MusicBeetle
Intelligent Music Royalties Collection and Distribution System

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Abstract: Music industry has been completely disrupted by a range of new online digital services and social networking systems that has forever changed the way users and businesses experience and use music. This had a tremendous impact on the established music business models that had guided a dozen year-old industry. On what concerns business music users, i.e. businesses that make use of music as part of their own business model, and on the business relation they establish with author societies or their representatives, they are required to pay royalties for the use of music. These royalties need to be distributed and authors will have the opportunity to see their work rewarded properly. The proper distribution of royalties is a non-transparent and complex process. In this paper, the authors present a system, called MusicBeetle that enables the identification, collection and distribution of music royalties through the usage of decentralised system and low cost hardware devices.

1 INTRODUCTION

The Internet and the digital technology has created serious challenges in terms of Intellectual Property protection and management of digital content assets, for both end-users, content authors, content distributors and rights collecting and distributing societies (Torres, Serrão, Dias and Delgado, 2008).

The Related Rights (RR) or Neighbouring Rights (NR) are terms in copyright law that represent the rights which are similar to the author rights but which are not connected with the actual author of the work (Frith and Marshall, 2004). Both the author rights and the related rights are copyrights. The RR/NR are independent of any authors' rights, which may also exist in the work (WIPO, 1961). The rights of performers, phonogram producers and broadcasting organisations are certainly covered, and are internationally protected by the RR/NR legislation (Correa, 2007). In the specific case of the music industry, and as an example, four different copyright-types rights will concurrently protect a CD recording of a song:

- The authors' rights of the composer of the music;
- The authors' rights of the lyricist;
- The performers' rights of a singer and the musicians;
- The producers' rights of the person or corporation, which made the recording.

Therefore one the most important activities of these Music Related/Neighbouring Rights Management Societies (MRNRMS) is the collection of neighbouring rights on behalf of producers and performers related to public performance of recorded music (Correa, 2007). Consequently the mission of a MRNRMS can be resumed in the following four major objectives:

- Raise public awareness to the reality of related/neighbouring rights and the need for its protection (a fact still relatively new and little known);
- Boosting the delivery of remuneration for distribution to the holders, be they producers or artists;
- Realize the collection of related/neighbouring rights to all places of public performance using recorded music for commercial purposes, as well as all the inspectors to use of recorded music, by any means;
- The community awareness in relation to associated rights will, in large part, be accomplished with the collaboration of public authorities with powers of supervision on Copyright and Related/Neighbouring Rights, as well as the users of

recorded music in various areas and industries that in compliance with the law, should ask for their license.

These MRNRMS are responsible for issuing licenses to businesses that use represented recording music as a mean to conduct their own business models. Moreover, they are also responsible for the effective collection and distribution of the associated fees to the music producers, performers and authors (Bustinza, Vendrell-Herrero, Parry, and Myrthianos, 2013). Most of these MRNRMS exist in nearly every civilised country in the World and they often operate their business based on manual and non-automatic processes, causing them to be less effective on their core business functions.

2 BUSINESS MUSIC USERS (BMU) AND ROYALTIES DISTRIBUTION

Businesses use in-store media entertainment content as a way to increase the perceived value of their core business while engaging more customers and creating the opportunities for them to stay longer and consume more (Teece, 2010). Music is an important part of their business model. They recognise its importance and therefore are willing to comply with the legal requirements that impose the payment of royalties to authors. Not only business music users (BMU) are required to use legal content (legally acquired music) but they also need a public execution license (Vaccaro and Cohn, 2004). Public execution licenses are a requirement for businesses that depend on the usage of music for public execution on their businesses - this includes, for instance, discos, bars, restaurants, stores, gyms, parking zones, hotels and many more.

The MRNRMS are responsible for collecting the rights royalties from the different BMU and distribute those royalties to the different beneficiaries of such royalties (artists, performers, and others). Usually this distribution method is performed through the sampling of the percentage of the number of times a given music is played on a given medium (Figure 1). Currently, some specific companies are hired to audit the music usage, using specific human auditors to listen to the different medium (radio stations, TV channels, and some other mass media mediums) for a given period of time and produce statistical data estimations that are used to extrapolate the real music usage ratings that are after used to perform royalties distribution. Also, some additional criteria are used to charge BMU, like the business space, the number of days the business operates during the year, and other similar.

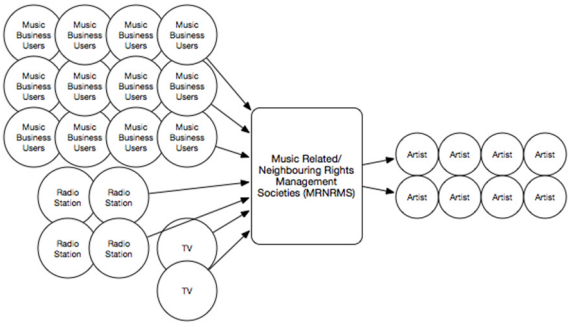

Figure 1: Related-rights distribution scenario.

The way, this all process is conducted, is completely error prone and not transparent. The process is not accurate, and leaves out from the royalties distribution chain some of the less well-known artists (Castro, Alves, Serrão and Caraway, 2010). Moreover, this system can only be used for larger music distribution channels, and are not adequate for the different BMU that use music as part of their business model - they represent a large amount of entities that are charged for a license that enable them to use music on their business and execute their business model.

These facts have created the need for a new type of system that allowed the MRNRMS to charge BMU in a fairer way and distribute owed royalties to artists in a more transparent manner.

The following sections of this paper present a system, called MusicBeetle, that is responsible for automatically auditing the music usage by BMU and by ensuring the appropriate royalties collection by the MRNRMS and distribution to the authors. The following section presents the MusicBeetle system that is divided into two different components - MusicBeetle.box and the MusicBeetle.cloud. The two components are further described and details about how they both operate to fulfil the automatic music auditing process and royalties distribution.

3 THE MUSICBEETLE SYSTEM

In order to improve the related-rights royalties collection and distribution process that is implemented manually by the MRNRMS, it was designed and implemented a system that automates the entire process.

The system, called MusicBeetle, was composed by two different components: (a) a critical client-side component that was capable of automatically identifying the music being used and create a report of all the music used on a given period of time by a specific BMU (MusicBeetle.box), and (b) a set of cloud-based services integrated with the MRNRMS information systems that registers all the different music business licensees, their music usage profile, and information about music identification and artists database (MusicBeetle.cloud).

In order for the entire system to work, the different BMU have to install specific hardware devices that are connected to the Internet (the MusicBeetle.box, that will be presented in the following section) and connected to the music sound system used by the BMU. On the other side, the MRNRMS has access to an large database of the entire music repertoire that they represent on a given country or has the means to access further information online.

The following sections provide an overview of these two different components of the system, how they interoperate and which are their major functionalities.

3.1 MusicBeetle.box

The MusicBeetle.box is one of the critical components on the system. This client-side hardware component allows the system to actively listen to the music being used at the BMU side, record the music candidate identification, and report back the music consumption to the MRNRMS.

Here are some of the most important requirements for the development of such critical component:

- The system should be able to connect to an external sound system;
- It should be able to listen to the music that is being played at the sound system;
- It should be connected to the Internet (or at least it should temporarily connected to the Internet - not requiring a permanent connection);
- The system should be able to create unique identifiers for the music that is listening (from time to time) based on audio fingerprinting technology (Cano, Batlle, Kalker, and Haitsma, 2005);
- The system should be able to record at least a month time of audio identifiers;
- And finally, another important requirement is that the system should be inexpensive.

All of the above requirements were considered in the design and development of a solution.

3.1.1 MusicBeetle.box Hardware Architecture

Having into consideration all of the previous technical and financial requirements, the obvious choice was to select an inexpensive hardware solution, based on the "all-in-one" boards that existed on the market. After analysing some of the existing ones (Raspberry Pi, CubieBoard, PandaBoard, BeagleBoard, and CuBox), it was decided to select the Raspberry Pi (RPi). The RPi represents a cost effective solution that also presents the processing capabilities required by the solution to implement.

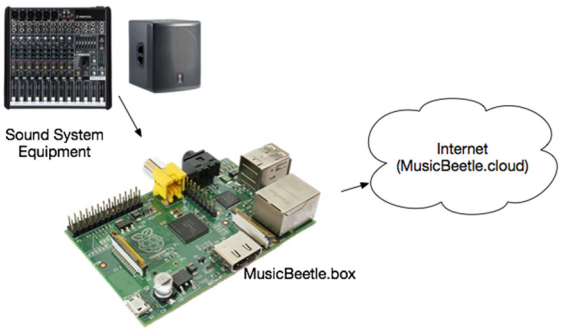

Figure 2: MusicBeetle.box (based on the Raspberry Pi hardware) and the integration with the client Sound System and the Internet.

Therefore, RPi was selected as the principal hardware component to implement the MusicBeetle.box prototype (Richardson and Wallace, 2012). Raspberry Pi is a credit card-sized single-board computer that was developed in the UK by the Raspberry Pi Foundation with the intention of promoting the teaching of basic computer science in schools. Raspberry Pi is based on the Broadcom system on a chip (SoC), including an ARM processor, a GPU, and some amount of memory (originally 256 MB and later 512 MB). The system has Secure Digital (SD) or MicroSD sockets for boot media and persistent storage (Upton and Halfacree, 2012). Moreover, Raspberry Pi has also an HDMI port, several USB ports, an Ethernet port and an audio connector (Figure 2).

The Raspberry Pi board has become the natural and adequate solution to sustain the MusicBeetle.box system and to implement crucial requirements, like the capability to listen to music and connect to the Internet to report the audited music. Additionally, each of the RPi boards costs around 35 euros, making it inexpensive enough for mass distribution.

3.1.2 MusicBeetle.box Logical and Software Architecture

Apart from the hardware that was selected, the MusicBeetle.box is also composed by a set of software that was specifically developed to implement some of the requirements of the system. All the developed software runs on the Raspbian Linux-based (on the Debian Wheezy distribution) operating system. On top of the operating system, a set of specifically developed software is running to implement a set of operations that enable the correct operation of the MusicBeetle.Box.

The following schema (Figure 3) depicts how the MusicBeetle operates to conduct the music audits at the BMU side.

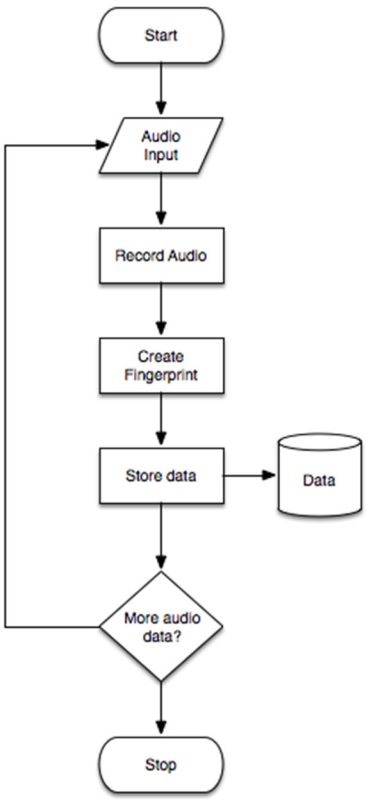

Figure 3: Schema that demonstrates how the MusicBeetle.box operates to audit music usage.

The implemented music auditing process is composed by the following operations:

1. The MusicBeetle.box has an active process that continuously listens for the existence of new music on the sound board;
2. Every time music/audio is detected, the process captures and records 15 seconds of audio data;
3. A candidate audio fingerprint is calculated for the audio sample from this 15 seconds of captured audio;
4. A timestamp of the date and time of the audio data capture and the candidate audio fingerprint are stored on a temporary MusicBeetle.box database;
5. After a waiting process of 30 seconds, the process verifies if there is more audio data available to capture. If there is, it repeats the entire workflow (returning to step 2).

In order to conduct this auditing process and being able to operate at the BMU side, the MusicBeetle.box implements the following software architecture (Figure 4). This software architecture lies on top of the specific Raspberry Pi Linux distribution (Raspbian), with some specific software developed for accomplishing the required tasks of the MusicBeetle.box.

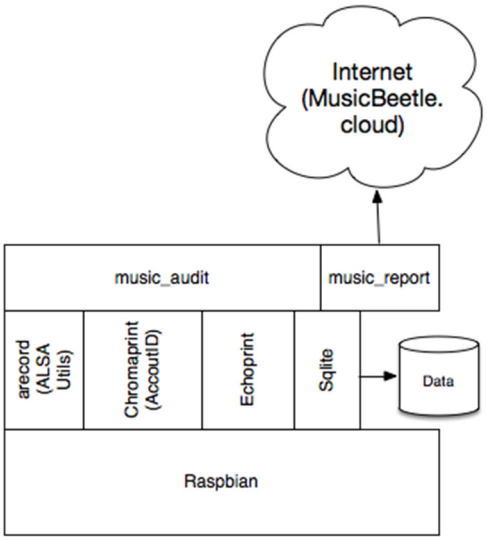

Figure 4: Schema that demonstrates how the MusicBeetle.box operates to audit music usage.

The MusicBeetle.box is composed by two different software processes that are running on the box. These two software processes are “music_audit” and “music_report”. Both of these processes are automatically activated immediately after the Raspberry Pi is turned on and the Raspbian operating system finishes booting up.

The “music_audit” is the process that is responsible for auditing and identifying the music that is used at the BMU side. This process conducts the following functions:

- Actively listens to the sound board for the existence of audio data. If that data exists, “mu-

sic_audit" records 15 seconds of the audio data, using "arecord" (an utility that is part of the ALSA utils package) and saves it to a temporary file;
- After this, "music_audit" uses two different audio fingerprint open-source tools (AccoustID and Echoprint) to create two candidate audio fingerprints from the audio samples that were previously captured and recorded, using "chromaprint" and "echoprint". These audio fingerprints are used to create a tentatively positive identification of the music being played, while performing a posterior comparison with a fingerprinting database in a matching process. The matching process takes place at the MusicBeetle.cloud;
- The following example describes how to how to use "echoprint" to create a audio fingerprint from an audio sample captured by the box: "./echoprint-codegen audio_sample_[01].mp3 0 15".
- After creating the two candidate audio fingerprints, "music_audit" saves them, together with a timestamp of the date and time of the audio sample capture. This data is saved on an temporary SQLite database ("sqlite");
- "music_audit" continues to actively monitor the existence of more audio data on the audio board of the Raspberry Pi, repeating the recording, audio fingerprinting and saving processes.

The "music_report" is the process that is responsible for the communication of the candidate music identifications detected by the MusicBeetle.box to the MusicBeetle.cloud system. This process is responsible for the following functions:

- "music_report" is a process that is run by the "crond" Linux daemon. "crond" runs "music_report" on a daily basis (every 24 hours), at a given time (the frequency and time can be configured on the MusicBeetle.box);
- "music_report" connects to the SQLite database and extracts all the available records that correspond to the last period of audited music that has not yet been send to the MusicBeetle.cloud;
- The process builds a JSON data structure (Figure 5) that contains the necessary data to be sent to the MusicBeetle.cloud. This structure contains information about the unique identifier of the MusicBeetle.box on the system (UUID), a timestamp of the data and time of the transfer (TIMESTAMP), the two values of the samples fingerprints (FP1 and FP2, each one created with a different audio fingerprinting algorithm) and the identifier of the audio sample (SID);
- After this, "music_report" establishes a secure connection, using SSL/TLS protocol, with the MusicBeetle.cloud service endpoint and posts the JSON data structure over the network. If no connection is available, MusicBeetle.box will retain the previous audit data and continues to store more data, until a connection becomes available and the transfer process concludes with success (after receiving a message from the MusicBeetle.cloud service confirming that the data reception was successful).

```
{
  "musicbeetlebox_uuid": "[UUID]",
  "transfer_timestamp":
"[TIMESTAMP]",
  "audits": [
    {
      "sample_id": "[SID]",
      "sample_timestamp":
"[TIMESTAMP]",
      "sample_fp": [
        "fp1": "[FP1]",
        "fp2": "[FP2]"
      ],
    },
    {
      "sample_id": "[SID]",
      "sample_timestamp":
"[TIMESTAMP]",
      "sample_fp": [
        "fp1": "[FP1]",
        "fp2": "[FP2]"
      ],
    }
  ]
}
```

Figure 5: Sample JSON data structure containing the data to be sent from the MusicBeetle.box to the MusicBeetle.cloud. [UUID], [TIMESTAMP], [SID], [FP1] and [FP2] are simply placeholders that are replaced by the actual values.

Both the "music_audit" and "music_report" are two important processes in the way the MusicBeetle.box operates and conducts its major functionality: audit the BMU music real usage and reporting that information back to the MRNRMS. All the matching, accounting and management is performed on

the MusicBeetle.cloud, that will be detailed in the following section.

3.2 MusicBeetle.cloud and Services

MusicBeetle.cloud is a key element in the MusicBeetle ecosystem. It represents the services that are run on a cloud service by the MRNRMS that will enable the management of the music portfolio (and artists) whose rights are represented and managed by the MRNRMS. These services have to assure the following:

- The MRNRMS should have a system with data that represents the music and artist portfolio whose rights they represent. This system should contain not only information about the music, but also about the artists;
- MusicBeetle.cloud should also have information about the BMU that are registered at the MRNRMS, and information about the MusicBeetle.boxes that are installed on their side;
- Also another important service that is required is the capability of being able to match the audio audits, sent from multiple MusicBeetle.boxes, and then perform the identification of the music tracks, and account for the number of times a given music track has been played by the BMU during a given period of time;
- The MusicBeetle.cloud service should also be capable of accounting the necessary amount to be distributed to a given artist, according to the music usage by the BMU ecosystem (that are legally licensed by the MRNRMS and possess a MusicBeetle.box) as well as to charge the specific rightful amount to the BMU according to the effective music usage.

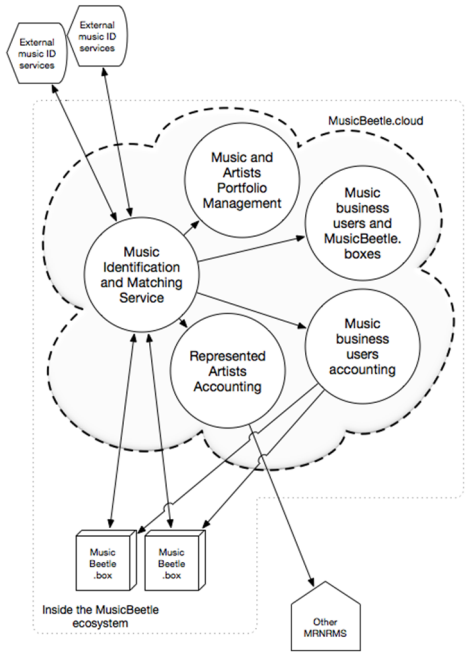

Figure 6: The schema represents the different services that are running on the MusicBeetle.cloud and how they interact with other systems (both internal to the MusicBeetle ecosystem or outside).

The different services present at the MusicBeetle.cloud (Figure 6) cooperate with each other and with external services to ensure that MusicBeetle can meet the requirements that were previously identified. One of the most crucial operations of these services is the capability to receive reports from the different installed MusicBeetle.boxes, and process such reports in terms of music identification, royalties accounting and fees to be charged to the BMU. This process is detailed on the next section.

3.2.1 Music Identification, Reporting and Royalties Management Process

One of the most vital operations that is executed at the MusicBeetle.cloud is the capability to receive the multiple reports from the MusicBeetle.boxes, and process them in terms of music identification, royalties distribution and fees charging.

In order for these services to operate properly, the following assumptions need to be fulfilled:

1. It is necessary to build a repository that contains the music meta-information (related to the music track) and audio fingerprints that are unique to each of the music tracks. Each music track must also be associated with an artist (or multiple artists and/or recording label, if it is the case);
2. A repository with the information about the artists that are represented (registered) by the MRNRMS is necessary, and a relation with their music tracks;
3. It is also necessary to have all the information about the BMU that are licensed by the MRNRMS and the list of MusicBeetle.boxes that are assigned to them.

After all of these pre-requisites are met, the process that is responsible for music identification, royalties distribution and fees charging is aligned with the following steps:

1. The process is initiated by the MusicBeetle.boxes while sending report data to the “Music Identification and Matching Service”;
    1.1. The “Music Identification and Matching

Service" receives the JSON data from the MusicBeetle.box;

1.2. The service verifies the field that contains "musicbeetlebox_uuid" and contacts the "Music business users and MusicBeetle.boxes service registry" to check if that specific MusicBeetle.box is registered and is valid within the MRNRMS context;

1.3. After validating the MusicBeetle.box, the service contacts the "Music Business users accounting service" to retrieve identification of the BMU that will be charged for the music usage.

2. After these initial steps, the "Music Identification and Matching Service" will try to identify the music tracks send on the JSON report.

2.1. The service looks into the "audits" field of the report and starts looking for existing music samples ("sample_id") identification;

2.2. For each of the samples, the "sample_id", "sample_timestamp" and "sample_fp" are retrieved;

2.3. Inside the "sample_fp" the values of both "fp1" and "fp2" are extracted;

2.4. "fp1" and "fp2" are used by the matching service to identify the music to which the samples refer to. The "Music and Artists Portfolio Management service" is used to perform this matching operation. If a match is found, the corresponding music meta-information can be retrieved and information about the music track and the corresponding artist can be used to establish the royalties distribution process;

2.5. If the sample fingerprints cannot be matched to any of the musics at the repository, it will be possible to pass that data to external matching and identification services to try a successful identification;

2.6. If it is not possible to identify a music sample, it is classified is a particular way, so that the MRNRMS can find a different way to distribute the royalties;

3. Finally, after the music track is identified, it is possible to direct the usage royalties to the appropriated artists and to charge the correct and fair fees to the BMU:

3.1. After the matching process concludes with success the service contacts the "Represented artists accounting service" to credit the artist for the corresponding value of its music usage;

3.2. The service also contacts the "Music business users accounting service" to debit the BMU on the usage of that specific music track.

This process is repeated for each of the MusicBeetle.boxes that report music auditing information to the services on the MusicBeetle.cloud.

4 CONCLUSIONS

The music industry has changed across time. The well-established music business models that lasted for decades were completely shacked by a new emerging reality boosted by technology. Information and Communication Technologies (ICT) (Rosenblatt, Mooney and Trippe, 2001) has altered the relation between recording companies, artists, music and end-users (both individuals and businesses) (Vaccaro and Cohn, 2004). At the same time ICT has also created new music business models and raised opportunities for key actors in the music value-chain to become more efficient in its mission fulfillment (Handke and Towse, 2007).

One of these actors is the Music Related/Neighbouring Rights Management Societies (MRNRMS), entities that are responsible for the collection and distribution of royalties on the behalf of the artist (or other entities that represent them) (Kretschmer, Klimis and Wallis, 1999). These MRNRMS license BMU, charging them a fee for using commercial music as part of their core business model and distribute these fees to the represented artists (Towse, 1999). The problem is that collection and distribution process is not fair, accurate or transparent. Therefore there was the necessity for a system that could charge BMU according to their actual music usage, and distribute royalties to artists whose music's have been played. The MusicBeetle system was developed to provide the necessary answer to these requirements.

The developed prototype was tested in the particular context of a Portuguese MRNRMS, where some of the properly licensed BMU were invited to participate in the system trials.

From the tests conducted it was possible to improve the way the license was charged to the MRNRMS customers, this more direct relation with the real music consumption, improved the way the royalties collection occurred (resulting from the direct music usage by the BMU) and also ensure more transparency on the way the royalties are distributed. Artists represented by the MRNRMS or by any of its associates received the royalties' value according to its real music usage.

MusicBeetle contributed to the rethinking of an old paradigm in Related Rights (RR) or Neighbouring Rights (NR) royalties' collection and distribution, enabling a fairer rights charging and collection and a transparent distribution of royalties. Besides this, the system also provided the necessary mechanisms to audit the charging and distribution of such royalties.

REFERENCES

Bustinza, O. F., Vendrell-Herrero, F., Parry, G., and Myrthianos, V. (2013). Music business models and piracy. Industrial Management and Data Systems, 113(1), 4–22.

Cano, P., Batlle, E., Kalker, T., and Haitsma, J. (2005). A review of audio fingerprinting. Journal of VLSI Signal Processing Systems for Signal, Image and Video Technology, 41(3), 271–284.

Castro, H., Alves, A. P., Serrão, C., and Caraway, B. (2010). A new paradigm for content producers. MultiMedia, IEEE, 17(2), 90-93.

Correa, C. (2007). Trade related aspects of intellectual property rights: a commentary on the TRIPS agreement. OUP Catalogue.

Frith, S., and Marshall, L. (2004). Music and copyright. Edinburgh University Press.

Handke, C., and Towse, R. (2007). Economics of copyright collecting societies. International Review of Intellectual Property and Competition Law, 38(8), 937-957.

Kretschmer, M., Klimis, G. M., and Wallis, R. (1999). The changing location of intellectual property rights in music: A study of music publishers, collecting societies and media conglomerates. Prometheus, 17(2), 163-186.

Richardson, M., and Wallace, S. (2012). Getting Started with Raspberry Pi. " O'Reilly Media, Inc."

Rosenblatt, W., Mooney, S., and Trippe, W. (2001). Digital rights management: business and technology. John Wiley and Sons, Inc.

Teece, D. J. (2010). Business models, business strategy and innovation. Long range planning, 43(2), 172-194.

Torres, V., Serrão, C., Dias, M. S., and Delgado, J. (2008). Open DRM and the Future of Media. MultiMedia, IEEE, 15(2), 28-36.

Towse, R. (1999). Copyright and economic incentives: an application to performers' rights in the music industry. Kyklos, 52(3), 369-390.

Upton, E., and Halfacree, G. (2012). Meet the Raspberry Pi. John Wiley and Sons.

Vaccaro, V. L., and Cohn, D. Y. (2004). The evolution of business models and marketing strategies in the music industry. International Journal on Media Management, 6(1-2), 46-58.

WIPO. (1961). WIPO-Administered Treaties: Rome Convention for the Protection of Performers, Producers of Phonograms and Broadcasting Organizations. Retrieved February 06, 2015, from http://www.wipo.int/treaties/en/text.jsp?file_id=289757.