

# Microgrids: the Essential Architecture for Smart Energy

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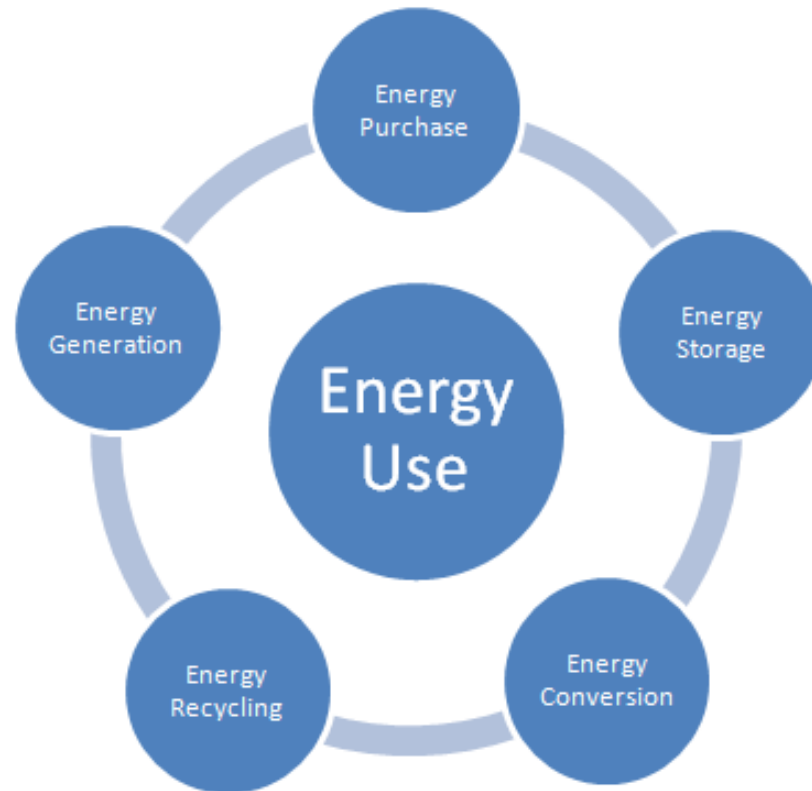
Grid-Interop 2012

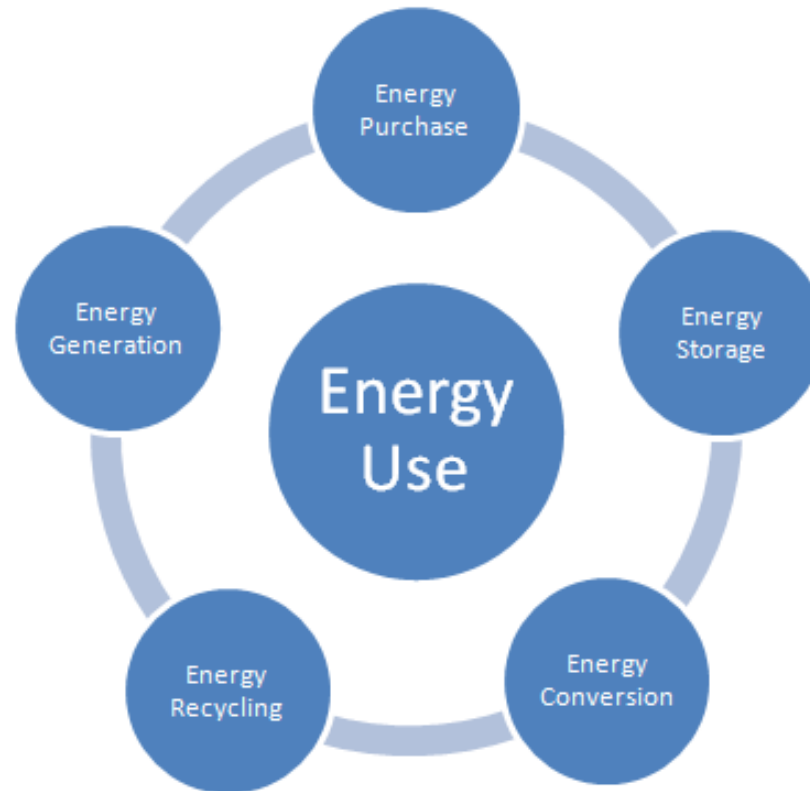
# We want rapid innovation and distributed energy

- Central control requires simplification and homogeneity
- Volatility of Supply
- Rapid change of Technology
- Unable to determine changing best application of changing supply to changing demand.

Break up the span of control, isolate diversity, empower consumers:

# Microgrids





# WHAT ARE THE CHARACTERISTICS OF MICROGRIDS

# What Are Microgrids?

- Each microgrid may always or sometimes be disconnected from other grids.
- Microgrids are self-managing
- Different microgrids have different purposes
- A microgrid *MAY* be a component in a larger microgrid
- A microgrid may be composed of smaller microgrids

# Microgrids are already all around.

- Industrial Microgrids
  - Includes District Energy
- Isolated Microgrids
- Development Microgrids
- Military Microgrids
- Motivational Microgrids
- Hidden Microgrids
  - Post-Sandy Experience

## The central issue for each microgrid is optimum allocation of energy

- Distributed Energy is local energy
- Priorities and purposes for each source and use of energy are ever changing
- Each microgrid presents a classic knowledge problem
- Markets are tested means to operate control systems
- OASIS Energy Operation defines market interface for any agent or system.



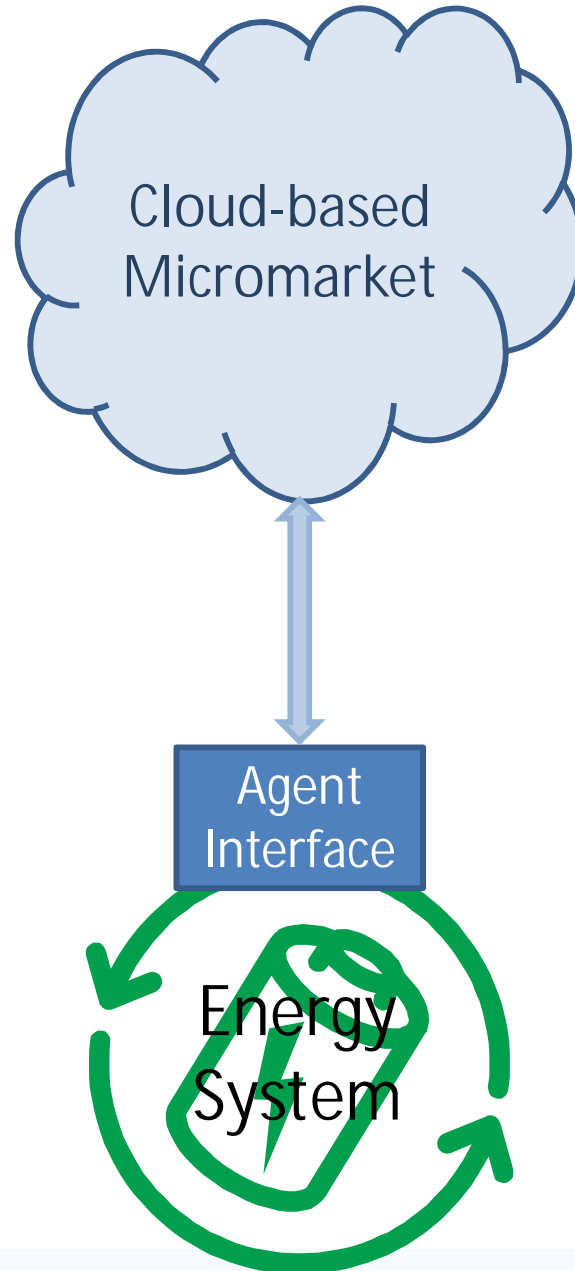
*Driving to Grid 2020*

OASIS Energy Interoperation provides semantics and interaction patterns for energy market operation

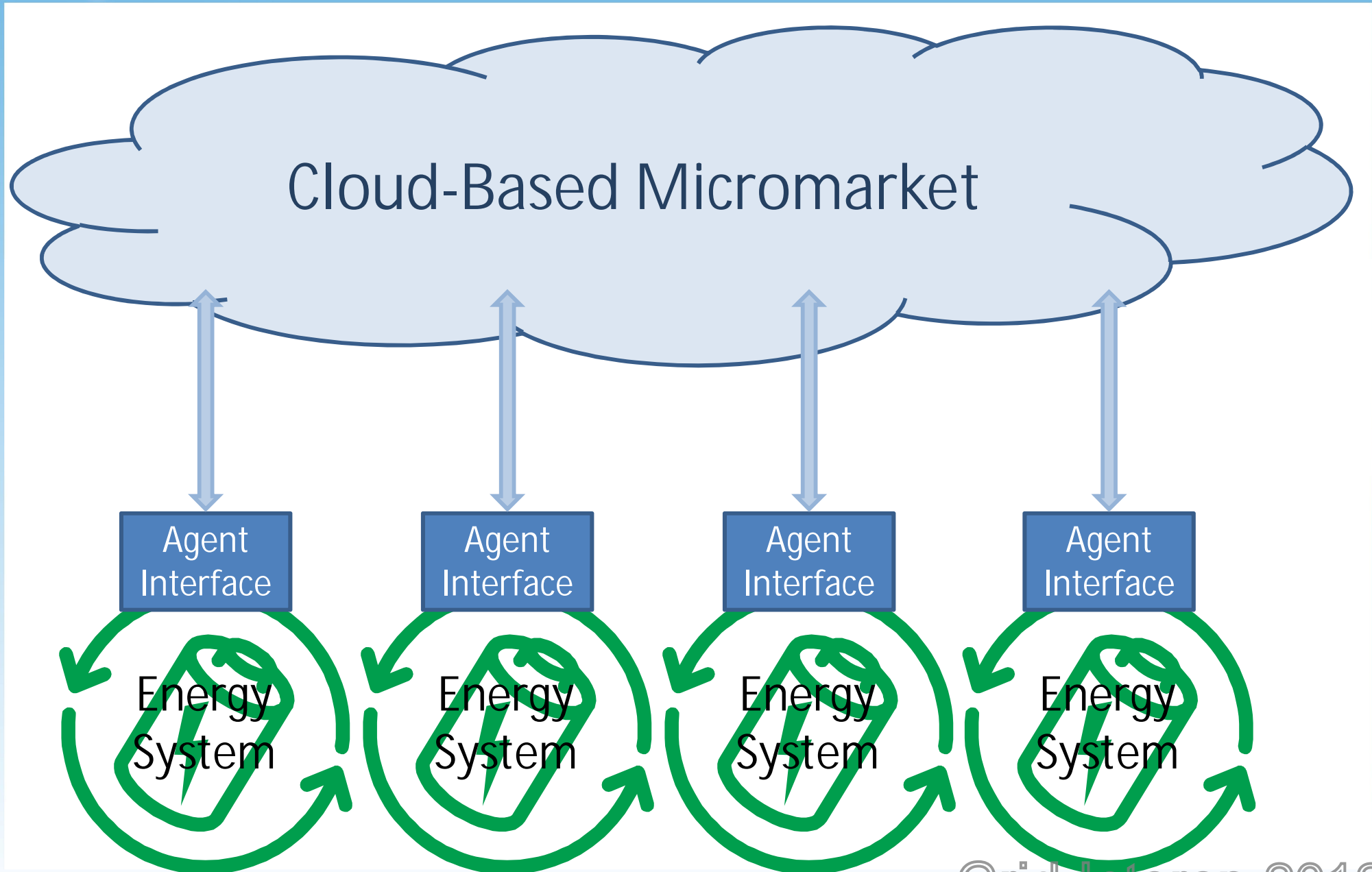
**USE TRANSACTIVE MARKETS TO  
SOLVE KNOWLEDGE PROBLEM**



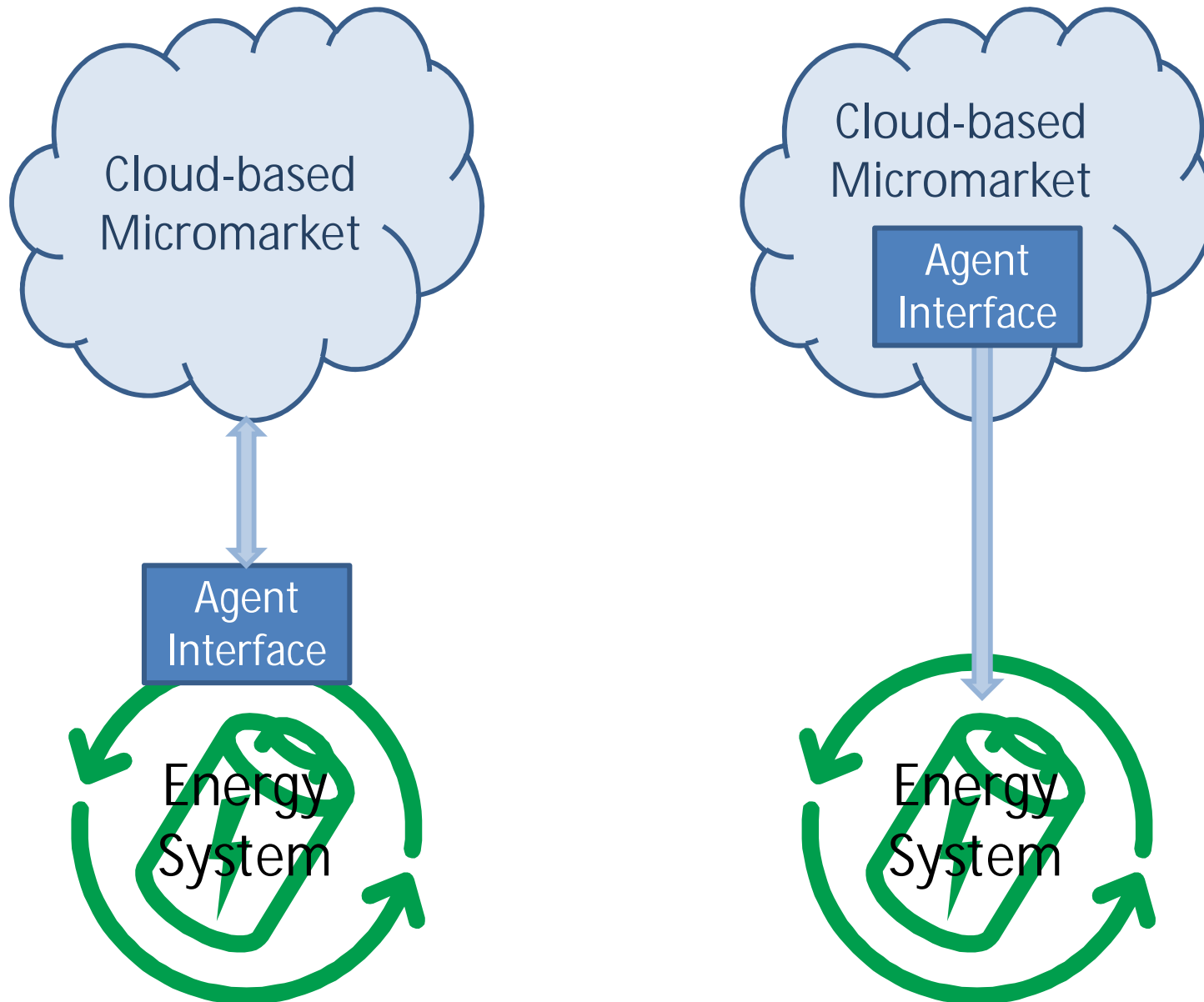
# Energy Systems interact with Micromarkets



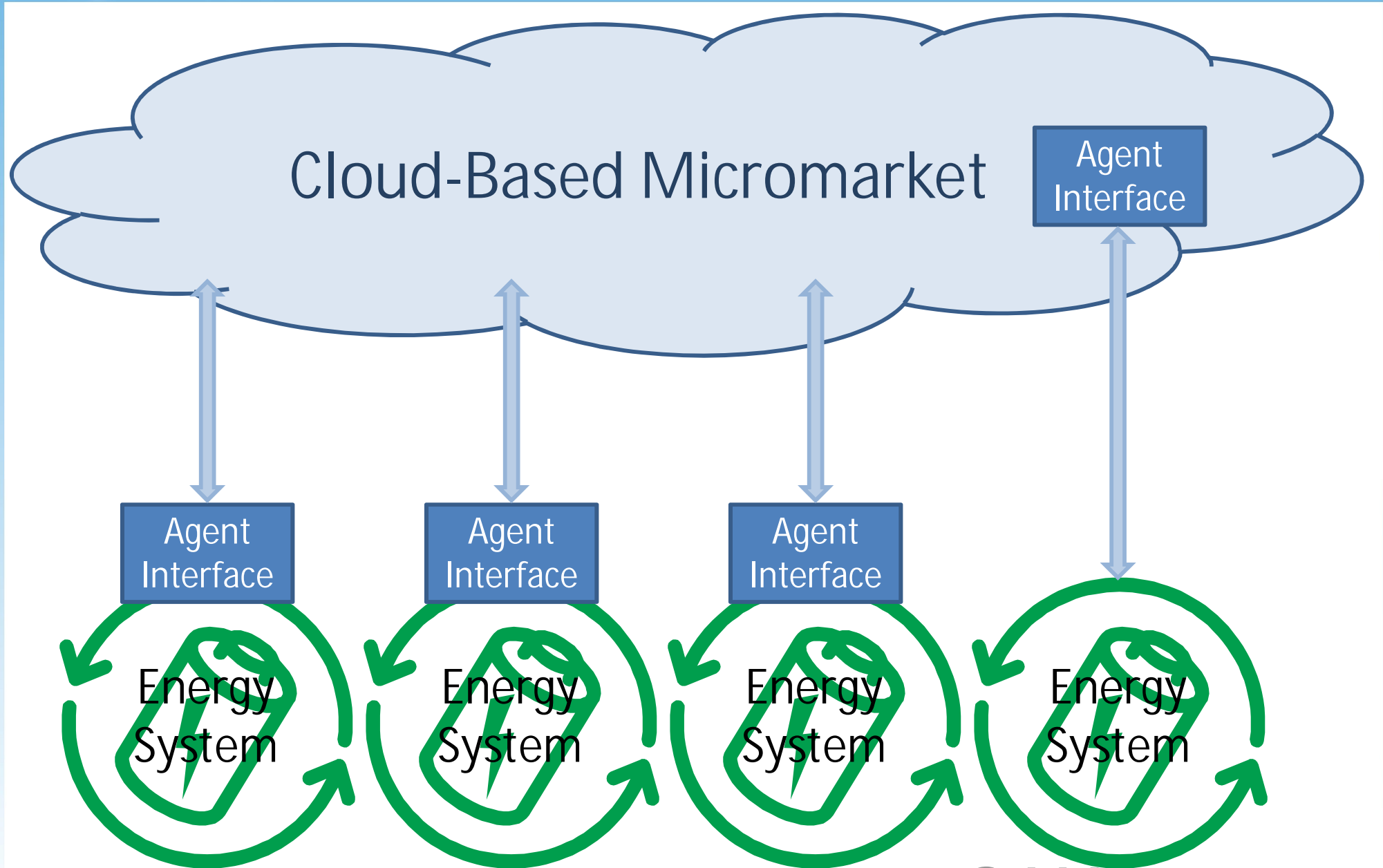
Each Agent competes in market to optimize its own system performance



# Agent functionality can be re-located to support legacy or low-capability systems



# Market interactions do not change if some systems are not agent-capable



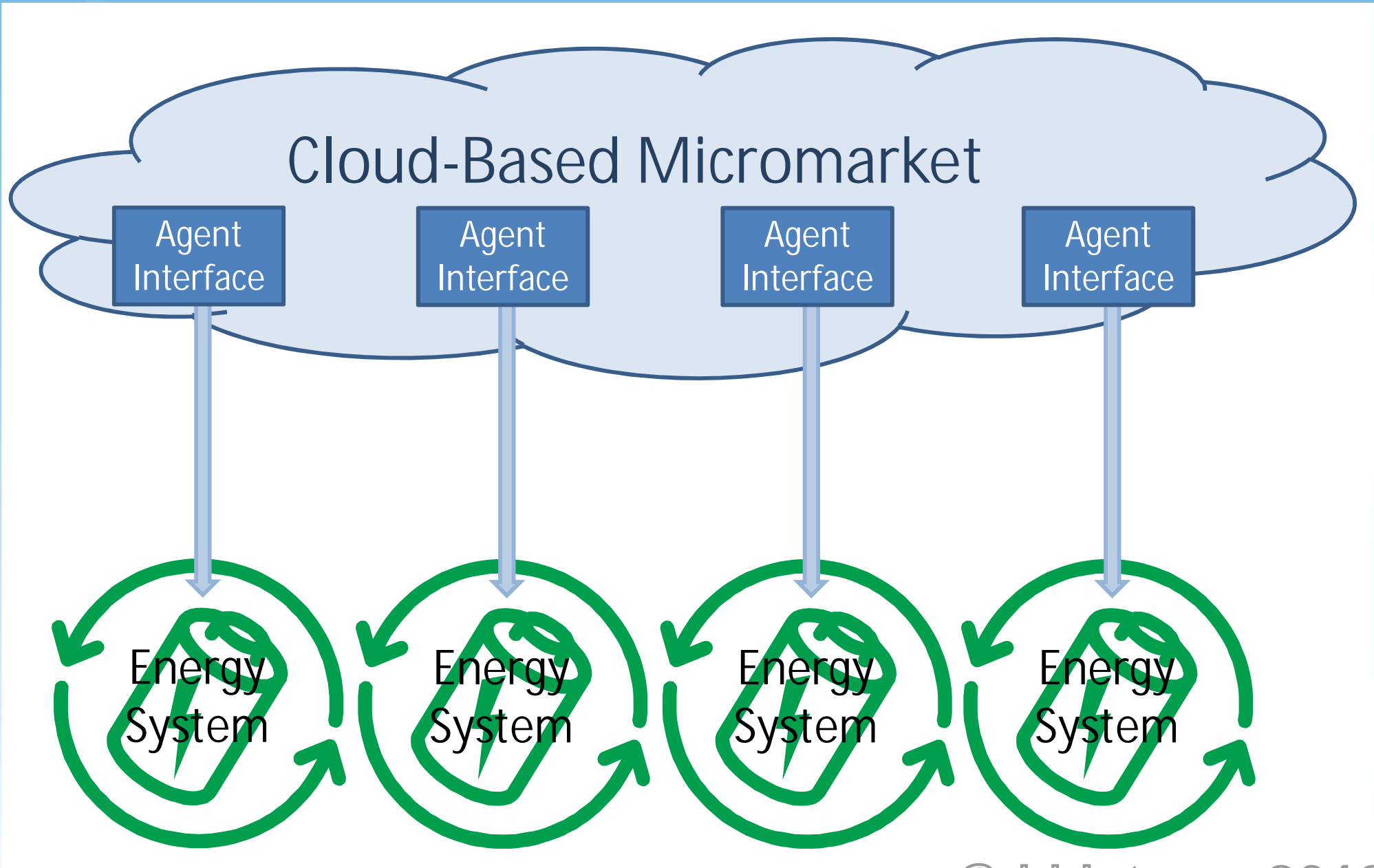


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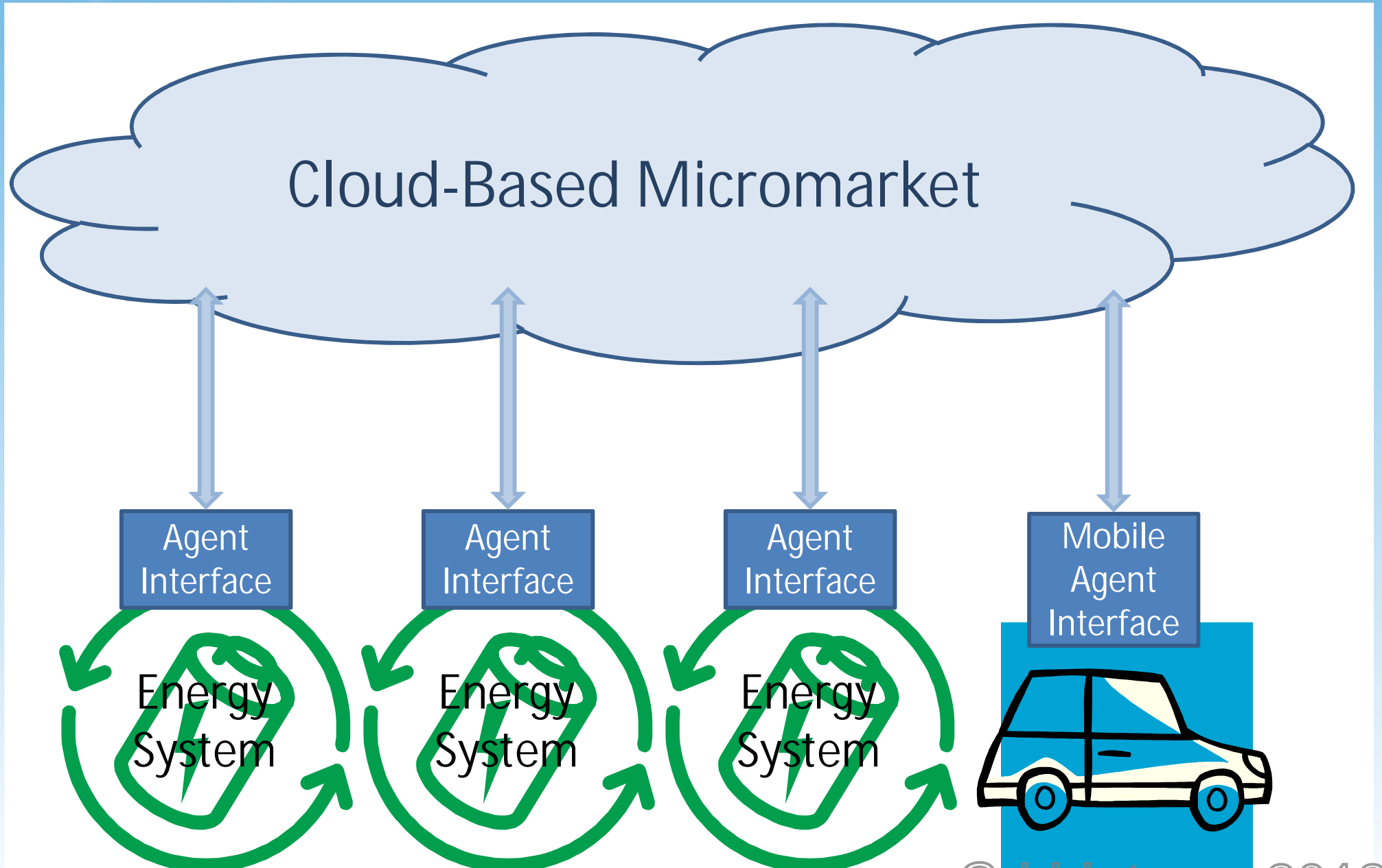
Many grids means diversity of purpose as well as of technology

# THE ARCHITECTURE OF MICROGRIDS

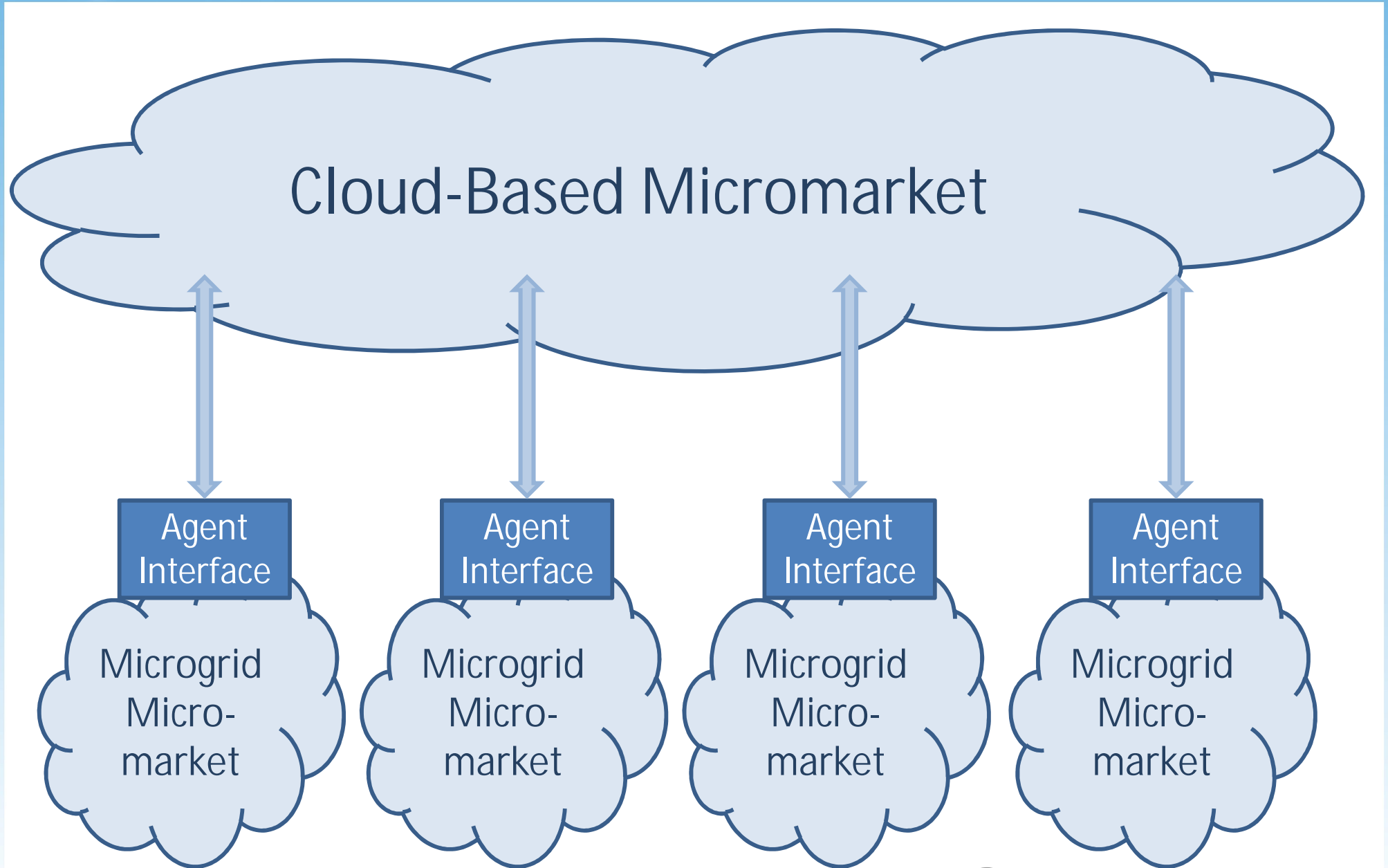
At the edge, Micromarkets of low-capability systems can resemble legacy integration



Vehicles may require some additional services, but do not challenge the model.

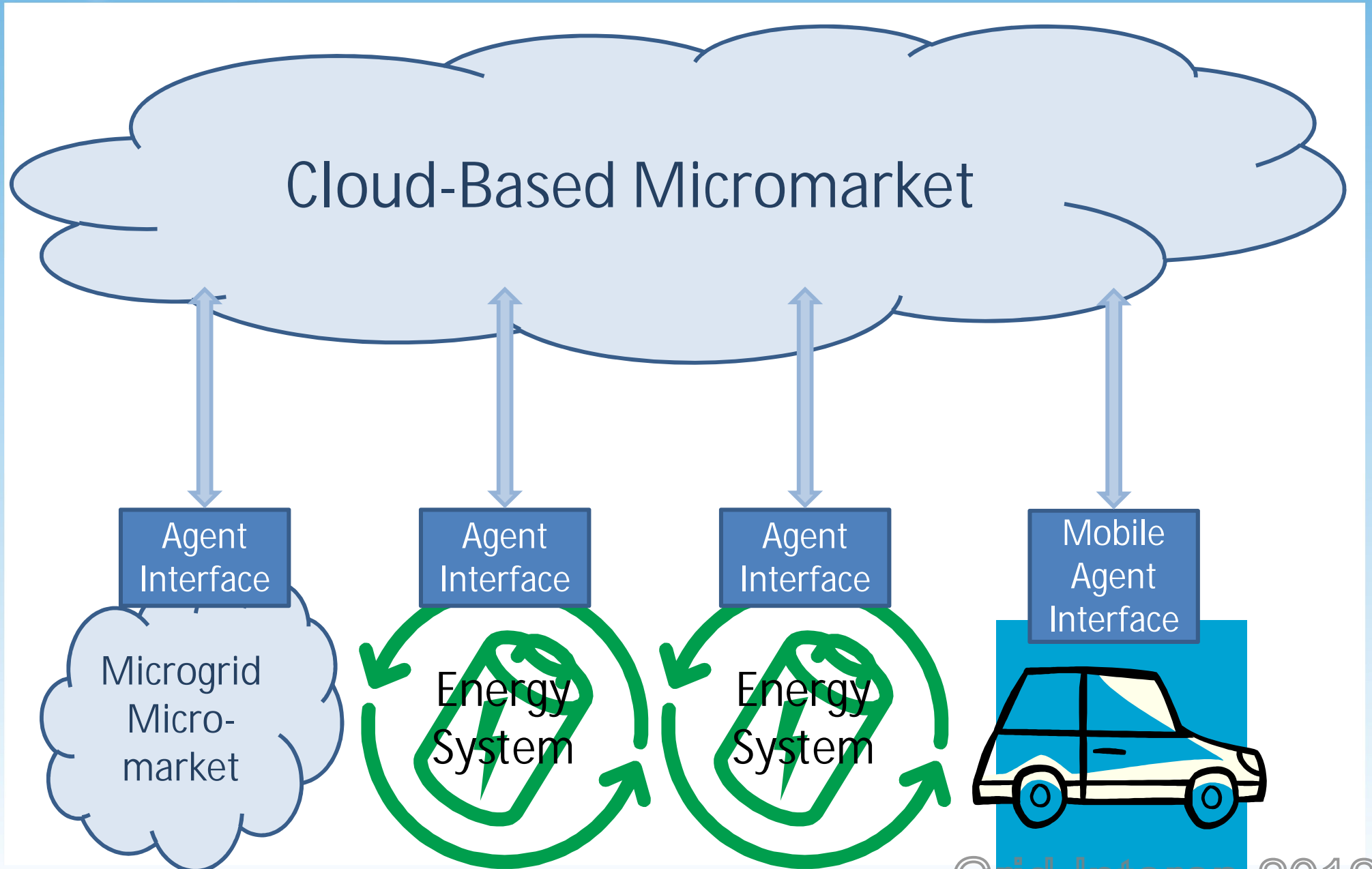


Microgrids are themselves energy systems that can interact in larger microgrids (Recursion)





The type of system represented by the agent does not change the market interaction



# Questions

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- B. Huberman and S. H. Clearwater, "Thermal markets for controlling building environments," *Energy Engineering*, vol. 91, no. 3, pp. 26-56, January 1994.
- B. Huberman and S. H. Clearwater, "A multi-agent system for controlling building environments," in *First International Conference on Multiagent Systems*, 1995.



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# Energy-Related OASIS Specifications

- OASIS Energy Interoperation
  - Designed to work to, from, inside, and outside microgrids
  - Committee Specification ballot in process
  - <http://www.oasis-open.org/committees/energyinterop>
- OASIS Energy Market Information Exchange
  - Price and product definition/description
  - Transactional EMIX Notes
  - Committee Specification pending publication
  - <http://www.oasis-open.org/committees/emix>

# Knowledge Problems and Spontaneous Order

- F. A. Hayek, "The Use of Knowledge in Society," *The American Economic Review*, vol. 35, no. 4, pp. 519-530, 1945.
- L. Kiesling, "The Knowledge Problem, Learning, and Regulation: How Regulation Affects Technological Change in the Electric Power Industry," *Studies in Emergent Order*, vol. 3, pp. 149-171, 2010.