Device as a Service – an Economic Model[1]

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Abstract. This paper describes an economic model of Device-as-a-Service, which has sufficient complexity to illustrate the benefits of using REA (Resources, Events, Agents) and POA (Possession, Ownership, Availability) over traditional models of enterprise information systems that focus on information and material flows, and to compare their modeling expressiveness.

1 Introduction

The Device-as-a-Service (DaaS), also called PC-as-a-Service (Moody 2018) and Surface-as-a-Service (Mehdi 2016), is a procurement model combining device leasing and managed services into a single periodic payment to one provider. Companies pay a monthly fee to receive a fully configured and supported device (a laptop, desktop, tablet or smartphone) (Beckett 2018, Foley 2016, Moorhead 2018, Hewlett-Packard 2018, Keizer 2018). After an agreed period, usually after 3 years, the devices are replaced by new models, configuration and data are migrated to the new devices, data on old devices are wiped-out and the old devices are returned for refurbishment or ecological disposal.

This paper describes a variant of the Device-as-a-Service model that best illustrates the POA and REA modeling aspects. In practice there are several other variants of Device-as-a-Service, some of which are briefly mentioned in footnotes.

The Device-as-a-Service involves collaboration between the following economic agents[2]:

- The *DaaS Recipient* is a company that has decided that its employees will receive their devices, such as laptops and smartphones, as a service. That is, the DaaS Recipient neither owns the devices, nor is responsible for their maintenance, updates and disposal at the end of their lifecycle.
- The *User* is a person who uses the device. The Users are usually employees and subcontractors of the DaaS recipient; in principle, a User can be anyone who the DaaS Recipient selects as eligible for DaaS.
- The *OEM* (Original Equipment Manufacturer) such as Lenovo, Dell and Apple, is the manufacturer and provider of the devices.
- The *Lessor* is a financial institution providing leasing services for the devices. Lessor buys the devices at the shipping time and receives them at the end of the leasing period for refurbishing, resale or ecological disposal.

[1] This paper represents work in progress.

[2] In practice, the DaaS model typically also includes Asset Recovery Center, Carrier and other service providers that are not relevant for the purposes of this paper, but trivial to include to the model if needed.

- *DaaS Provider* is responsible for orchestrating the information flows and the flows of economic resources (devices, services and money) among all economic agents in the DaaS ecosystem (DaaS recipients, Users, OEMs, Lessors and potentially other involved service providers). For example, DaaS Provider is responsible for guiding Users in selection of new device model and for providing instructions about how to return an old device. The DaaS provider is also responsible for device asset management, which encompasses:
    - Precise and accurate information about which Devices, Services and Money have been and will be available to, owned and in possession of each economic agent in the DaaS ecosystem, at any given time in the past, at present and in the future.
    - Ability to provide complete history and traceability of all economic transactions related to Devices, Services and Money between all economic agents in the DaaS ecosystem.

A typical flow of events in the DaaS ecosystem is described below:

1. The DaaS provider informs the OEM about Refresh Schedule[3], an estimated need of the devices, usually several months before the order date, so the OEM can allocate production capacity in its factories.
2. The DaaS provider guides the eligible Users how to choose a new device, for example, whether a manager approval is needed for some models and how to obtain it.
3. The DaaS provider sends a purchase order for the device to the OEM.
4. The OEM ships new device to the User. At the shipping (dispatch) time the ownership of the device is transferred from the OEM to the Lessor.
5. The Lessor pays the OEM for the new device, usually after receiving an invoice from the OEM.
6. The User receives the new device and is given certain time (about two weeks) to transfer data from the current device to the new device. The DaaS provider is responsible for automatic or assisted setup and configuration of the device and for data synchronization.
7. The User sends the old device to the Lessor according to the shipping and packaging instructions received from the DaaS provider.

In parallel with the flow above, the following flows take place periodically:

1. The DaaS provider pays lease fees to the Lessor during leasing period of the device.
2. The DaaS provider receives periodic, usually monthly payments from the DaaS recipient, combining leasing costs and device management services.
3. Provisioning of DaaS encompasses information flows in both directions between the DaaS provider and DaaS recipient: The DaaS recipient receives periodic reports from the DaaS provider about service provisioning, catalog of available device models and their configurations,

[3] Often there are several refresh schedules with increased level of accuracy as the order time approaches.

fulfillment of service level agreement, and provides to the DaaS provider required information, such as a list of Users eligible for the service, and approved catalog of devices and configurations.

2 The POA Model of DaaS

Scheller and Hruby (2016) formulated the POA (Possession, Ownership and Availability) model to solve certain problems that emerged during designing software based on the REA ontology. The POA model refines the concepts of REA economic event and commitment, both representing change in *control* over economic resources, by more specific changes in *possession*, *ownership* and *availability* of economic resources.

- *Possession* is the ability to control (e.g. use or manipulate) an economic resource. For example, shipment and payment are flows (transfers) of possession.
- *Ownership* is the unconditional right to possess an economic resource (to exercise the maximum degree of formalized control over a resource). For example, purchase and sale are flows (transfers) of ownership.
- *Availability* is the conditional right to possess a resource. For example, sales order line is a flow (transfer) of availability of a resource. Contracts, agreements and partnerships represent flows (transfers) of availability of resources.

Fig. 1 briefly summarizes the POA notation used in the following figures.

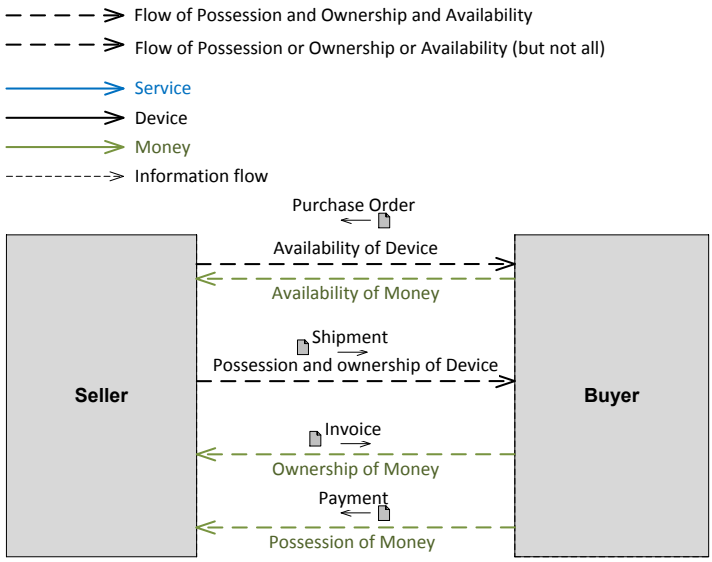

Fig. 1. The POA notation. Business documents are shown only for clarity.

Note that the economic flow sometimes has opposite direction than the corresponding business document, such as an invoice may transfer ownership of money from the buyer (invoice recipient) to the seller (invoice issuer), and some business documents, such as a purchase order, include several flows in different directions.

The POA model of DaaS is illustrated in Fig. 2.

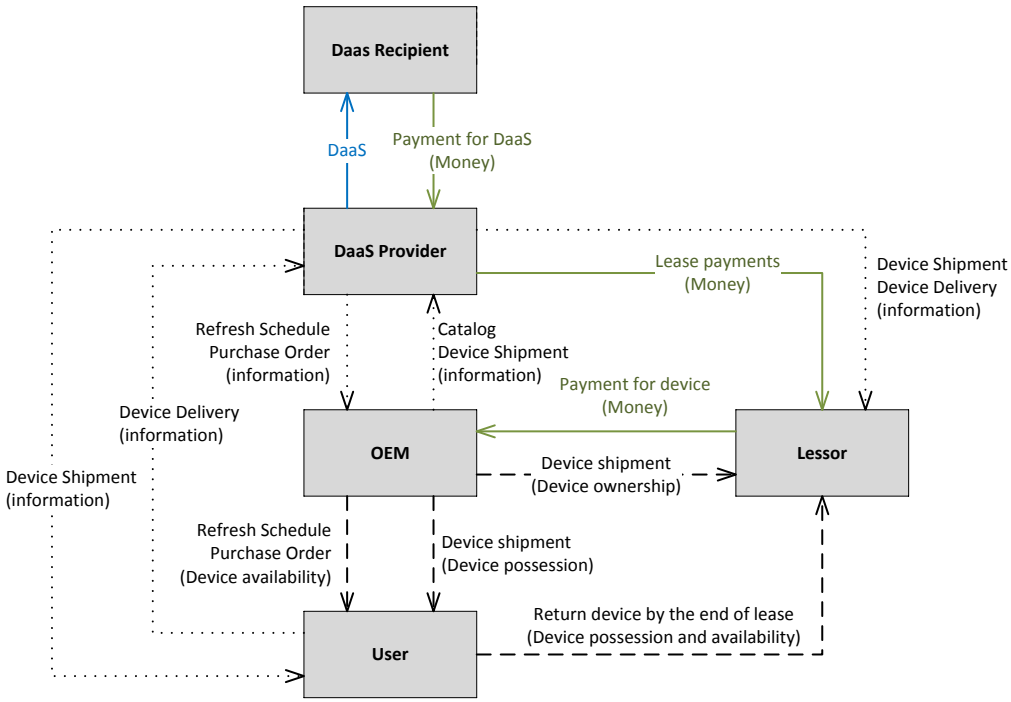

Fig. 2. The POA model of DaaS[4] with examples of information flows derived from the economic flows.

It is worth noting that the DaaS Provider has the responsibility to initiate transactions binding *others* and the responsibility of keeping everybody else informed about all transactions relevant to *them*. For example, the Purchase Order sent by DaaS Provider to the OEM is basically an information flow, not economic flow. The device ordered by the DaaS Provider will be sold to the Lessor and shipped to the User. The purchase order only commits the DaaS provider to pay leasing fees to the Lessor during the leasing period[5].

The information flows can be mechanically (by an algorithm) derived from the economic model. For example, a *single* Device shipment (possession) economic flow triggers the following *five* information flows, indicated by dotted lines in Fig. 2:

- The OEM notifies the DaaS provider about device dispatch and provides configuration data of the shipped device.
- The DaaS Provider notifies the User about device dispatch and provides instructions how to setup a new device and how to return the old one.
- The DaaS Provider notifies the Lessor about device dispatch, as the Lessor acquires device ownership at this moment.
- The User or Carrier[6] confirms device delivery to the DaaS Provider.

[4] A possible alternative to this model is to replace DaaS flow as a flow of device availability.

[5] In certain DaaS variants, this commitment can be transferred to the DaaS Recipient, thus the purchase order becomes purely information flow from the DaaS Provider point of view.

[6] In some DaaS variants.

- The DaaS Provider confirms delivery to the Lessor, so the Lessor may now invoice the DaaS Provider and the leasing period starts.

The fact that a single economic flow contains information about many required information flows, illustrates great advantage of the economic model, as it provides both simplicity and consistency of an otherwise complex information model.

3 The REA Model of DaaS

The REA (Resources, Events, Agents) was originally developed by McCarthy (1982) as a generalized accounting model. Since approximately 1995, it has been evolved by McCarthy and Guido Geerts into an ontology for economic systems (Geerts and McCarthy 2000, 2002). One of the main features of the REA ontology is the concept of duality, which is a relationship binding incremental and decremental economic events together, thus forming a value-adding process. The REA model in the independent view allow for modeling networks of independent business entities, such as DaaS ecosystem.

A possible REA model of DaaS is illustrated in Fig. 3. The overall layout, placement of the agents and color of the resources are the same as in Fig. 2. for easier comparison.

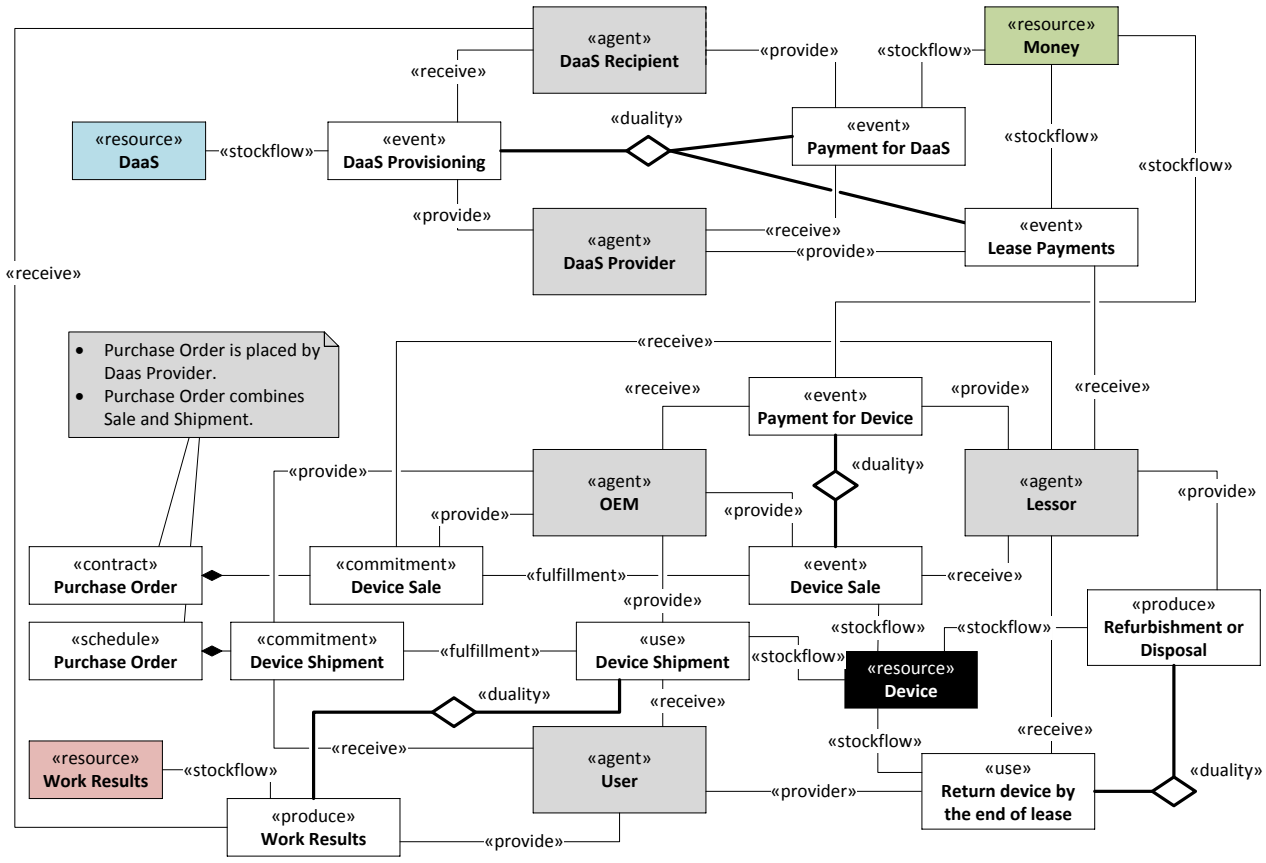

Fig. 3. The REA model of DaaS

The greatest challenge in creating the REA model is modeling the fourth item in the flow of events on page 2: "*The OEM ships a new device to the User. At the shipping (dispatch) time the ownership of the device is transferred from the OEM to the Lessor*." While transfer of ownership can be modeled using the "Device Sale" economic event in Fig. 3, REA does not have any unambiguous way to specify that the device *does not ship* to the Lessor.

REA also does not have any unambiguous way to model transfer of possession, without transfer of ownership, from the OEM to the User. We decided in Fig. 3 to model the flow of possession using the "use" economic event, however, this approach has at least two issues: (i) semantics of the REA "use", as opposite to "consume" means that the resource still exists[7] after the "use" economic event, but this definition does not imply possession; (ii) in POA, the difference between possession and ownership creates a claim. That is, the Lessor, as an owner of the device, may claim the device from the User, and it, indeed, does, by the end of the leasing period. However, the REA "use" event does not create claim, so this model does not describe why the user *must* return the device to the Lessor[8].

An advantage of the REA model is that the concept of duality between REA economic events guides the business analyst to answer questions such as why (for what benefits) the User uses a device; the answer requires introducing an increment event «produce» Work Results, and what benefits Lessor receives, when User returns the device at the end of the leasing period, which requires introducing an increment event «produce» Refurbishment. These events can also be included in the POA model, however, the consistency rules in the POA model do not require them.

4 The POA and REA Models Compared

While simplicity is clearly an advantage of the POA model, requiring 5 elements and 8 relationships[9] to depict the same information as 22 elements and 35 relationships required by the REA model, there is a difference between semantic expressiveness, summarized in the following table:

POA concept without matching REA concept	REA concept not required in the POA model
Device shipment (ownership)	
Device shipment (possession)	
Refresh schedule (availability)	
Refresh schedule (information)	
Purchase order (information)	
	Work results (resource)
	Work results (produce event)
	Refurbishment (produce event)

Table 1: Comparison of POA and REA models for DaaS

[7] We use the semantics of use and consume as in Hruby, Kiehn, Scheller (2006), and as it is in plain English (i.e. "what is consumed is eaten"), in contrast some older REA literature where the semantic of use and consume is swapped.

[8] In some DaaS variants the user or DaaS recipient are offered to purchase the device for its residual value, which also settles the claim.

[9] Not counting the information flows, because they can be derived from the economic flows.

5 Conclusions and Final Thoughts

From the perspective of the design of the enterprise information systems, the fact the 8 economic flows represent information about approximately 40 information flows, illustrates great advantage of the economic model over traditional information modeling. The economic model is more succinct, simpler and the derived information model is guaranteed complete.

The economic model can be represented in various ways, the REA, POA and probably also e3-value, Gordijn (2001 and 2003) and VDML (2015). In this short paper we modeled DaaS in REA and POA only.

We have not found a fully satisfactory way[10] how to model in the REA ontology, without ambiguity, a flow of possession without flow of ownership, and flow of ownership without flow of possession. As the result, we are not certain whether the presented REA model is the right model of DaaS, and whether DaaS can be modeled in REA at all. On the other hand, the REA concept of duality guides the business analyst towards discovering more facts about the business system, and in including to the model economic events and resources that the POA model does not require.

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[10] The authors wish a discussion and feedback on this topic from fellow workshop participants.

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