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Transactive Energy Concept Model Overview

A SEPA Transactive Energy Working Group Work Product

GridWise® Architecture Council Meeting

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Topics

- What is a concept model?
- Purpose of TECM
- The knowledge graph
- Concept definitions
- Using the TECM – Case studies
- Next steps

What is a concept model?

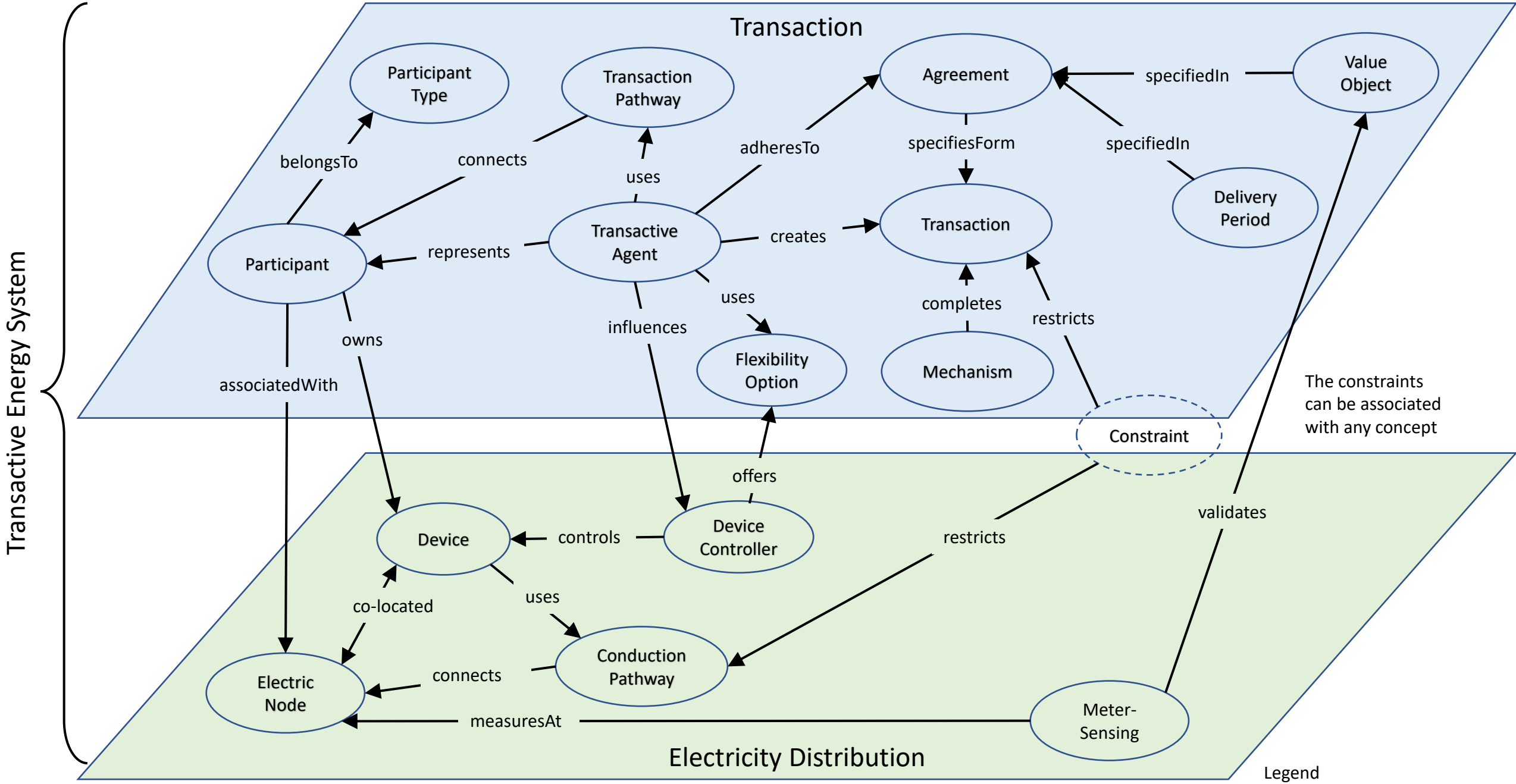
TECM: a representation (or abstraction) of concepts relevant for conveying a transactive design that is consistent with the distributed decision-making principles and basic functionality of TESs*.

- TECM is composed of terms, definitions, and loose relationships between the terms
- Concepts cover elements common to describing TESs
- Model does not stipulate how to design a system – it is non-prescriptive, not an architecture
- Model covers high-level concepts knowing that TES designers use various design methodologies
  - E.g., UML, entity-relation, E^3-Value, RDF/OWL

* TESs: transactive energy systems

Purpose of the TECM

- Explain different TES designs using a common set of terms
- Allow effective communication about specific TES designs and how each works
- Provide common terms and conceptual structure for future TES designers
- Provide common language to compare different types of TES designs.
- Future: insights from common aspects of TES designs may identify areas for standards, methods, and tools



TECM knowledge graph

Concept Definitions

Name	Layer	Definition
agreement	transaction	An agreement documents the contract between participants that is framed by a transaction. It covers performance expectations and reconciliation for non-performance for final settlement between participants. Transactive agents are subject to the agreement.
conduction pathway	electricity distribution	A conduction pathway is an edge of an electricity distribution graph that connects certain electric nodes.
constraint	electricity distribution transaction	A constraint places a restriction (e.g., physical or financial constraint) on the functioning of any concept.
device	electricity distribution	A device consumes or generates electricity and is co-located with at an electric node to fulfill the transactions that are entered into by its participant. Devices comprise the electromechanical aspects and can be unitary function devices or complex systems of equipment (as in a commercial building or factory). Devices use conduction pathways to exchange electricity.
delivery period	transaction	A delivery period is the time interval over which a transaction's value objects are exchanged as specified in an agreement.
device controller	electricity distribution	A device controller represents the operations management aspects of a device. A device controller controls the device, and it represents state and characteristics of the device that define its operational flexibility as an offer of a flexibility option for coordination with the transaction system.
electric node	electricity distribution	An electric node is a vertex of the electricity distribution graph that consumes or generates the aggregate electricity of its co-located devices. Electricity may flow between electric nodes via conduction pathways.
flexibility option	transaction	A flexibility option is a set of device controller operation capabilities that can be called upon by a transactive agent for a specific transaction. It represents a device's ability to exchange different levels of value objects under specific conditions for a specified delivery period for a specific transaction.
mechanism	transaction	A mechanism defines the cycle of interactions between transactive agents that results in completed transactions of value object exchange quantities for each delivery period in an agreement. Examples include bilateral exchanges, auctions, and iterative consensus mechanisms.
meter-sensing	electricity distribution	A meter-sensing system measures the electrical characteristics at an electric node that are used to validate the delivery performance of a value object from a transaction.
participant	transaction	A participant connects to other participants using transaction pathways. A participant uses a transactive agent as its surrogate to interact in the transactive system by creating transactions on its behalf with other participants and their transactive agents. A participant is associated with an electric node and may own none, one, or more devices.
participant type	transaction	A transaction involves at least two different participant types. A participant may act as a different participant type in different transactions. Participant type is necessary to describe how transactions work. Examples of participant types could include (but are not limited to) buyer, seller, aggregator, auctioneer.
transaction	transaction	A transaction records the exchange of value objects between two participants. A transaction is constrained to an allowed transaction pathway between participants in the transaction graph. An agreement specifies form of each transaction that pairs quantities of a value object that are to be exchanged for a delivery period.
transaction pathway	transaction	A transaction pathway is an edge of a transaction graph and exists between certain participant pairs. It is used for transactive agents to communicate.
transactive agent	transaction	A transactive agent represents the participant in transactive interactions. It may be the cyber surrogate of a participant or the participant itself. A transactive agent interacts with other transactive agents using transaction pathways to create transactions on behalf of its participant. A transactive agent has a high degree of autonomy while it adheres to the terms of an agreement. Based on the completion of a transaction, it influences a device controller to control the associated device in line with expectations of the agreement. A transactive agent respects the participant's preferred strategies concerning supply and allocation of electricity and may have options for participant override during operation. To do this it uses a flexibility option offered by the device controller.
transactive energy system	electricity distribution transaction	A transactive energy system defines the extent of the transactive design. It defines the scope and boundaries of the transaction and conduction pathways and electric nodes within which the system operates. It allows for description of external interfaces to the system.
value object	transaction	A value object is the thing specified in an agreement that is exchanged between participants and recorded in transactions. Examples include a quantity of energy for a delivery period or a reservation for energy to be held for a delivery period and called upon as needed. In a transactive system these are usually exchanged for a monetary remuneration value object. The performance of delivery of the value object defined in a transaction is validated using meter-sensing.

Case Studies

- Evaluate the effectiveness of the TECM terms to describe different TES designs
- Format
  - Overview
  - Participant types
  - Pathways: transaction and conduction
  - Transactive agent interfaces
  - TE mechanism
  - Flow constraints

Case study terms comparison

TeMIX	LO3	PowerMatcher	DSO+T	TECM Concept
black: exactly like, red: close to, orange: narrower than, green: broader than, blue: related to				
transaction state	market mechanism, smart contract		agreement	agreement
transport value	element, external resources	transport constraint, line agent, cluster	distribution circuit	conduction pathway
forward transport service, spot transport service	constraint	constraint, transport constraint, ramping constraint, line agent	flow constraint	constraint
delivery period, delivery state	settlement interval		delivery period	delivery period
end-device asset	device	local device (participant)	device, responsive device	device
transaction platform provider	Part of device and initiated by logic in smart meter.		device agent, device model	device controller
pricing node, aggregated pricing node, service location, service delivery point	node	root node, leaf node, cluster	electric node, customer site electric node, distribution system electric node	electric node
tender	smart contract	bid	range of operation	flexibility option
matching engine	market mechanism	PowerMatcher, auctioneer	double-auction mechanism, day-ahead market, real-time market	mechanism
meter asset	smart meter		meter	meter-sensing
energy service party, transport service party, intermediary	participant	local device, auctioneer, concentrator, objective, line agent	participant	participant
energy service party, transport service party, intermediary	participant type, prosumer, consumer, intermediary	local device, auctioneer, concentrator, objective, line agent	customer participant, DSO participant, retail market participant	participant type
transaction, transaction state	transaction	Commodity transaction (financial), price, bid	transaction, bid, price-quantity curve	transaction
service area	Exergy network	cluster	distribution circuit	transaction pathway
transaction platform provider	smart contract	auctioneer, node, line agent	transactive agent, customer device agent, retail market agent, DSO agent	transactive agent
	Brooklyn Microgrid		transactive system, retail marketplace	transactive energy system
forward energy service, spot energy service, forward transport service, spot transport service	commodity, energy service	energy, transport, losses	energy, bill	value object

Case study insights

- All cases can be described using TECM terminology
  - Terms are different but good similarity
  - Coverage reasonable but potential for expansion of model, e.g.,
    - Multiple market products being transacted (e.g., day-ahead and real-time energy)
- Participants and transactive agents: clarified how design is structured
- Pathways
  - Clarified design decisions like star, meshed, and nested networks
  - Separates the transaction pathways from the electric conduction assumptions
- Mechanisms: clarifies price formation
- Flow constraints: clarified if design handles them, e.g.,
  - Brooklyn microgrid did not address them
  - TeMix used a separate delivery check to prohibit transactions impacting constraints

Next Steps

TECM task force workplan

A. Debrief meeting held this morning
    1. Resolved final review comments on TECM SEPA whitepaper
    2. Review task force experience
    3. Identify future actions
        a. Adoption within SEPA task force work products
        b. Collaboration with others (such as GWAC)
        c. Explore formal information modeling and standardization
B. SEPA to distribute final document