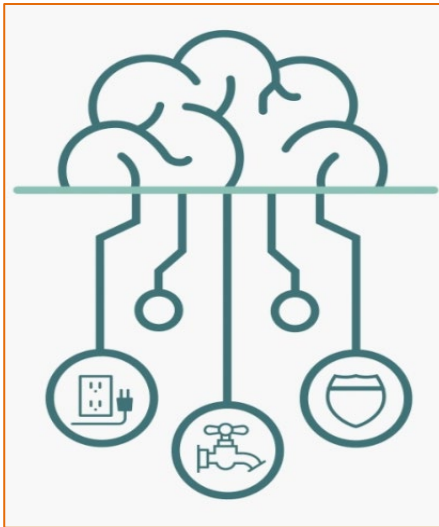# Intelligent CyberInfrastructure With Computational Learning in the Environment (ICICLE)

PI: Dhabaleswar K (DK) Panda, The Ohio State University

**An Overview by
Raghu Machiraju, The Ohio State University**

The Vision

A **national infrastructure** that enables AI at the flick of a switch, ICICLE will:

- **Democratize AI** through **integrated plug-and-play AI**.
- Catalyze **foundational AI/CI** and transform application domains.
- **Transparent and trustworthy** infrastructure for AI-enabled future,
- Address **societal problems** (conservation, food insecurity) and **national priorities**
- Grow **new generations of workforce** and Incubate **sustainable and inclusive** communities

Participating Institutes
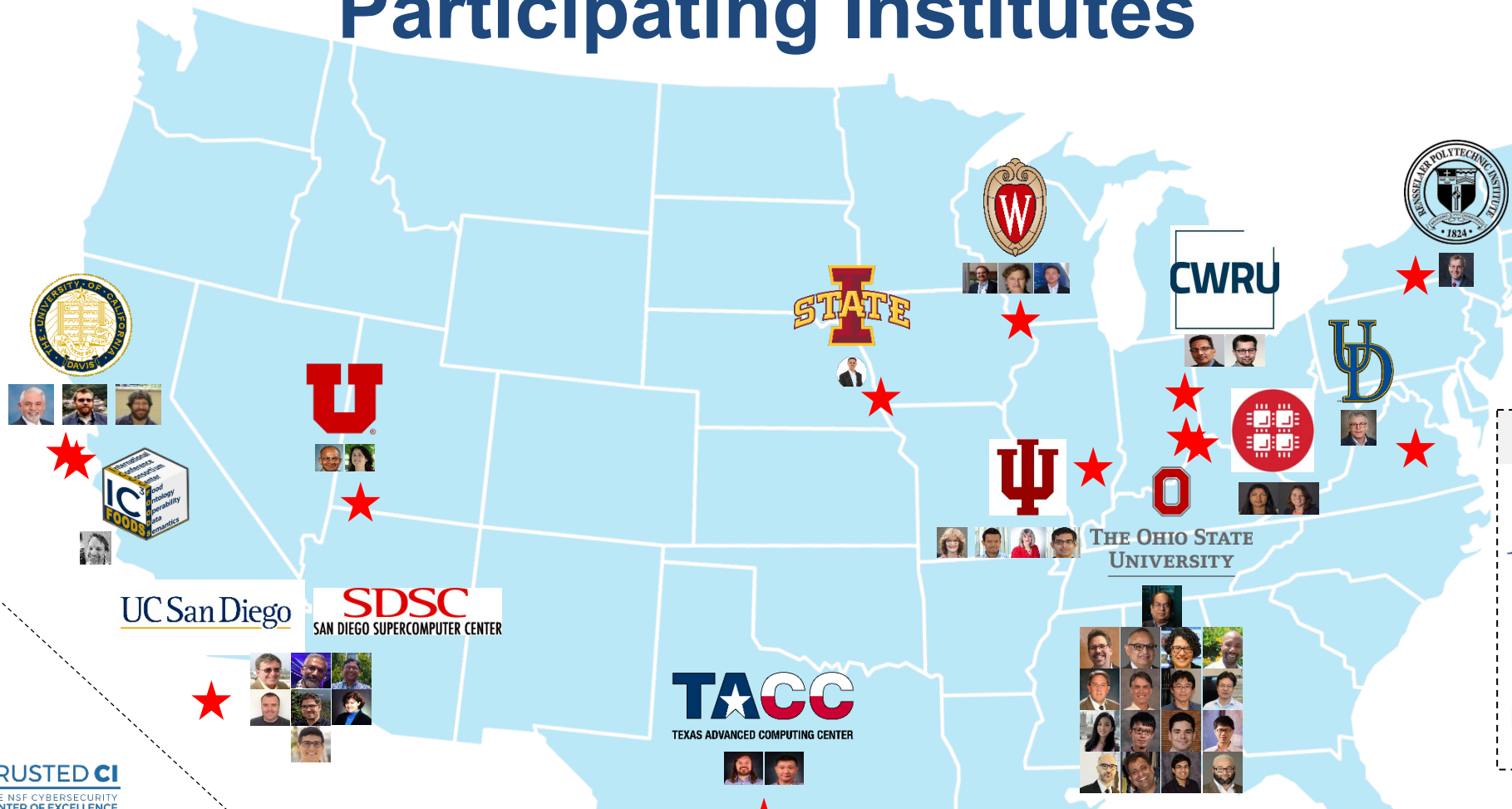
ICICLE Leadership Team

OVERALL LEADS

Fosler-Lussier (Co-PI) (OSU)
Machiraju (Co-PI) (OSU)
Panda (PI) (OSU)
Chaudhary (Co-PI) (CWRU)
Plale (co-PI) (IU)
Savardekar (MD) (OSU)

EDUCATION & WORKFORCE DEVELOPMENT

Lange (IC-FOODS)

FOUNDATIONAL SYSTEMS AI

Fosler-Lussier (OSU)
Su (OSU)

CO-DESIGN FOR USE INSPIRED SCIENCE

Berger-Wolf (OSU)
Hoy (OSU)
Shearer (OSU)

INTELLIGENT CYBERINFRASTRUCTURE

CI FOR AI
Blanas (OSU)
Zhang (TACC)

AI FOR CI-FOR-AI
Chaudhary (CWRU)
Eigenmann (UDel)

SOFTWARE ARCHITECTURE AND DESIGN
Stubbs (TACC)
Zhang (TACC)

VISUAL ANALYTICS FOR CI AND AI EXPLAINABILITY
Machiraju (OSU)
Shen (OSU)

PRIVACY, ACCOUNTABILITY AND DATA INTEGRITY
Ayday (CWRU)
Plale (IU)

BROADENING PARTICIPATION IN COMPUTING

Biggers (IU)
Thomas (SDSC)

COLLABORATION & KNOWLEDGE TRANSFER
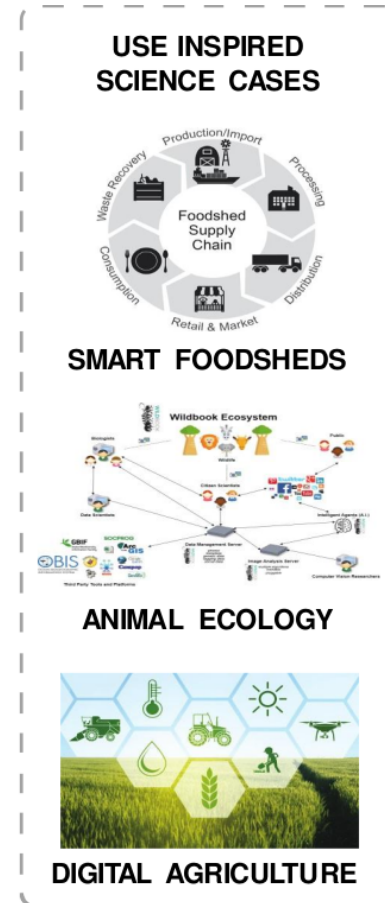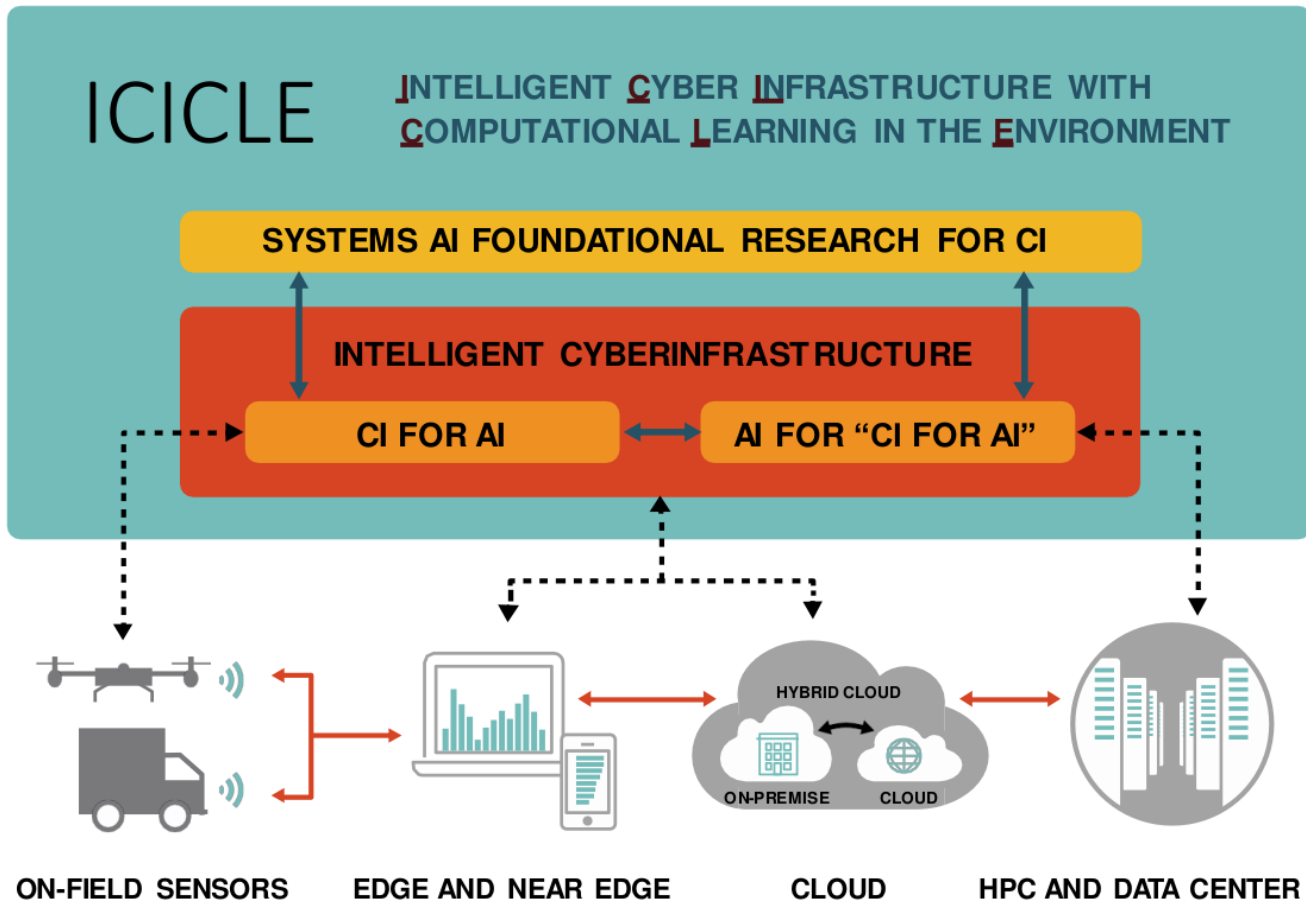
Lange (IC-FOODS)
Ramnath (OSU)

CI DEVELOPMENT FOR INTEGRATION WITH SHARED RESEARCH FACILITIES

Majumdar (SDSC)
Tomko (OSU)

Rationale: Co-Design w/ Use Cases

Integrating a broad range of
  – Scientists-in-the-field
  – Engineers
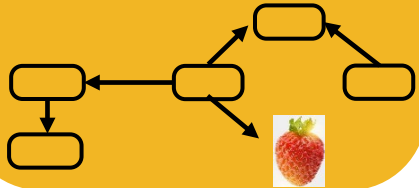 – Educators
  – Collaborative partners
  – Institutions

under one roof enables
democratized,
adaptable,
plug-and-play AI
and **long-tail science.**

The DNA: Foundational Systems AI

Knowledge Graphs

- Multimodal
- Spatio-temporal
- Auto construction
- Knowledge-based reasoning and pre-training

Model Commons

- KG-supported
- Precise profiling
- Flex Composition
- Versioning and provenance

Crop Yield Model
Midwest
Corn, Strawberry…

Adaptive AI

- Context-aware
- Interactive
- Continual learning
- Distillation-based compression

Federated Learning

- Heterogeneity
- Applicability to a variety of models
- Context-aware
- Privacy-preserving and robustness

Conversational AI

- KG- and model-commons-aware
- Bootstrapping and adaptivity
- Multimodal contextual response

The Enabler@Edge : CI4AI

High Perf. Training	High Perf. Data Management	*Edge Intelligence*	AI-Adaptive Edge Wireless	Control and Coordination
• Deep Learning Communication Optimization • Deep Learning I/O Improvement • Multi-level data/model/spatial parallelism	• Unified storage of data, model and hyperparameters • Model lifecycle management for AI orchestration • Data location transparency with migration	• Adaptive Training/Inference and FL on Edge • Novel Edge Offloading/Caching Orchestration • Intelligent Anomaly Detection to improve QoS	• AI-adaptive, Predictable Comm. Capacity Allocation • Predictable Wireless Comm. via Rateless-Coding & Multi-Modal/Path	• App/CI Interface Design • Tapis Integration • Production-ready Service Hardening and Optimization

The Enabler@Scale-And-@Edge: AI4CI

- **Efficient plug-and-play:** Constantly adapt and optimize heterogenous (cloud, HPC, and edge) CI to meet requirements of ICICLE applications
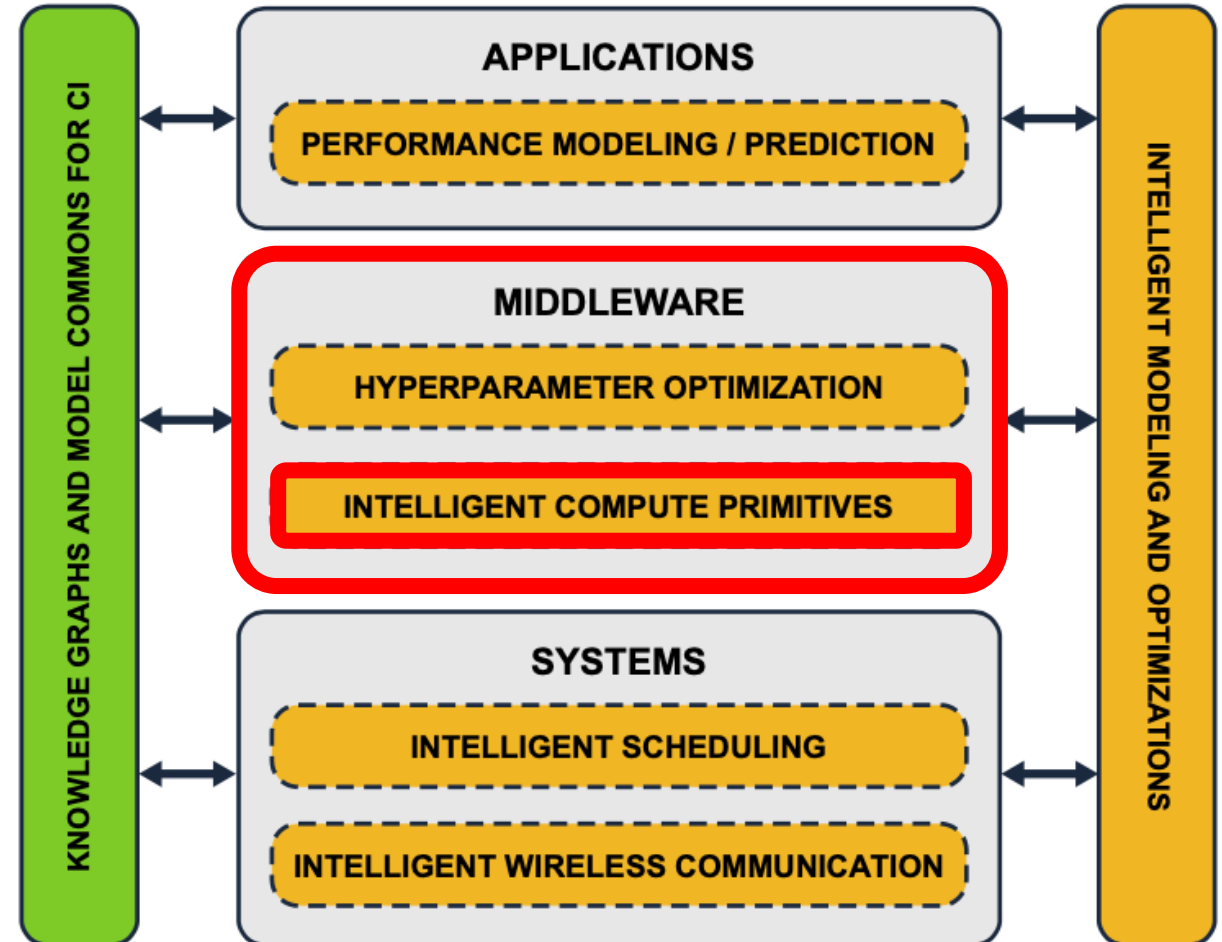
Intelligent Primitives (sparse/dense)
Product: High Performance Library
(Powered by AI to maximize the utilization of CI)

Innovation: **Learn** from hardware (e.g., SIMD width), network (e.g., bandwidth/latency), and data sparsity to **extract best attainable performance**

Utility: (1) **Portable** high performance on diverse HPC systems (2) **Usable** at the backend of any other AI system

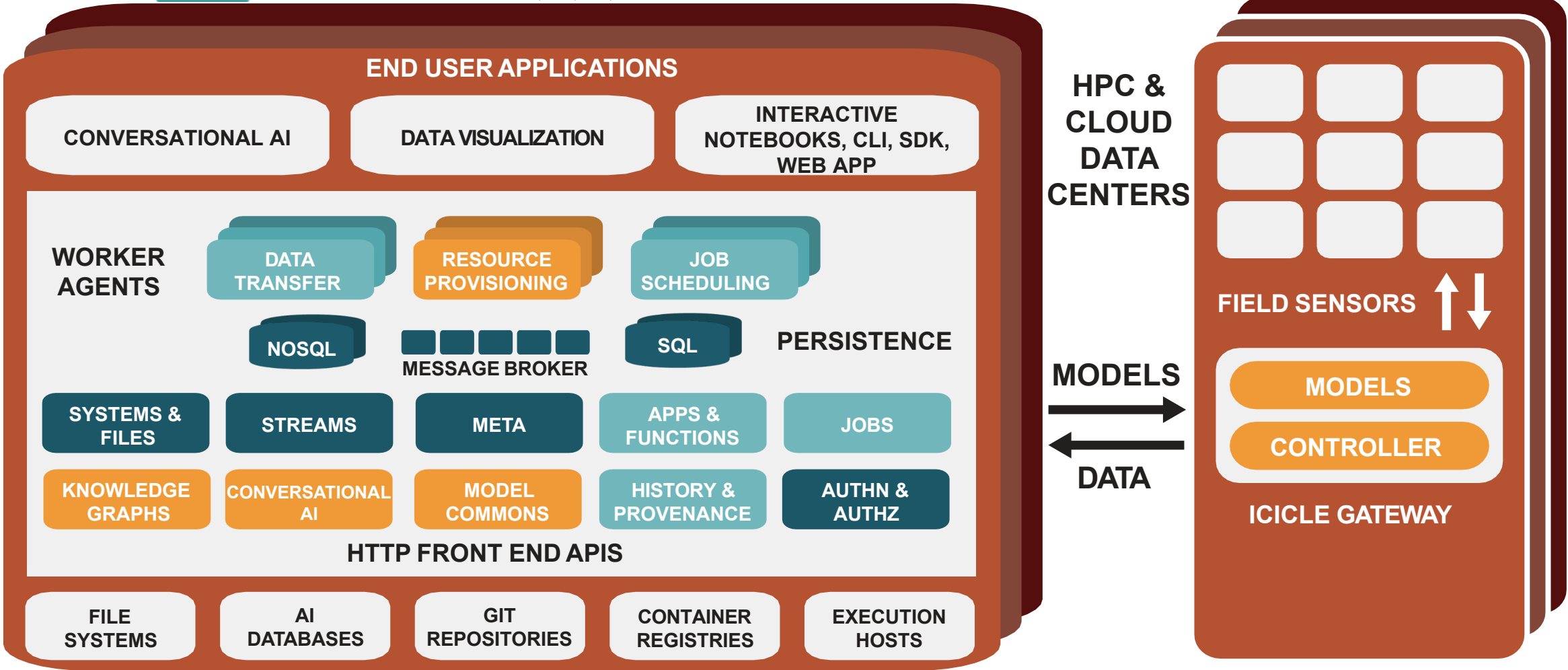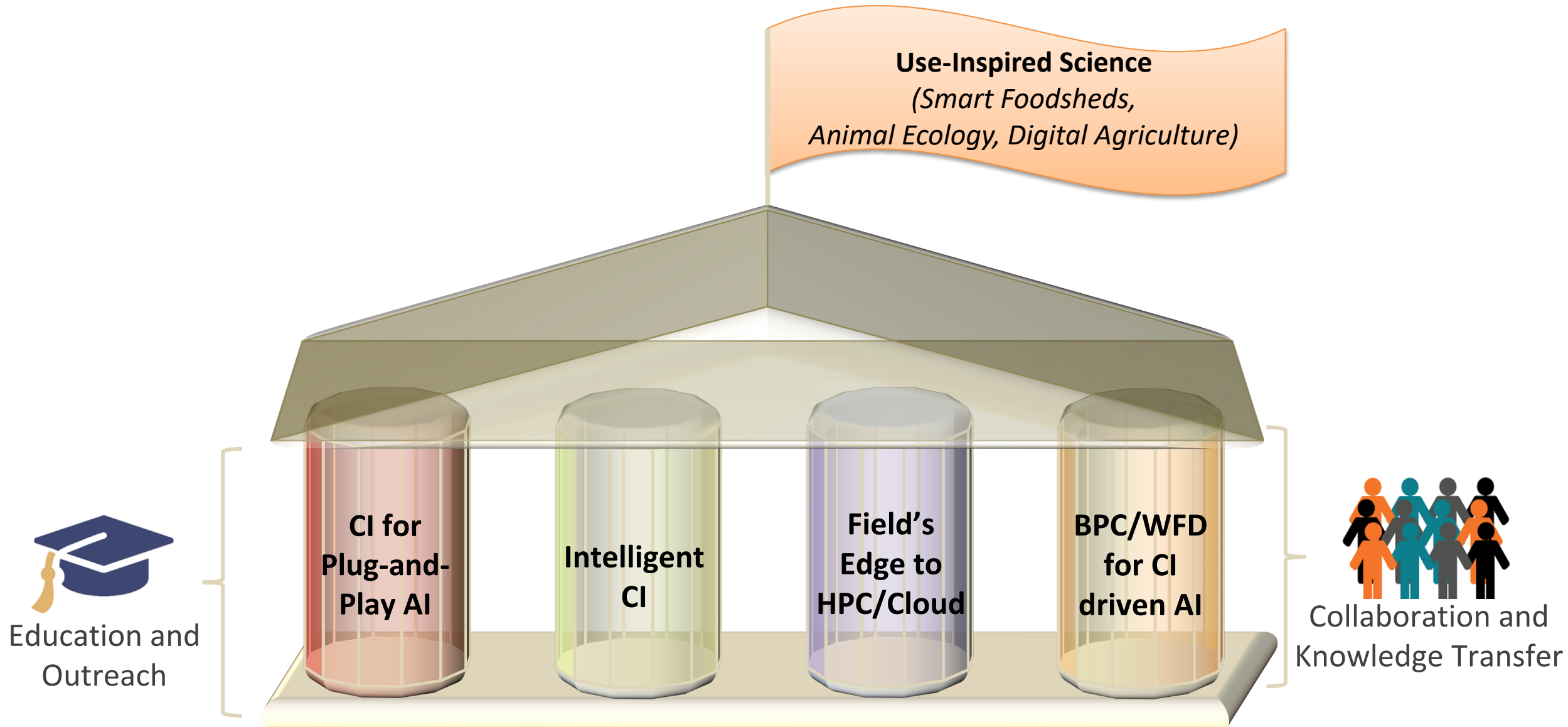**Heterogeneous and rapidly evolving platform (CPUs, GPUs, Supercomputers, edge devices)**

KNOWLEDGE GRAPHS AND MODEL COMMONS FOR CI

APPLICATIONS
PERFORMANCE MODELING / PREDICTION

MIDDLEWARE
HYPERPARAMETER OPTIMIZATION
INTELLIGENT COMPUTE PRIMITIVES

SYSTEMS
INTELLIGENT SCHEDULING
INTELLIGENT WIRELESS COMMUNICATION

INTELLIGENT MODELING AND OPTIMIZATIONS

ICICLE
DEMOCRATIZING AI

A Deliverable: The ICICLE Software Architecture

ICICLE As A Whole

Use-Inspired Science
*(Smart Foodsheds,
Animal Ecology, Digital Agriculture)*

Education and Outreach

CI for Plug-and-Play AI

Intelligent CI

Field's Edge to HPC/Cloud

BPC/WFD for CI driven AI

Collaboration and Knowledge Transfer

ICICLE
DEMOCRATIZING AI
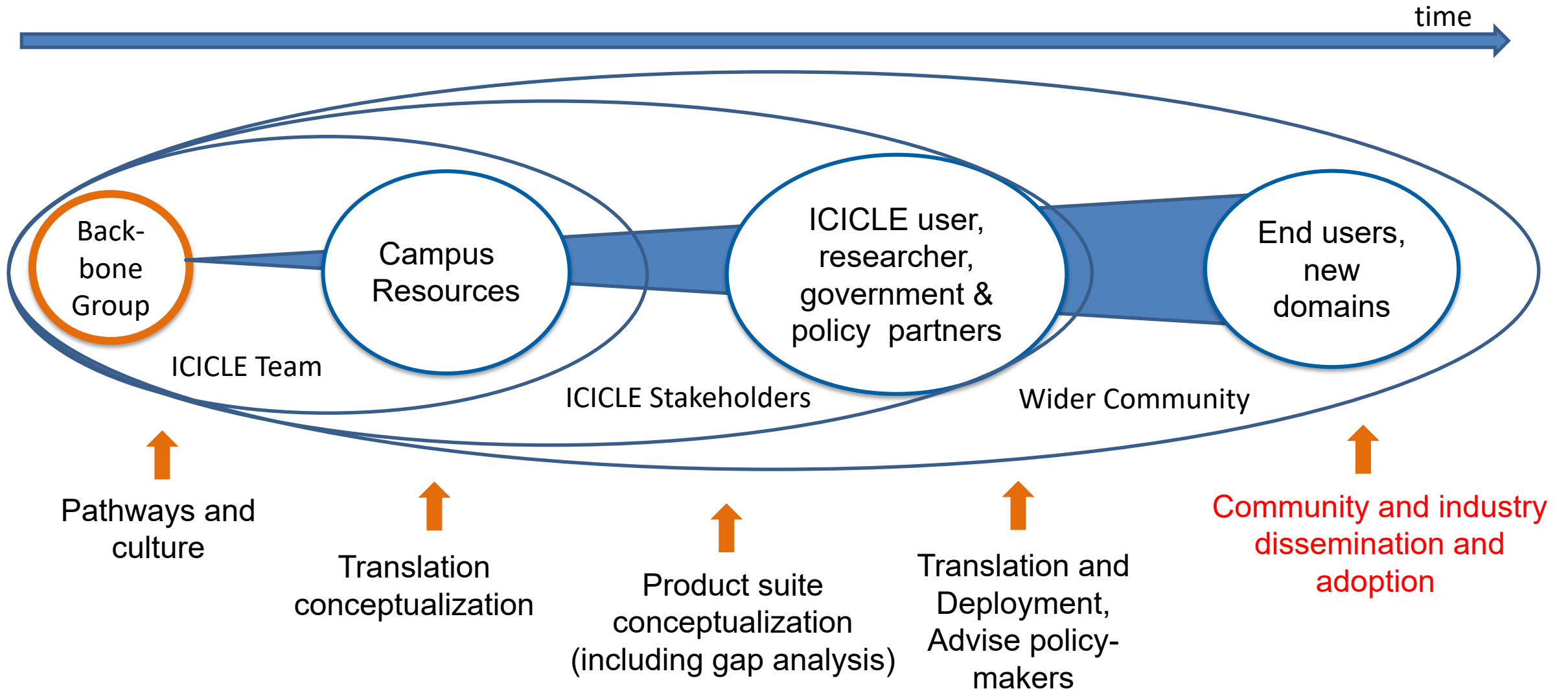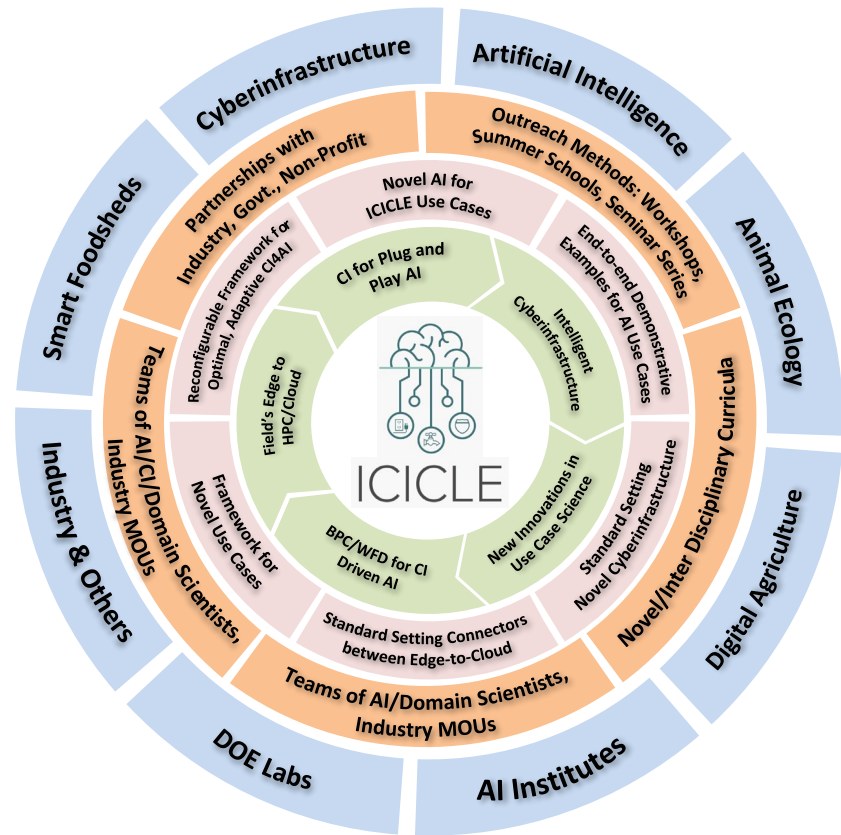
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Broader Impacts: Workforce Development
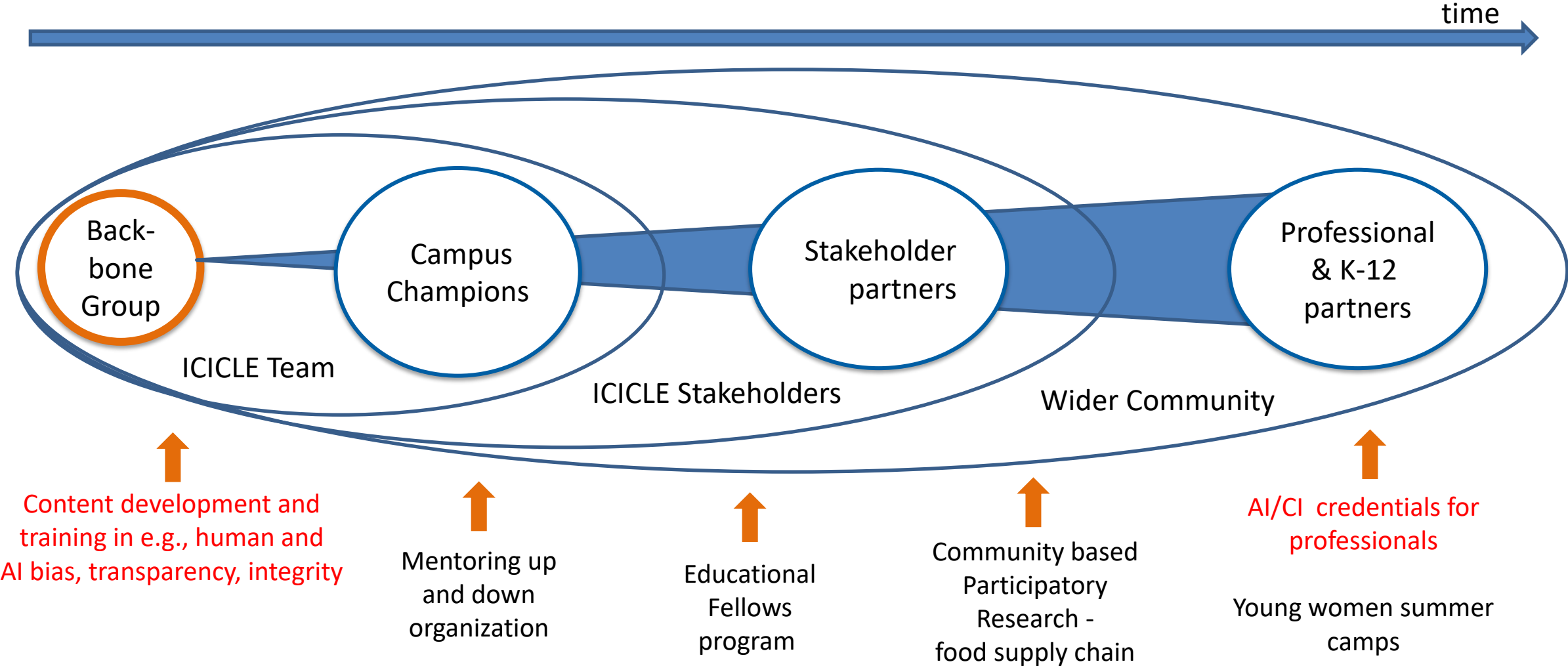
Broader Impacts: Collaboration & Knowledge Transfer: A Phased Approach

time

Back-bone Group

Campus Resources

ICICLE user, researcher, government & policy partners

End users, new domains

ICICLE Team

ICICLE Stakeholders

Wider Community

Pathways and culture

Translation conceptualization

Product suite conceptualization (including gap analysis)

Translation and Deployment, Advise policy-makers

Community and industry dissemination and adoption

ICICLE Enables Global AI leadership

- **Integrate into the National CI Ecosystem**

- **Integrative and Interoperable**

- **Leverages existing recognized capabilities**
  - Centers of Excellence, AI Institutes, Large Facilities

- **Collaborative**

- **Sustainable**
  - Workforce Development, Broadening Participation, Collaboration and Knowledge Transfer
  - Benefits other institutes, large facilities, and all sciences beyond lifetime of award

Engaging With ICICLE
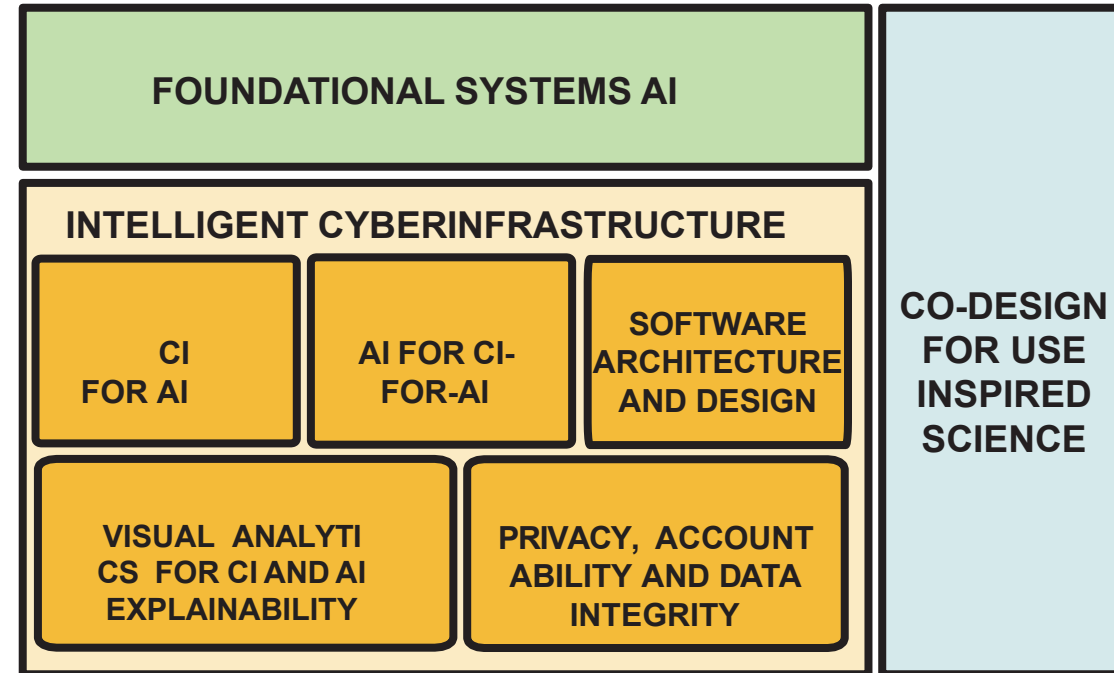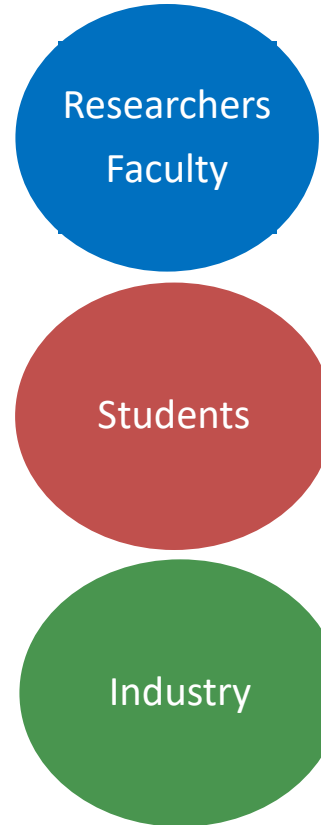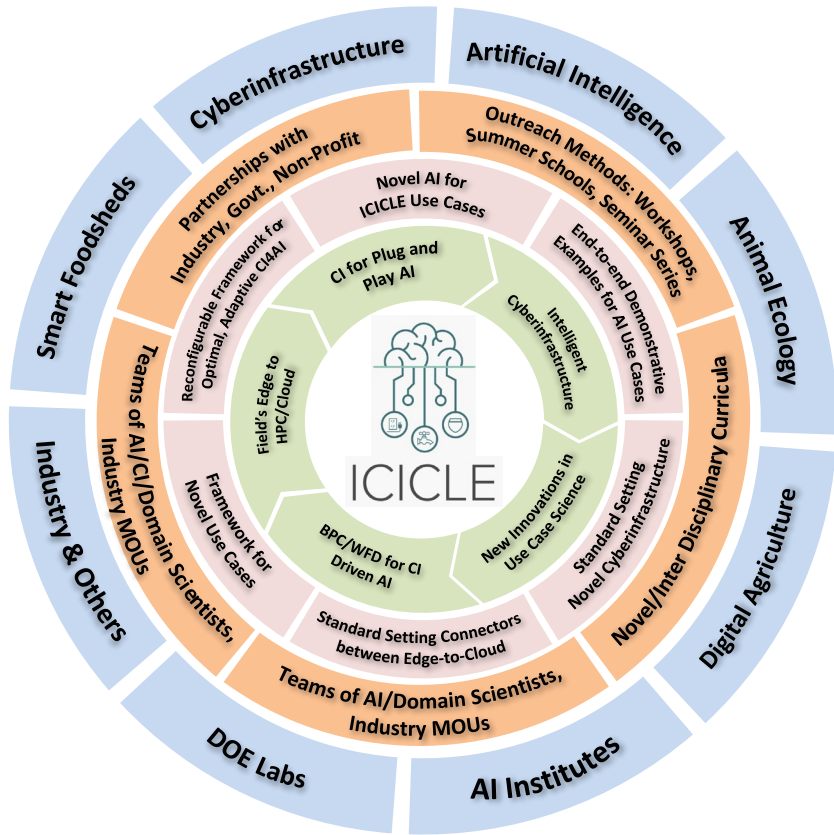
Co-develop & Adopt ICICLE developed CI!

Contact: panda@cse.ohio-state.edu