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A Technology Transfer Activity Diagram: describing TTO's main processes

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Abstract: This article describes an UML model which provides a powerful view over Technology Transfer valorisation and commercialization process. Such diagram shows the interrelations among phases and internal actions in each phase of the technology transfer process, specifying that each phase is closely related to the next phase and should not be considered separately. The objective is to describe key procedures and processes in order to provide opportunity to build commercialize knowledge/technology from research to return on investment. The research's contributions focus on: (1) Clarifying procedures and activities that should be part of any operational plan to assure broad economic outcomes; (2) As the novelty of the model, presenting a fourth phase of procedures that usually are not noticed compromising administration and policy makers work; (3) Offering a strategy to conduct empirical studies on TTO's operational plan efficiency and effectiveness.

Keywords: Technology Transfer; Technology Management; Technology Valorization; Technology Transfer Office.

1 Introduction

As observed by The Association of University Technology Managers (AUTM), the central mission of a university Technology Transfer Office (TTO) is to manage and operate Technology Transfer (TT) activities. Some researchers consider TTOs' operational process as a single phase (Thursby and Kemp 2002; Chapple et al. 2005; and Anderson et al. 2007). In such studies, the input-to-output process of TTOs is seen as a "black box" with little consideration of the intervening steps with select inputs and outputs to different phases of technology transfer processes. Such an approach provides little insight regarding determining sources of inefficiency (Lewis and Sexton 2004) and also provides limited process-specific guidance to help improve the effectiveness of TTO operations. Additionally, if sub-phases of TT processes are identified and evaluated, the separate phases approach does not account for the continuity of links between adjacent phases (Tone and Tsutsui 2009).

Although through literature review a large set of factors which affects TTO performance was perceived, we feel there still are procedures and variables not contemplated. In an effort to evaluate Technology Transfer process inside TTOs, there was a pressing requirement to truly understand the process as a whole. In such endeavor, we ended up with a detailed diagram of TTO activities. The novelty of this diagram is to present a fourth phase of procedures that usually are not noticed compromising administration and policy makers work.

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2 Understanding the whole process

A clear organizational structure for TTO activities has not been provided in the literature. To approach this question, we must describe the key tasks and processes and relate these to one another and identify clear relationships and handoffs that will define Phases in the technology transfer process. We have used Unified Modeling Language (UML) to document the activities of a generic TTO (Figure 1). Clearly other activities can be present in any specific TTO, but the activities presented in Figure 01 are central to the purpose, function and outcomes associated with TTOs from the literature and the authors' experience.

Effective technology transfer involves many activities but these must be built together into an operational plan through which commercialization outcomes create broad economic impact [Siegel and Phan, 2005]. Figure 1 also depicts a generic TTO activity diagram (designed in UML – Unified Modeling Language) describing key procedures and processes to commercialize knowledge/technology from research to return on investment. This diagram shows the interrelations among phases and internal actions in each phase, specifying that each phase is closely related to the next phase and should not be considered separately.

To date, the literature has focused on the elucidation and evaluation of Phase 1-3 with little awareness or attention to Phase 4. We argue that all Phases are essential for TTO success.

We have grouped activities into four phases of activity:

1. Disclosure
2. Value Add
3. Licensing
4. Royalty Allocation and Compliance

The principal processes of technology transfer are:

1. Disclosure Process

    a. R&D Funding
    b. Researcher Engagement
    c. Assessment
    d. Further development through Sponsored research or grants
    e. Sponsored Research or Corporate Engagement functions

2. Value Add Phase

    a. Define IP asset and IP mode
    b. Determine tech transfer vehicle – partner
    c. IIA relationships – shared IP
    d. File for IP

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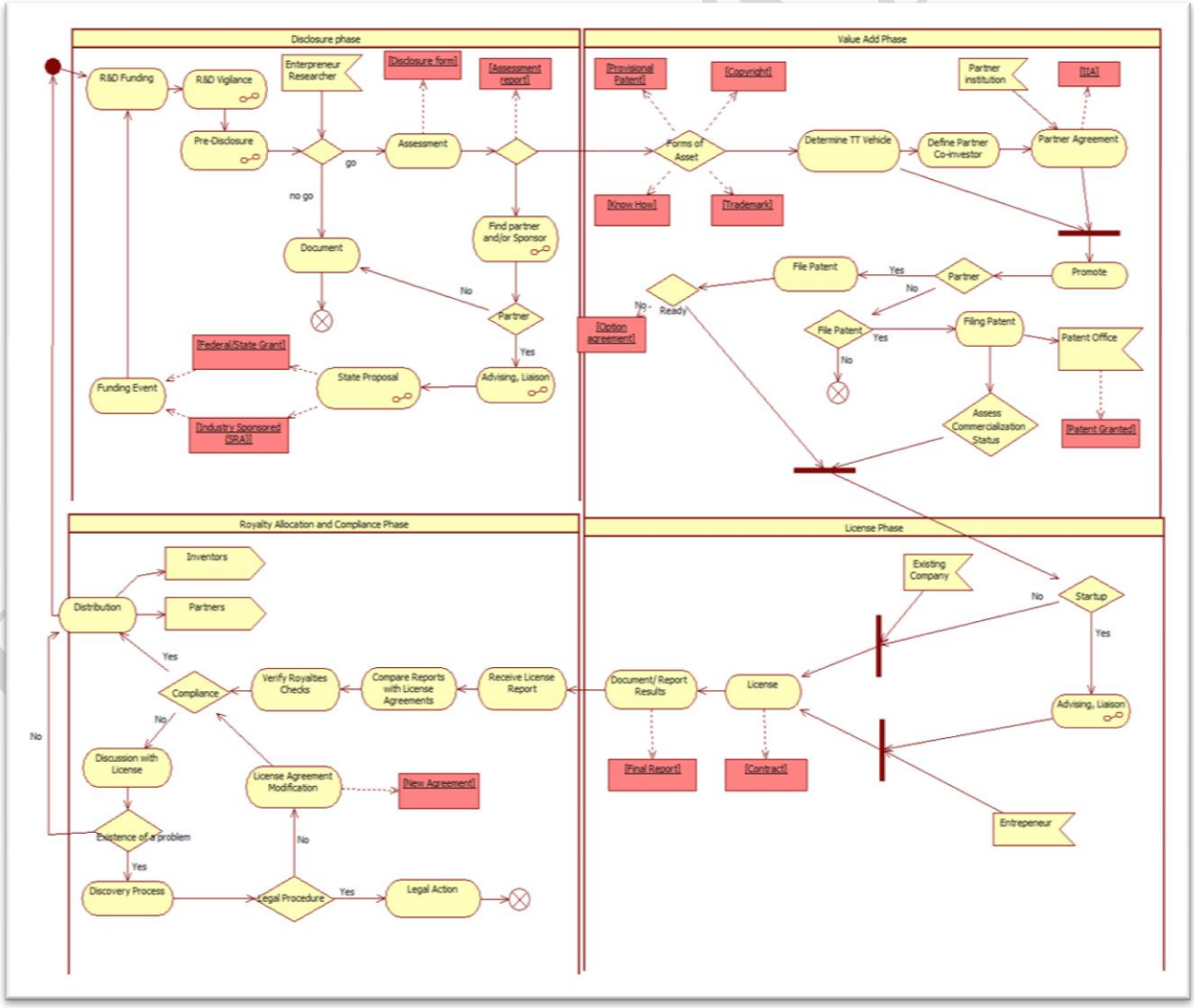
e. Assess commercialization status

3. License Phase

   a. Business Strategy Development
   b. Existing company license
   c. Startup
   d. Documentation

4. Royalty Allocation and Compliance

   a. License status and royalty reports
   b. Compliance Analysis
   c. Revise Agreements
   d. Litigation
   e. Royalty Distribution
   f. R&D funding



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1. Disclosure Phase:

The commercialization process begins with R&D funding. Funding is the fuel that drives innovation and continued research activities. The outcomes of funding are innovative data, technology and methodologies typically reported in the peer-reviewed literature and incorporated into subsequent future funding requests in response to government, corporate or private agency Requests for Proposals. The appearance of innovations and associated data in the public domain before creating an intellectual property asset puts the ownership and commercial potential of the innovation at risk. Therefore, the first action in the TTO process is R&D vigilance where the TTO engage researchers to understand the relationship between research projects and market problems. Vigilance is carried out through direct interaction with researchers through electronic, telephone or in-person visits. From these discussions, researchers are encouraged to provide a written or oral "Pre-Disclosure" whereby both the researcher and the TTO can make an informed decision whether the research data merits the efforts to develop a full written disclosure and assess its market potential or not. The development of a written invention disclosure is the next step in the process.

A key function for a written disclosure is to memorialize the innovation in structural manner for effective assessment and historical and legal record. The content of an invention disclosure differs widely between institutions, but in its barest form, it should detail the nature of the invention, the names of inventors, the source of funding supporting research resulting in the invention, barriers to obtaining intellectual property protection, known barriers in the scientific literature, and competitors in the marketplace [Thursby and Thursby, 2002]. Researchers need to clarify the funding source(s) that supported innovative research and provide an explicit declaration of inventorship. Both of these elements reveal obvious encumbrances to commercialization such as prior assigned ownership rights, joint ownership with other institutions, and necessity for cooperative agreement to secure rights to commercialize. Written disclosures, either in printed or online forms, also clarify the responsibilities shared between researchers and the TTO in the commercialization process [Friedman and Silberman, 2003] reducing confusion and uniting researcher and TTO in a "team" structure to jointly achieve commercialization goals.

Assessment of the invention disclosure is the next activity for the TTO, one connected with the key decision regarding timing of commercialization and next steps to be taken. Assessment, as originally defined in 1983 by Goldhor and Lund, involves a process to identify innovations that are: revolutionary, ripe, defensible, portable and possessing broad commercialization potential. Two active dialogues are required in the assessment phase: one with the inventor and the second with the market. The science supporting an innovation must be competitive, and field leading to support intellectual property asset development. Further, the fit of an innovation into existing or new commercial activities may start with discussion with the researchers, but must quickly involve primary and secondary dialogue with the marketplace to validate assumptions, test and develop a value proposition and fit within a defined value chain in a given market. The salability of the invention in the marketplace and the time required to realize a product integrating the invention [Jensen and Thursby, 2001]; [Siegel, Waldman and Link, 2003] are often the key factors of the assessment process that will drive a decision to: 1) move the innovation into the Value Add phase for further commercialization activities; 2) seek a partner, government or private sector source, to provide further research funding to perfect or further develop the innovation so that it is more ready for proximal market entrance; or 3) decline interest in the innovation as not having strong commercial merit and either return rights for commercialization to the research inventors or simply remove from the TTO docket. In each case, decisions must be

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memorialized with rationale and clear decision statements to allow relationships, rights and processes to be preserved in the research organization.

2. Value Add Phase:

This phase begins with the documented assessment of an innovation and the hypothesis that it offers value to the marketplace. To realize this value, one must convert intangible knowledge into a more defined and tangible asset. Innovative ideas, disclosed compositions or new methodologies are readily copied in a world where technology and knowledge are both commodities. Therefore, innovations must not be treated as "safe" to disclose outside the TTO or innovating institution until they are converted into defined and protectable assets through appropriate intellectual property (IP) mechanisms. The form of the IP must be determined by the TTO, be it a copyright, trademark, know-how/trade secret, or patent. The form depends on the laws and policies of the corresponding geographies where the tangible market opportunity is hypothesized to exist. The Disclosure Phase also allows issues of joint inventorship and relationships with other institutions to be unveiled. Joint invention and/or ownership will impact the technology transfer vehicle to be used. If an inventor has a prior relationship exists with another institutions, a partnering agreement must be developed to define the inter-institutional roles, responsibilities and sharing of commercial outcomes. Often this relationship is memorialized in an Inter-Institutional Agreement (IIA). With the clarification of inventorship, ownership and commercialization collaboration roles and outcome sharing, the TTO can know determine commercial strategy. This is usually done through passive promotion – conversations with close-in contacts in an industry to confirm the general outcomes of the assessment and affirm that commercialization interest is still present in the marketplace. The promotion will often result in a list of potential partners. Based on commercialization potential – as determined by direct market feedback and partner list, the TTO will determine if a patent should be filed. If a partner is likely to be identified, filing a provisional patent or a utility patent, if sufficient data supports, is logical. This could result in the completion of an Option Agreement rapidly through the identified partner. If a partner is not immediately available, the TTO can still determine to file a patent to support outreach and commercialization through the partner list. At each stage in the patent process, conversions, office actions, etc., the TTO must assess the commercialization status of the innovation and determine the cost-benefit associated with continued IP prosecution. Since the filing of a patent is the first investment in an innovation, TTOs must view their pursuit of and investment in IP like an investor and spend limited resources on those IP assets most likely to yield a good return on investment through efforts in the Licensing Phase.

3. Licensing Phase:

This Phase begins with the strategic assessment regarding the best vehicle for commercialization of an innovation. Three principal business strategies are used as technology transfer outlets:

a. Industry Sponsored Research
b. Licensing to Established Company in Appropriate Industry Sector
c. Licensing to a Start Up Company

Industry Sponsored Research was discussed in Phase One as a key tool to perfect and extend innovation technical capabilities and status. Often this mechanism carries with it a licensing option or other prior commercialization agreement. Licensing decisions require the TTO to determine the best placement of the innovation into a commercial entity – is licensing best

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pursued through an existing company or through an entrepreneur and a startup entity. This decision is complex and must be determined both strategically and pragmatically. An IP asset at an early stage of development and offering a platform of potential commercial applications may be best developed through a startup entity. Identifying a qualified and motivated entrepreneur is usually the limiting issue with regards to startup creation. The TTO provides critical liaison and advising activities connecting the entrepreneur and researchers to appropriate commercialization support. Development through a startup allows a new commercial strategy to be custom-created for the IP, without other constraints facing existing companies, which may help increase the IP's value. Other inventions provide value to existing products or to companies with a dominating market position. The existing enterprise provides existing product development, manufacturing and market channel capabilities to accelerate commercialization and return on the TTO's investment. The license or contract provides legal memorization of these decisions. Often a TTO will also describe the outcomes of a commercialization effort in a report to oversight groups or the researcher inventor.

4. Royalty Allocation and Compliance Phase:

The imperative of the first three Phases, determining and executing an appropriate business strategy, is to culminate in a business deal. The literature has focused on the first three Phases and largely ignored what occurs after the business deal (…). However, once a deal is completed, the work of the TTO has not ended. With a 3 to 7-year lag between licensure or startup creation and the initiation of royalty receipts [Friedman and Silberman 2003], the TTO must monitor all licensees to insure that technology/product development internally in the licensee enterprise does not eliminate the validity of the license agreement provisions and that emerging products provide a fair and reasonable return to the institution providing the innovation. This usually occurs through the receipt and review of quarterly or annual reports from the licensee detailing activities relevant to the licensed asset, product status, product sales and justification of royalty payments. When royalties are received, the TTO must ascribe these to the appropriate licensee and distribute revenue to the inventor and institution (as called for by the Bayh-Dole Act). This activity requires accurate accounting, soft skills to explain royalty-sharing proportions to researchers and/or inventors and insure that receipts support institutional goals and research. Partners in IIA arrangements must also receive their share of the royalties and distribute internally as appropriate.

Often, the "deal is never done".The circumstances and plans surrounding the original license agreement change over time necessitating changes in the license – typically renegotiation of timing for development or sales milestones, royalty tiers or percentages. Such changes are also necessitated when compliance to the license provisions becomes problematic or the licensee. The TTO faces a choice in this situation – to terminate the license and see a new commercializing entity or modify the license agreement to fit the new realities the company faces. Consistent and purposeful lack of compliance with an executed license by the licensee may require further analysis and a formal discovery process to determine the nature and extent of the lack of compliance. These data could be used in legal proceedings to either 1) drive the licensee to the table to renegotiate the license with more appropriate and mutually beneficial terms, or 2) to legal action to terminate the license or force the payment of royalties and penalties. The royalty allocation and compliance activities are essential to insure that licensees cooperate with license provisions and that all involved in commercialization of an invention reap the reward of the success.

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3 Conclusions

In order to identify and study sub-phase interconnected framework of university-based TTO's processes this research had to confront research challenges. Two underpinning challenges focus on looking inside "the black box" of a TTO by identifying and defining four sub-phases of operations and analysing university TT processes from a network perspective. This paper describes TTO's multi-phase process using an UML activity diagram and illustrates these processes in a generic technology commercialization diagram. After modelling the complicated multi-phase TT process, we foresee two other challenges: evaluating in time series, and focusing on efficiency and productivity change analysis. In order to calculate efficiency scores in cross section, it is important to highlight the overall efficiency as well as the sub-phase efficiency. Comparison of efficiency scores among the four sub-phase efficiencies offers insights into different phases of the TT process. The final challenge concerns how key activities of a TTO will influence TTO's efficiency in commercialization processes.

This paper main contribution is to present a model to study the efficiency of TTO's operational process from valorisation to commercialization. We observe TTO's operational process from a network perspective linked by interdependent phases allowing this study to present new insights about multi-dimensionality and feedback loops present in TTO's operation. It is hoped that this research approach will lead to more in-depth studies within TTO operations in measuring TTO efficiency. One future perspective of studies that we can foresee is to extend efficiency evaluation by taking into consideration not only the well-known three-phase model of operation and activities, but the four-phase model where final outputs are linked to initial input of Phase I. More specifically, in a more complete perspective, the license phase, or the final phase in this proposal, is not an end of the TTO's operations or impact, but is an antecedent phase for the TTO to monitor outcomes from Phase III to insure license compliance as well as distribution of proceeds from licenses to the TTO and perhaps academic entrepreneurs and researchers. Accordingly, the outputs of the license phase play a role of inputs in Phase IV when they result in funds to be distributed to the TTO and reinvested in the host institution. In this way, in terms of overall efficiency and effectiveness the TTO's operational process can be described as a circular model which considers feedback factors from Phase IV into Phase I and emphasizes the significance of these effects.

The perspective of a fourth phase includes the compliance process. Any business activity, as this technology commercialization activity diagram is based on, is engaged in for the primary purpose of making a profit. Even though after licensing there should be a contract creating obligations enforceable by law, it does not mean that all the commitments will be respected. So it is up to TTOs to monitor outcomes by comparing reports with license agreement insuring conformance, verifying possible problems as business activities are not static (the market changes so an agreement that has been pulled off in one year could become outmoded in the next one), working on license agreement modification, monitoring distribution and finally making ongoing efforts to further interests on research.

The present research's contributions focus on two areas: (1) Analysing and modelling TTO valorisation and commercialization process with a UML activity diagram to provide a clear picture of TT procedures and processes; (2) Offering a strategy to conduct empirical studies on TTO's operational efficiency thereby helping to better understand future research operational problems.

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