Grid-Interop

Structured Energy: A Topology of Microgrids

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- Leaders in collaborative energy
- Cox
  - Consulting Software Architect
  - Definition and structure for interoperation
  - Venture and startup guidance and technologies
- Considine
  - Informational standards for building design, operation, energy use
  - Strategic Technology Consulting in emerging markets and Venture Formation

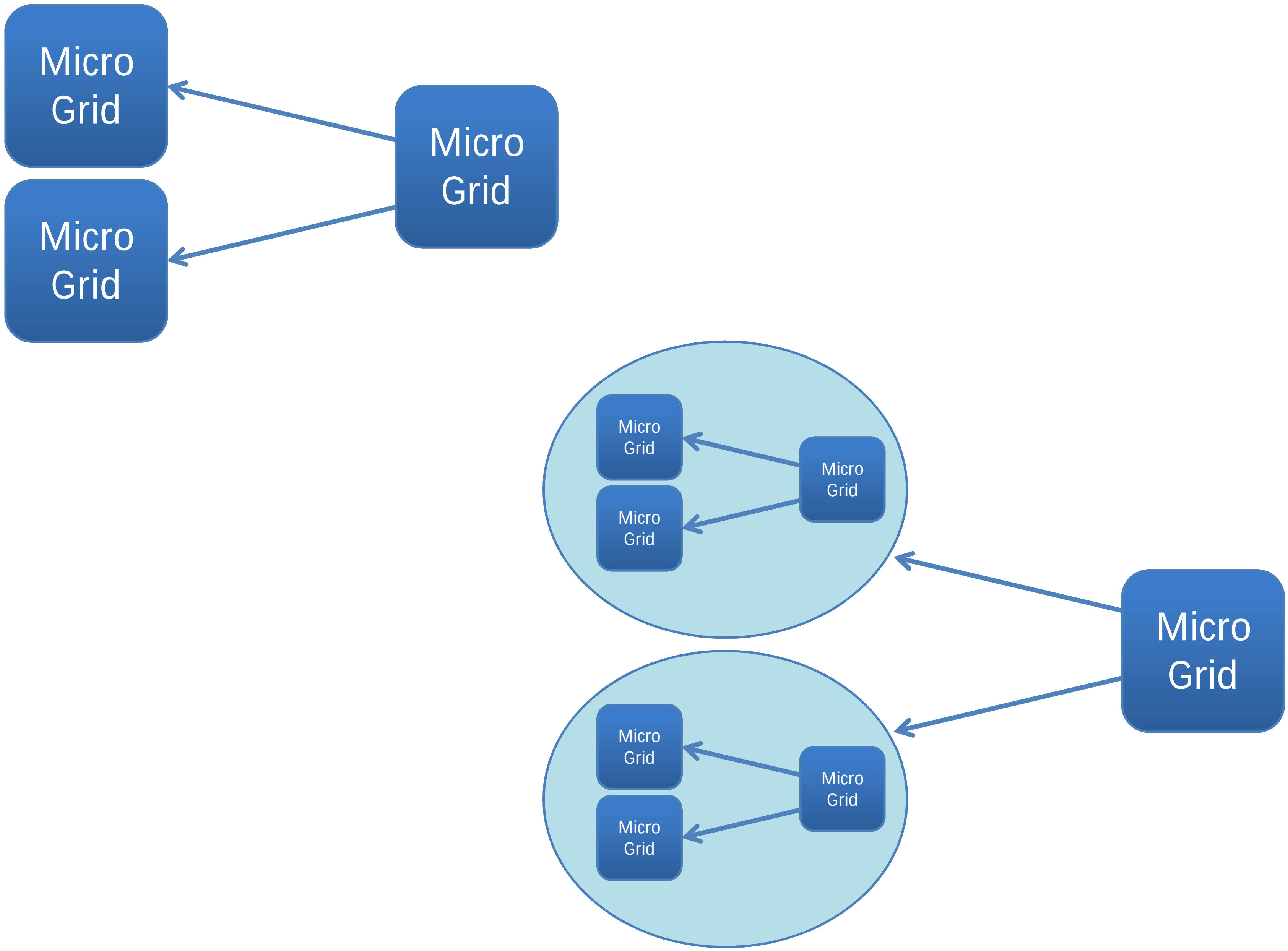
Introduction

- How do we assemble larger microgrids from smaller?
- What is well-behaved microgrid for energy?
- How do we collaborate across microgrids?
- Why would we assemble microgrids from devices and microgrids?
- We describe formal terminology for union and intersection and how to expand or narrow collaboration accordingly

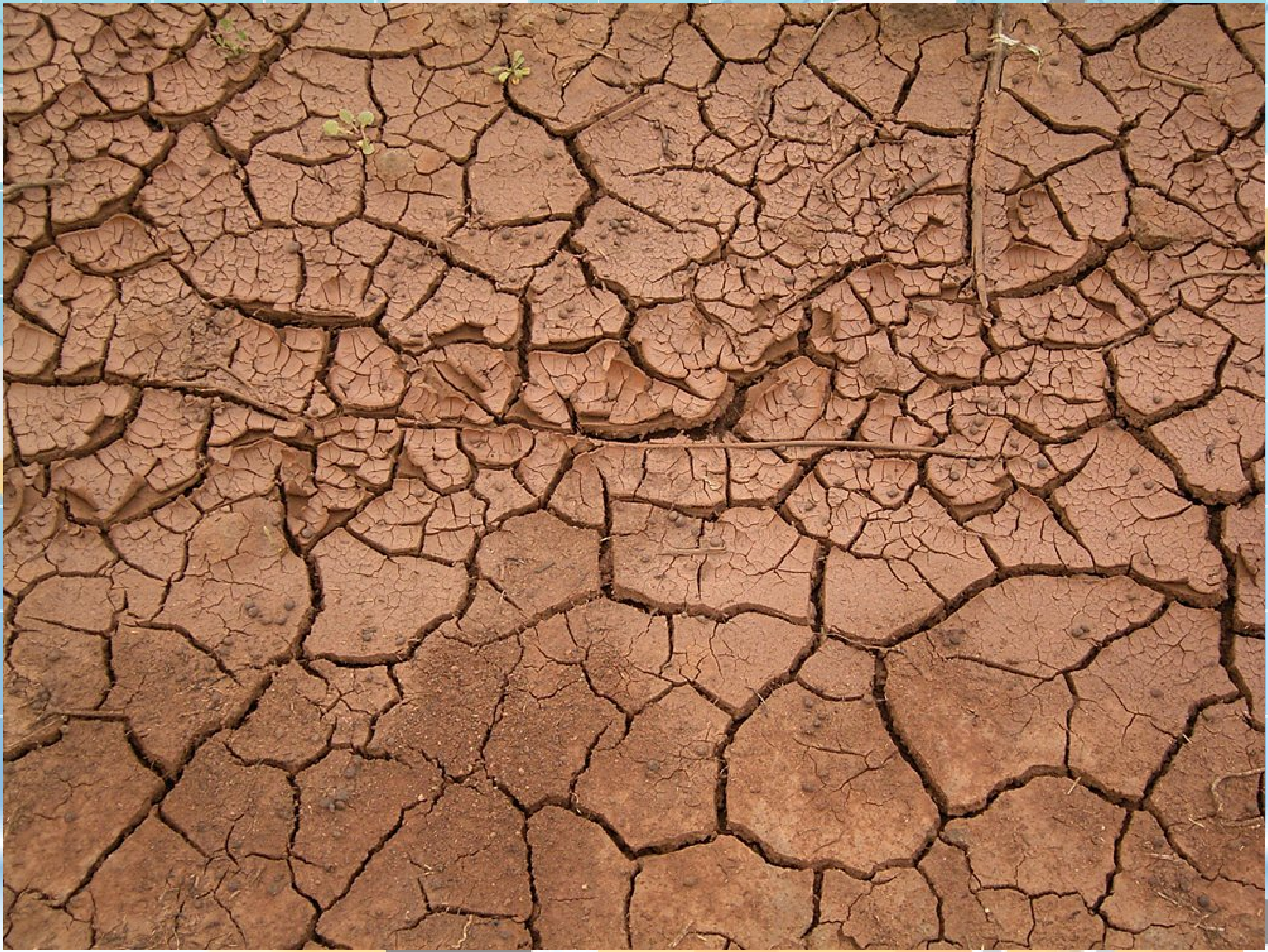
Managed and Collaborative Energy

- Managed Energy
  - Managed to different goals
  - Scale and control are issues
- Collaborative Energy
  - Choices consistent with business goals
  - Consider markets and requirements
  - *Ask* versus *tell*
- Balancing Energy Supply & Demand
- See Cox and Considine, “Smart Loads and Smart Grids—Creating the Smart Grid Business Case,” Grid-Interop 2009

An Illustration



An Illustration (2)



Microgrids

- Microgrids [Galvin]
  - “[Microgrids] achieve specific local goals, such as reliability, carbon emission reduction, diversification of energy sources, and cost reduction, established by the community being served.”
  - “[S]mart microgrids generate, distribute, and regulate the flow of electricity to consumers, but do so locally.”
- Microgrids can be considered to be self-managed

Structured Energy: Relationships

- A microgrid is a group of devices with self-management, and optionally
  - Storage,
  - Generation, and
  - Consumption of energy
- A microgrid is an aggregation of one or more microgrids which provides energy switching, transportation, and management across its constituent microgrids
- This creates a hierarchical structure where the edges are from a microgrid to its constituent microgrids

Self-management Is Key

- Consider a Microgrid as an abstract object with information and operations, some private
  - Provide an interface to the outside
  - Private operations to the inside
- Struggle over knowledge and control

Information within a Microgrid

- Information within a microgrid comes from
  - Other components
  - Aggregated or summarized by contained microgrid management systems (MGMS)
  - Markets (specific to the microgrid or external) for information sharing and coordination
  - In Structured Energy microgrids are the fundamental building block

A Topology of Microgrids (1)

- Clarify the definition of a microgrid:
    - Inside-the-node generation, storage, and consumption are each optional (but must have one)
- “Local” is a flexible term
    – The critical question is “is the node self-managed”
- “Micro” is a flexible term
    – Some use the term “nanogrids” for small microgrids [in this conference]
    – Commonality of interest and location is more important than mere size
    – How big is no longer “micro”?
        - These definitions work for “the big grid” as well

Why an Algebra?

- An algebra is a structure
- Take M to be the set of microgrids in a region
- Define a binary operation, union, that results in a microgrid
  - A union of two microgrids is itself a microgrid
  - The operation is associative
- This meets the definition of an associative magma, or semigroup
- But we must have self-management of the union, that is, The union of two microgrids permits self-management
- Coordination again

A Topology of Microgrids (2)

- To move to a formal [open set] topology, we need to define intersection that maps to the set
  - Is the intersection of two microgrids a microgrid?
- A microgrid may participate in more than one higher level microgrid
  - Structure can be described geographically, as we already define DR events to affect a county or region
  - Intersection can allow us to disaggregate microgrids
- Subset of a microgrid can be managed within, and coordinated with other components
- Coordination again

What Do We Gain?

- A combination of microgrids is itself a microgrid
- Joining my office park's microgrid M1 with that of a nearby industrial park M2 creates a new microgrid M3
- Self-management of M3 needs to take place
  - Coordination of behavior, inputs, and outputs supports self-management
- How do we coordinate?

What Makes a Microgrid Effective?

- A combination of two or more of energy
  - Storage
  - Generation
  - Consumption
- Goal is to permit
  - Reduction of net energy consumption
  - Reduction of cross-constituent microgrid communication & energy flow
- We'll focus on cross-microgrid energy and coordination and ignore size

Well-behaved Grids...

- Provide better behavior to the Microgrids in which they participate
- Energy flows can be net, not separate
  - Regulation often distorts the electrical reality typically in the name of incentives
- Markets can be local to the microgrid for local interactions
- Combine microgrids by spanning markets and response
- Markets must be external to the microgrid for import/export interactions

Structured Energy: Collaboration (1)

- Collaborative energy interfaces and information exchanges with minimal information of the other side
- Transactive interactions to define local markets
- Use the terminology of markets and business
- Avoid the “knowledge problem” of more centralized management

Structured Energy: Collaboration (2)

- The simplest way to collaborate might be for one microgrid to control another (managed energy)
- But "simpler" actually means "more complex"
  - Does one controller understand the business needs of the constituent parts of the other microgrid?
  - The scope and number of devices or microgrids controlled can be very large
- Lessons from multi-tier applications in eCommerce
  - Use hierarchical structures to reduce complexity and performance bottlenecks
  - A simple structure can more easily be used effectively and realigned to changing business needs

OASIS Collaborative Energy Standards

- These standards are in or approaching final status:
  - WS-Calendarallows synchronization and common communication of schedules in a high level business manner
  - Energy Market Information Exchange [EMIX] defines cross-cutting price and product definition communication for the Smart Grid
  - Energy Interoperation defines DR, DER, and usage/demand projection and measurements and price+product distribution
- All three are defined to, from, within, and outside of microgrids
- All drafts publicly visible

Structured Energy: Collaboration (3)

- Collaborative energy is the way to succeed
- View the constituents as independent entities who have agreed to collaborate
- Use open standards to connect and define markets and information exchanges
- Use Service-Oriented Architecture (SOA) to request service
- Compose security and reliability as indicated by business needs (See Security Section 5 in Energy Interoperation CSD)

What About Smart Microgrids?

- Smart Loads improve business value
  - Cox and Considine, Grid-Interop 2009
- Aggregation of fluctuating and partially balanced supply and demand has value
- Cross-microgrid interactions can be minimized
- Higher level microgrids coordinate more smooth demand and generation shapes
- Energy consumed and produced at a lower level / smaller microgrids, extra passed up the tree

Conclusions

- We have described
  - a topology of microgrids
  - Tools for assembling collaborative microgrids
  - Benefits of smoother and better managed loads
  - Reduction in complexity of managed and collaborative approaches
  - Simplified collaboration and management
- In the context of structured energy