hardman [10], the NM2 Tools support the author in creating narratives with a combination of the graph-, structure- and script-based paradigms. We take a declarative approach to modelling interactive programmes, where the narratives are represented in a formal language called the Narrative Structure Language (NSL) [11, 12], made of building blocks called Narrative Objects (NO). The smallest building block that can be used to specify a narrative is the media item, pointing to a media asset, such as a video clip. Note that it is assumed that standard non-linear
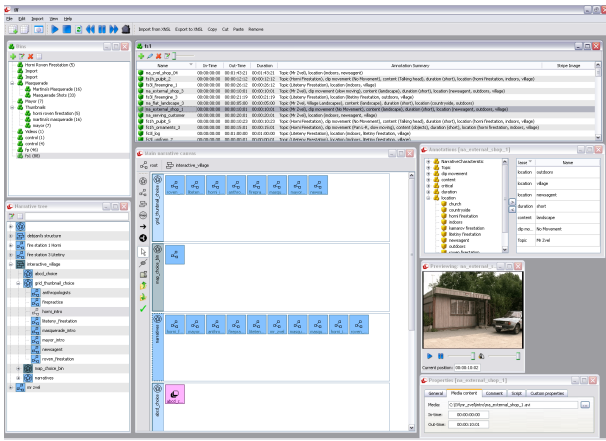
Figure 2: The NM2 Tools.

editing tools, such as Avid or Final Cut pro are used to edit media assets.

An Atomic Narrative Object refers to a media item (i) by directly referencing it, or (ii) using an expression. For example, a Narrative Object could query for some material that *is about soccer*, *has an interview* in it and *starts with a pan left* camera motion. To realise the match, a set of existing technologies is utilised. MPEG-7 [13] is utilised for representing low-level features of the media items, such as colour descriptors. OWL-DL [14] is used to formalise production specific entities.

A non-atomic Narrative Object (NO) is called a Structured Narrative Object and is a grouping of other NOs. The NSL consists of a set of recursive primitive narrative structures through which higher level narrative structures, such as "3-Acts", are expressed [15]:

- A **link structure** is a directed graph, possibly with cycles. Each node is a NO, each edge specifies a potential path a narrative could take from the origin to the target node. Each edge has an enabling (boolean) condition referring to the metadata of narrative objects, input from the engager and context information (such as the play-list compiled so far).

- A **layer structure** has a number of layers, each consisting of a narrative object. Reaching a layer structure leads to the media asset referred to by each layer being added in parallel to the play-list. This means that they are played concurrently, starting at the same time. Layer structures can be used, for example, to associate a background-audio with video.

- A **selection group** has content, selection criteria and constraints. The content is a collection of narrative objects. The content may be specified by directly referencing narrative objects, or using an expression, as in the case of an atomic NO. Each selection groups has an optional termination condition which may be used to loop its interpretation.

2.2 Example NM2 Productions

The NM2 Tools, as shown in Fig. 2, have been used and evaluated in seven media productions[3]. These media productions were chosen to reflect a range of content genres (including drama, fiction, news, and a documentary). Three example productions are discussed in the following.

Accidental Lovers [16], is a participatory romantic black comedy, for television, mobile phone and Internet. The end-user can affect in real-time the unfolding drama of the unlikely romantic couple, Juulia in her sixties and Roope in his thirties. The outcome of the drama is shaped by sending text messages to a system that triggers story events based on keyword recognition. The interaction grammar is based on keyword-recognition: each submitted SMS is scanned for keywords selecting a single clip for either one of the main characters.

My News & Sports My Way (MNSMW), a digital interactive archive that allows end-users to discover, select and recombine news and sports items into stories which meet their individual tastes. The MNSMW production, produced in collaboration with the Swedish public service television (SVT), aims to show how the production tools of the NM2 system may improve the possibilities for producers of news and sports to create a reconfigurable media output that can be offered to end-users in different situations and in different formats. The idea is that as a finished product, the output will reach the end-users through broadband and will be consumed with the help of Windows Media Center.

Gormenghast Explore (GX) [17] is an experimental, spatially-organised drama for interactive delivery over broadband, made from the original footage of BBC TV's 4-part adaptation of Mervyn Peake's "Gormenghast" novels. The visitor enters the virtual Octagonal Gallery, and approaches any of the eight "living portraits" around it, guided by the direction of the lighting as well as by sound. The portraits are video loops, each offering a taster of the character whose story can be found behind the portrait panel. In GX, viewers can choose to follow the story of a particular character, or explore the rooms of the castle to find what happens there.

In section 3 the three above presented productions will be used to exemplify parts of concrete NM2 workflows.

2.3 Lessons Learned

In NM2 the productions are made with audio-visual material, such as video-clips, audio recordings and graphics. In the case of fiction or scripted factual stories, the pool of media items reflects the pool of script items (such as scenes in the action treatment or voice over commentary). The media items are automatically assembled at viewing-time according to the rules determined by creators into stories which reflect both the narrative patterns devised by the creators, and the choices and preferences of end-users.

Due to production-specific requirements, the NM2 tools have to support a range of import functions (metadata, media),

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[3]For an overview the reader is referred to an on-line video available at `http://www.ist-nm2.org/media_productions/CU_intro_video/CU-intro.htm`
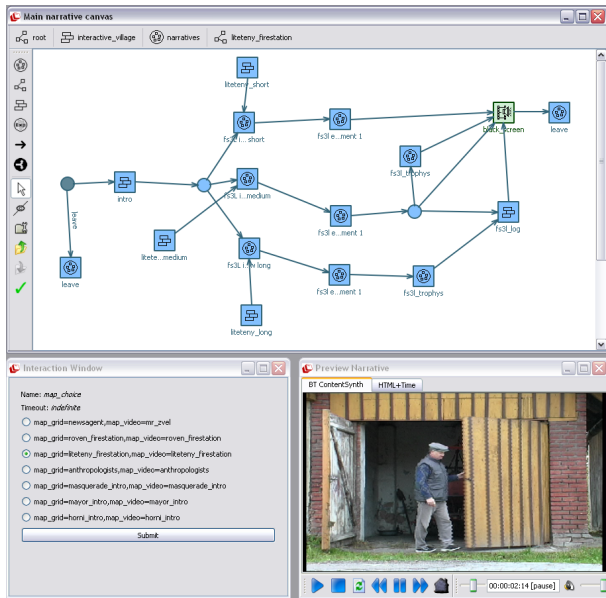
Figure 3: Preview a narrative of a non-linear media production.

while providing a generic interface for the narrative design. Depending on the genre (fiction, news) it is possible to identify production assets that influence the workflow:

- Script items are available, hence can be used to assist in the post-production phase in certain genres, such as fiction or drama.

- The audio-visual material itself can be available in advance, or just-in-time, as is the case with news.

- Multimedia metadata [18] for the audio-visual material can be extracted and/or annotated manually.

One of the findings in the NM2 project is that handling the above mentioned issues—independently of the type of production–is hard to realise. This is due to the actual production requirements: For example, in the news domain, certain events (such as the eruption of a volcano) demand for an immediate change of a programme; the annotations in this case are only available after a while (e.g. for archiving purposes), hence may not be available for shaping the narrative.

Another challenge is the need for iteration based testing of the narrative. Due to the potential numbers of ways a story might evolve, a preview of parts of the story has to be offered. As the end-user devices along with the physical interaction can take many forms, a generic interface is required to render the preview of the narratives. This interface simulates the logically choices an end-user is able to make, hence drives the actual construction of the specific story. This functionality is offered by the NM2 system, called the Narrative Preview (Fig. 3). In using the Narrative Preview, a non-linear media editor is able to verify how, and if the story works, both on the logical level and from the artistic

point of view. Through the Interaction Window, the editor is able to test all branches; a challenging task for complex and deep-structured narratives.

Although validating a story on the syntactic level is possible and available, it turns out that 'debugging' a story on the semantic level is a laborious and time-consuming task. Whilst for a human being it is rather straightforward to tell if a story is consistent and compelling, for a computer it is not. To this end we found that enforcing artistic aspects, a human in the loop is still required.

3. THE NM2 WORKFLOW IN TERMS OF CANONICAL PROCESSES

In this section we describe the NM2 workflow (Fig. 1) and suggest a mapping to the Canonical Processes [7]. Note that no single NM2 production precisely instantiates this workflow. The actual workflow depends on, e.g. the genre of the production, or the availability of existing production assets (such as scripts). In the following, the three NM2 productions introduced in section 2.2 are used to highlight concrete NM2 workflows.

3.1 Preproduction

In NM2 the embodiment of the canonical **Premeditate** process heavily depends on the genre of the actual production. Ranging from a news production that directly incorporates existing metadata structures over a drama that utilises existing scripts, each production has its own requirements and ways to express `what` and `why` to capture. For example, in the *My News & Sports My Way* production, local events may be more interesting to the end-user, compared to global, unspecific ones. On the other hand, the story-world of *Accidental Lovers* was carefully designed long before the actual shooting.

Typically in the NM2 preproduction phase a production ontology is defined. It extends the NM2 core ontology in order to represent production specific entities, such as objects, actors, places. In the *My News & Sports My Way*, for example, the production ontology was initially derived from a taxonomy provided by the SVT; in a second step the production ontology was extended with other concepts, such as location and people. On the other hand, in *Gormenghast Explore*, the ontology was created from scratch, based on Aristotle's categories, such as time, place and action.

Another aspect influencing this process are decisions regarding the logical interactions, i.e. the way the end-user can influence the shaping of the material. The author has to decide where branches are introduced and how and when the branches join again. The NM2 Tools can be used in this phase to experiment with narrative structures. This is occasionally valuable even without the presence of actual media assets to, e.g. test if and how a narrative works. Again, take for example the *Accidental Lovers* narrative. The global story with its basically four options (Juulia falls in love with Roope, Roope falls in love with Juulia, both fall in love with each other, or both do not) as well as the micro-stories within each branch could be examined—prior to the (expensive) production.

3.2 Production

In NM2 we assume standard-NLE tools to be used to actually edit clips. This is due to the focus of the NM2 project rather than due to technical limitations. Although media assets have actually been created in the realm of NM2 productions (for example in *Accidental Lovers*), it happened outside of the scope of the NM2 Tools. We therefore understand that the **Create Media Asset** process of the canonical model is not present in the NM2 workflow.

The NM2 Tools allow for a number of ways to import media assets and metadata. After manual import, or a bulk import into the NM2 Tools, the single piece of essence is a `media item`. The author is supported during the import through filters (such as media type or date) allowing to select certain media assets (**Query** canonical process). Data structures called *bins* are used to logically group media items. In case of a manual import (e.g. in *Accidental Lovers*), the editor selects a clip (and may choose to trim it). The editor can import the media item into an existing bin, or a create a new bin to hold he imported media asset; this task can be understood as the **Package** canonical process.

3.3 Description

The canonical **Annotate** process is present in manifold ways in the NM2 Tools' workflow. Most commonly used are semantic annotations, based on the production ontology.

The editor is supported in describing media items in two modes: On the one hand automatic content analysis yields low-level features that are represented in MPEG-7. For example shot boundaries have been extracted in several productions, allowing the definition of smooth transitions. An author can, e.g. state that a pan-left shot must not follow a pan-right shot; this can be achieved based on the automatically extracted shot boundaries. The extracted low-level features can further be used to generate high-level descriptions rooted in the production ontology [19]. On the other hand, an editor may—again based on the production ontology—manually annotate the media items. This can be done globally, for example stating 'this media item is an interview' in *My News & Sports My Way*, or using temporal annotations, such as 'this media item starts with a pan-left followed by a two people sitting next to each other'. For example, in the *My News & Sports My Way* production the media assets are directly exported from the SVT archive; the metadata (available as Dublin Core attributes) is mapped to instances of the production ontology. The editor then extends the description based on a taxonomy provided by SVT to capture a category (e.g. economy) a media item belongs to.

In some of the NM2 productions, logging tools, such as a shot logger, have been utilised to record information on the usefulness of the rushes. This information can be imported as well.

In order to find media items to manually annotate them, the author uses a **Query** process of the canonical model.

3.4 Authoring

The construction of the story world (the authoring) in NM2 can be performed bottom-up, top-down or middle-out. This phase in the NM2 workflow (upper half of Fig. 1) can be mapped to the **Package**, **Query**, **Construct Message**, and **Organise** canonical processes of [7].

An author might start off with a set of micro-stories and use narrative constructs of the NSL (cf. section 2.1) to generate bigger blocks of the story. Another authoring style that has been used in NM2 productions is to start with a rather rough, global set of narratives, and iteratively—as the material is available—refine them (*My News & Sports My Way*).

Within the narrative objects the NM2 system allows for two ways to select media items: by directly referencing a media item, or via an expression (**Query** and **Construct Message**), using the vocabulary from the production ontology. Expressions in narrative objects define the desired content, e.g., 'I need a media item here that is maximally 45s long, starts with an interview, and followed by a close-up onto a painting'.

The actual story is created dynamically depending on the editing rules, and on the usage of by reference/by expression in narrative objects. The actual shape of the story is defined only when user interaction takes place. This process of actually calculating a concrete path in the story world can be mapped to the canonical **Organise** process.

Narrative preview. The narrative preview is an integral part of NM2 authoring phase. However, testing a story—as discussed in section 2.3—is a non-trivial task. During the NM2 authoring phase one is very likely interested to see and interact with the outcome in the NM2 Tools; this is achieved via the so called narrative preview functionality. Note that authoring and narrative preview are actually interdependent and represent two sides of the same coin. The narrative preview renders the logical decision points of a NM2 narrative in a generic way, hence allowing the emulattion of the production-specific front-end; it can be mapped to the canonical **Organise** and **Publish** processes.

3.5 Delivery

In the NM2 Delivery system on the one hand the Realisation Engine calculates dynamically a linear play-list—based on the narrative and the interaction of a particular user—and on the other hand the Playout System takes care for the actual rendering on a client device, including the physical interaction. Regarding the first part, i.e. the Realisation Engine, this is identically implemented as within the narrative preview. The actual playout is always production-dependent and represented through the NM2 Playout system. For example, *Accidental Lovers* was broadcasted on the TV, using mobile phones (SMS) as the back-channel; a majority-vote of all the incoming messages would influence the story. In contrast, *Gormenghast Explore* was realised using the Windows Media Centre along with an remote control.

Taken together, several canonical process can be identified. Driven by the end-users interaction, the global story is populated with media assets (**Query**), converted into a linear path (**Organise**), and rendered on the client device, where the physical interaction takes place (**Publish** and **Distribute**).

In Table 1 the generic NM2 workflow phases are gathered and described in terms of the canonical process.

4. DISCUSSION
This paper introduced the development of non-linear media productions using an integrated toolkit. It has shown that the developed toolkit has the flexibility and facilities to enable workflows for at least three production types: News and Sport, Documentaries, and Drama.

We note that each phase in the generic NM2 workflow can be understood as an instantiation of one or more of the identified canonical processes, or indeed a complex process, which combines several canonical processes. Non-linear movie productions have special needs and characteristics, such as a highly iterative workflow, strong emphasis on previewing and testing the story.

The content in a non-linear movie is assembled on-the-fly, triggered by the end-user's interaction with the content. Our finding was that mapping the canonical process is straightforward in the case of linear productions. For the domain of non-linear, interactive movie productions it might be handy to specialise the canonical process allowing to capture non-linear workflows, especially delivery and assembly of the media assets. The same need has been identified regarding the impact of an end-user's interaction with the media, which could be emphasised in an adapted version of the core canonical process.

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Canonical process	Non-linear media production workflow phases
Premeditate	In the *NM2 preproduction* phase (cf. section 3.1) the author conceptualises the global narrative. She outlines where branches should be made (decision points) and defines the production ontology (see also section 2.1). Existing metadata sources can be mapped to the production ontology. Input: Creative idea, news event (cf. section 2.3) Output: Depending on the genre, e.g. scripts (fiction) or characteristics for assets (news).
Create Media Asset	In the *NM2 production* phase the shooting takes place. The clips are edited, sound recordings, and overlays are created. Note that the actual production of media assets, including their editing, is not in the scope of the NM2 Tools. Rather, clips are imported into the system and are further used along with different types of metadata (cf. section 3.2).
Annotate	The *NM2 description* phase covers the semantic annotations (cf. section 3.3): Either through automatic content analysis or based on a manual annotation performed by an editor. The semantic annotations are instances of the production ontology. Input: Media assets (imported into the NM2 Tools). Output: Media items (media asset and metadata, see section 2.1)
Package	Present in the *NM2 production* phase (cf. section 3.2), when importing media assets. The same is true for the *NM2 authoring* phase (cf. section 3.4), where the content of an Atomic Narrative Object (see section 2.1) is defined using an expression. *NM2 production*: Input: Media assets (from standard NLE-tools, such as a video clip) Output: Media items. *NM2 authoring*: Input: Expressions Output: Media items.
Query	In a number of phases present: In the *NM2 production* phase (cf. section 3.2) for importing media assets; in the *NM2 description* phase (cf. section 3.3) for manual annotation of media items; in the *NM2 authoring* phase (cf. section 3.4) for defining a Narrative Object's content; finally in the *NM2 delivery* phase (cf. section 3.5) for populating the play-list. *NM2 production*: Input: Media assets. Output: Media items. *NM2 description*: Input: Media items. Output: Media items. *NM2 authoring/delivery*: Input: Narrative Object, expressions. Output: Media items.
Construct Message	The construction of the narrative, through defining narrative object, along with their connections (see section 2.1); instantiated in the *NM2 authoring* phase (cf. section 3.4). Input: Narrative objects, decision points, selection rules. Output: Narrative objects.
Organise	Instantiated in the *NM2 authoring* phase (cf. section 3.4, especially in the narrative preview, where narrative objects are being arranged, as well as in the *NM2 delivery* phase (cf. section 3.5) in order to create the linear play-list. *NM2 authoring*: Input: Narrative Objects. Output: Narrative Objects. *NM2 delivery*: Input: Narrative Objects. Output: Media items.
Publish	The global narrative is populated with media assets and converted into a linear playlist—i.e., in the *NM2 authoring* phase (cf. section 3.4) and the *NM2 delivery* phase (cf. section 3.5) Input: Narrative objects, media items from the NM2 authoring and description phase. Output: A play-list of media items resulting in an on-the-fly cut clip.
Distribute	Instantiated in the *NM2 delivery* phase (cf. section 3.5) through the NM2 Playout system. The physical interaction is handled, and the rendering of the content on the end-user device takes place (including the back-channel management). Input: A media item play-list and physical user choices. Output: Selection for further Narrative Objects in the global narrative.

Table 1: **Non-linear media productions in terms of the canonical processes.**

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