Echo Messaging Systems, Inc

Quantum Computing
in Agent-Based Technologies

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Primary Goal: Create applications where we reduce <u>Complexity,</u> while increasing <u>Scalability,</u> <u>Reusability,</u> and <u>Integrity</u>
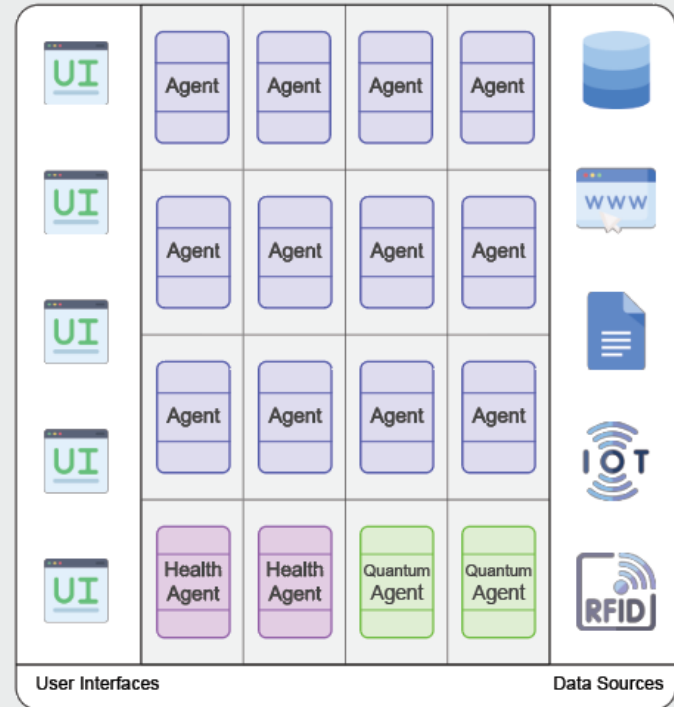
We solve common, but difficult problems using a divide-and-conquer approach using Agent-Based Technology.

A.D.I.N

ANOMALY DETECTION AND INTELLIGENT NOTIFICATION
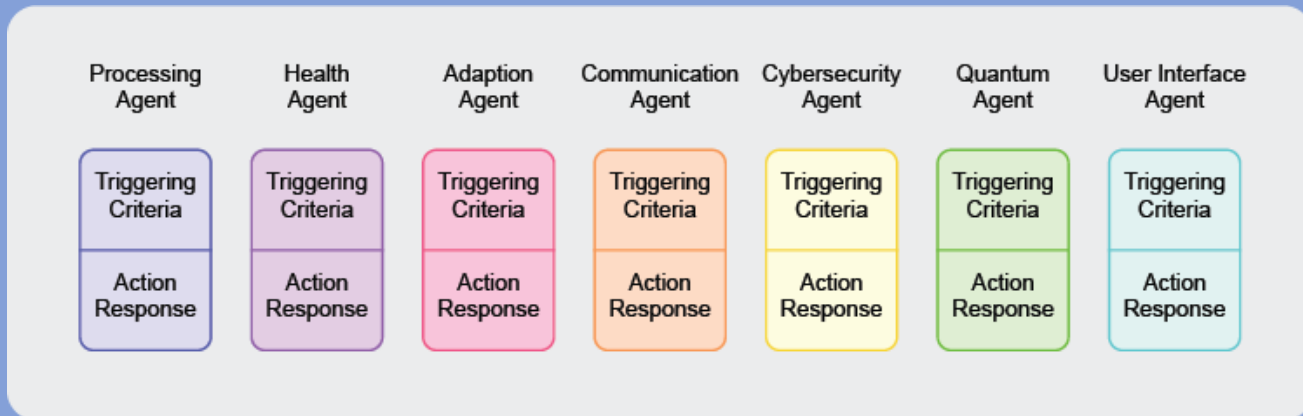

ADIN Cell
Application Agents

Agents run in Docker Containers.

Example Triggering Criteria:

- New/updated record or status in DB, API, IoT Device
- Timer interval
- Distance interval
- Combination of Data, Time, Space

Example Action Responses:

- Create/Update record in another DB, API, IoT Device
- Notify via email, text, any digital communication method
- Update ADIN agent parameters
- Clone/Create/Pause/Stop ADIN agents
- Compound, Series-based actions

ADIN Agent has 2 key components:
1. Triggering Criteria
2. Action Response

Processing Agent	Health Agent	Adaption Agent	Communication Agent	Cybersecurity Agent	Quantum Agent	User Interface Agent
Triggering Criteria	Triggering Criteria	Triggering Criteria	Triggering Criteria	Triggering Criteria	Triggering Criteria	Triggering Criteria
Action Response	Action Response	Action Response	Action Response	Action Response	Action Response	Action Response

Example Agent Types:
- Health Agents monitor other agents, checking agent metadata.
  Trigger: change in metadata stats. Action: Notify administrator

- Adaptation Agents monitor how much data is being processed in ADIN Cell.
  Trigger: measure quantity of data metrics. Action: Clone processing agents to increase data throughput.

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By combining & recombining agents, we quickly create many different types of applications

ADIN™ AI Engine used commercially:

- Automated Notification Systems
- Emergency Safety Apps
- Data Syncs, Bridging Software
- Unstructured-to-Structured Data
- Container Technology
- Geospatial Applications
- IoT applications
- Dashboards for Cognitive Apps
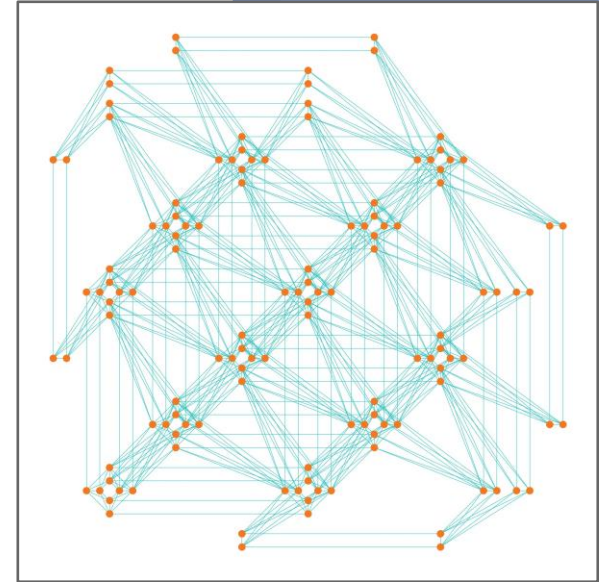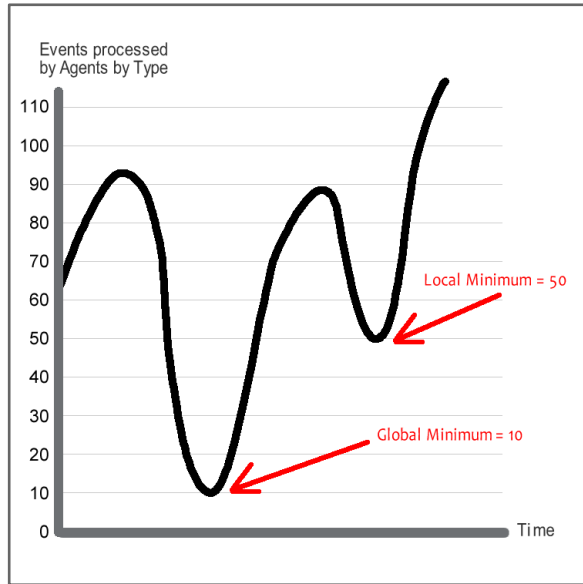- Digital Twin Technology
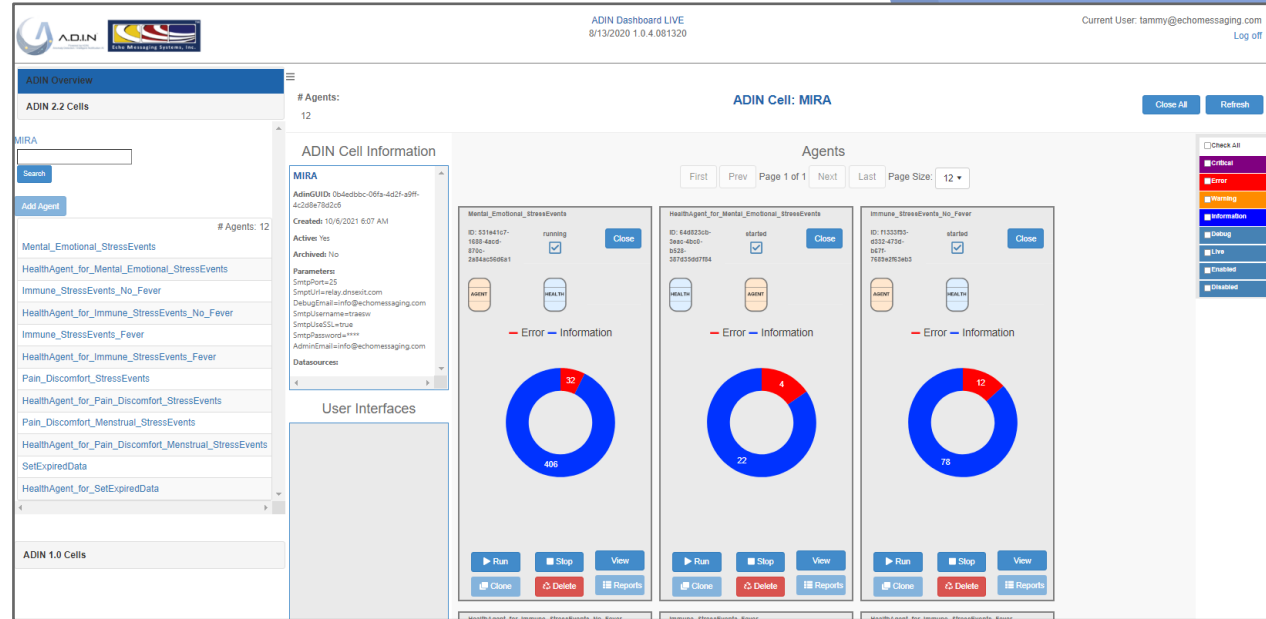
ADIN UI allows for full introspection of decisions

Opposite of AI's

"black box problem"
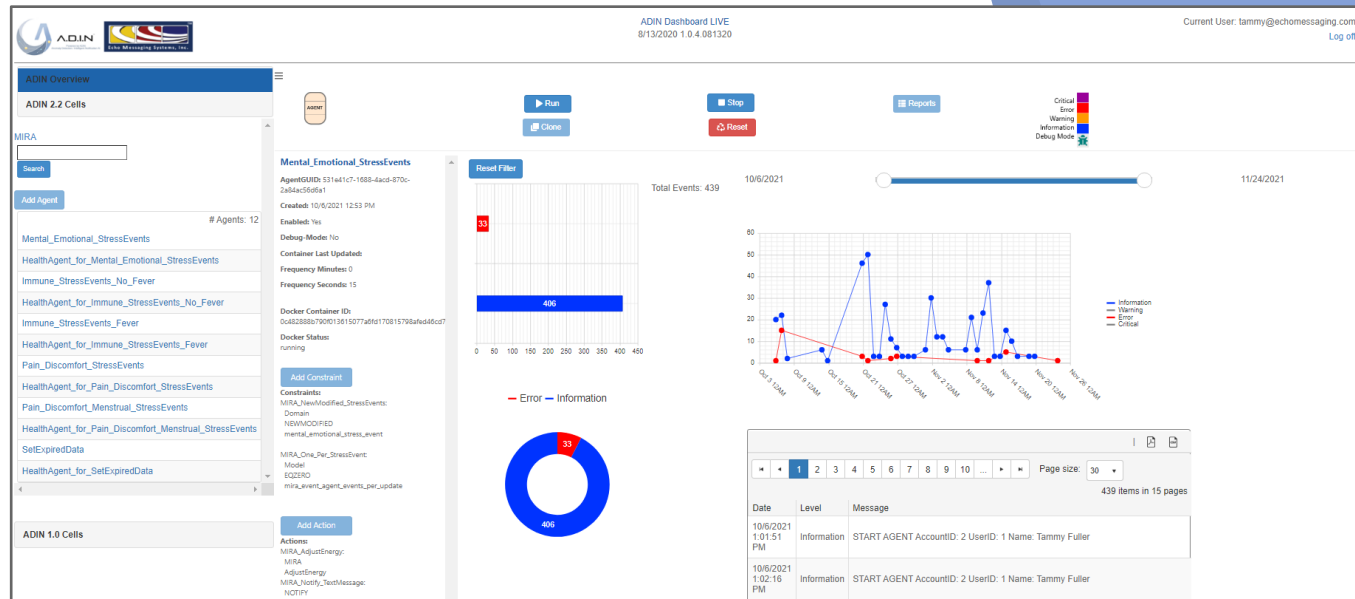
Quantum Computers solve problems, such as Constraint Satisfaction Problems (CSP), that are difficult for Classical Computers to solve.

Search for minimum energy in a global system via QUANTUM ANNEALING

Quantum ADIN Agent formulates energy minimization model and connects to DWAVE API

- ADIN Quantum Web Service provide Python interfaces to DWAVE API

Quantum Agent

Triggering Criteria
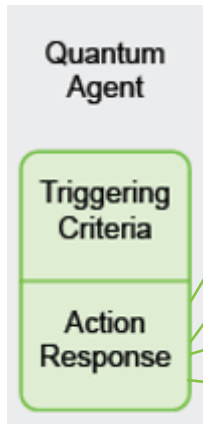
Action Response

Action Responses:

- Optimization

- Resource Allocation

- Scheduling

- Routing

```python
num_agent_types = len(agent_types)
total_load = sum(loads)
LPA = int(total_load / max_agents) ## a lower priority constraint than the other 2 constraints

cqm = ConstrainedQuadraticModel() ## create Constrained Quadratic Model
bqm = BinaryQuadraticModel('BINARY')

# Build a variable for each agent at each possible agent type
bin_variables = [[Binary(f'A{str(i)}_{str(j)}')for j in range(max_agents)]
                 for i in range(num_agent_types)]

## add following constraints to Constrained Quadratic Model
for j in range(max_agents):
    ## MUST: each agent has one agent_type
    cqm.add_constraint(quicksum(bin_variables[i][j] for i in range(num_agent_types)) == 1,
                       label='c1_one_per_agent_'+str(j))

for i in range(num_agent_types):
    ## MUST: each agent type is represented in at least 1 agent
    cqm.add_constraint(quicksum(bin_variables[i][j] for j in range(max_agents)) >= 1,
                       label='c2_agent_type_'+str(i))

    ## BEST: sum of loads processed by agents of same agent type are >= to load reqs
    # for agent type
    c1 = [(f'A{str(i)}_{str(j)}', LPA) for j in range(max_agents)]
    bqm.add_linear_inequality_constraint(c1, lagrange_multiplier=1, label='load',
                                         lb=int(loads[i]), ub=total_load)
cqm.set_objective(bqm)
sampler = LeapHybridCQMSampler()
sampleset = sampler.sample_cqm(cqm, label='Optimize ADIN')
```
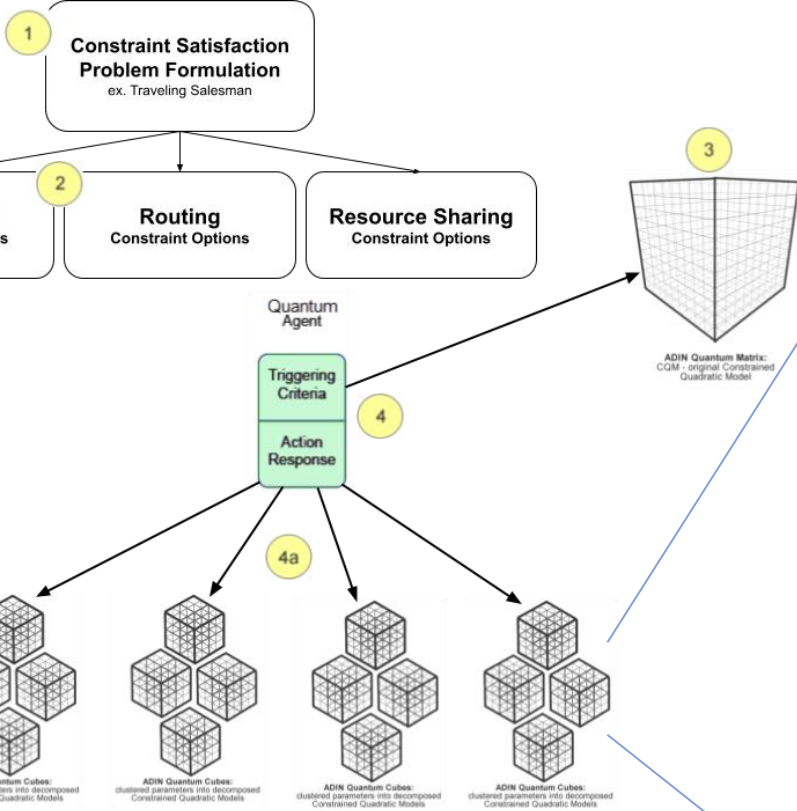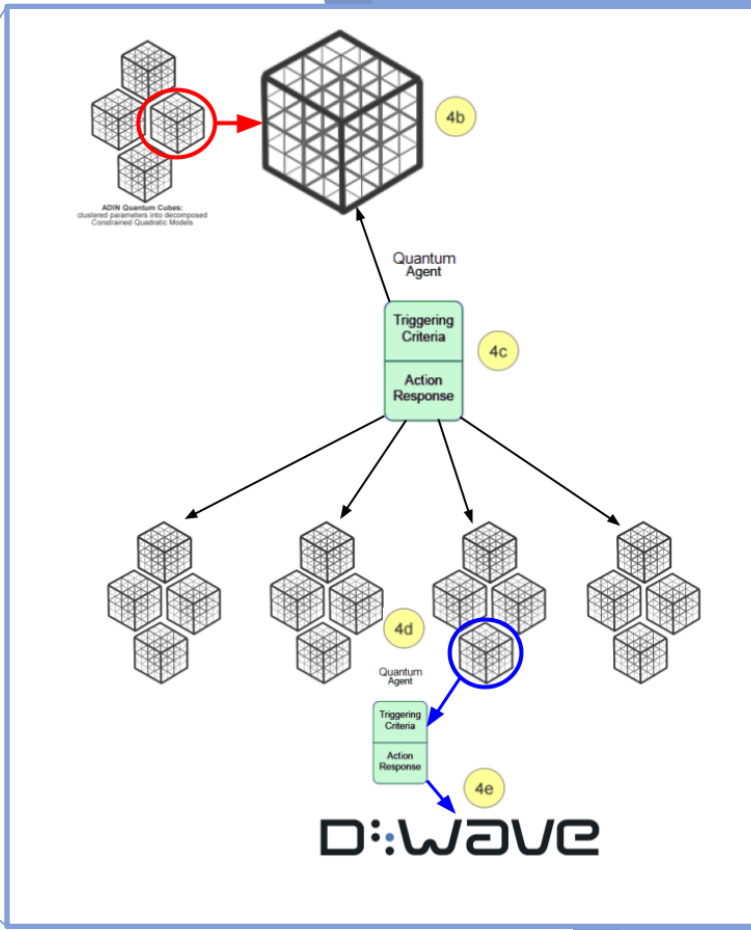
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Agent Action Responses to iteratively divide along linear constraint dimensions to create formulated models fit limits of quantum computer

Agents decompose the problem space as action responses

ADIN Quantum Matrix:
CQM - original Constrained Quadratic Model

ADIN Quantum Cubes:
clustered parameters into decomposed Constrained Quadratic Models

ADIN Quantum Agents:
CQM fits Quantum Computer size limits

Quantum Agent sends decomposed CQM to Hybrid Solver
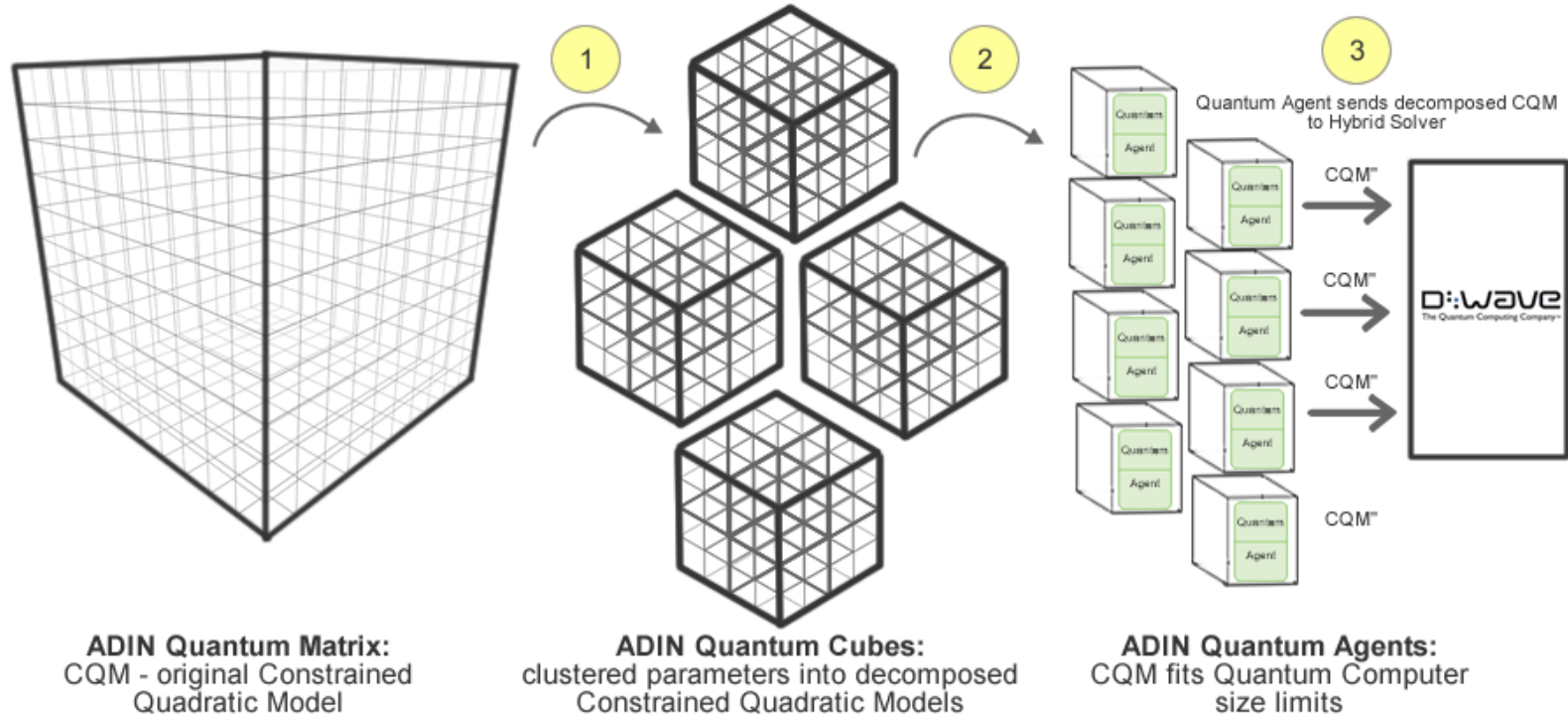
As DWAVE solves each portion of the problem, greedy sort selects best answer during reconstruction

ADIN Quantum Matrix:
CQM - original Constrained Quadratic Model

ADIN Quantum Cubes:
clustered parameters into decomposed Constrained Quadratic Models

ADIN Quantum Agents:
CQM fits Quantum Computer size limits

Hybrid Solver returns local minima for each Quantum Agent

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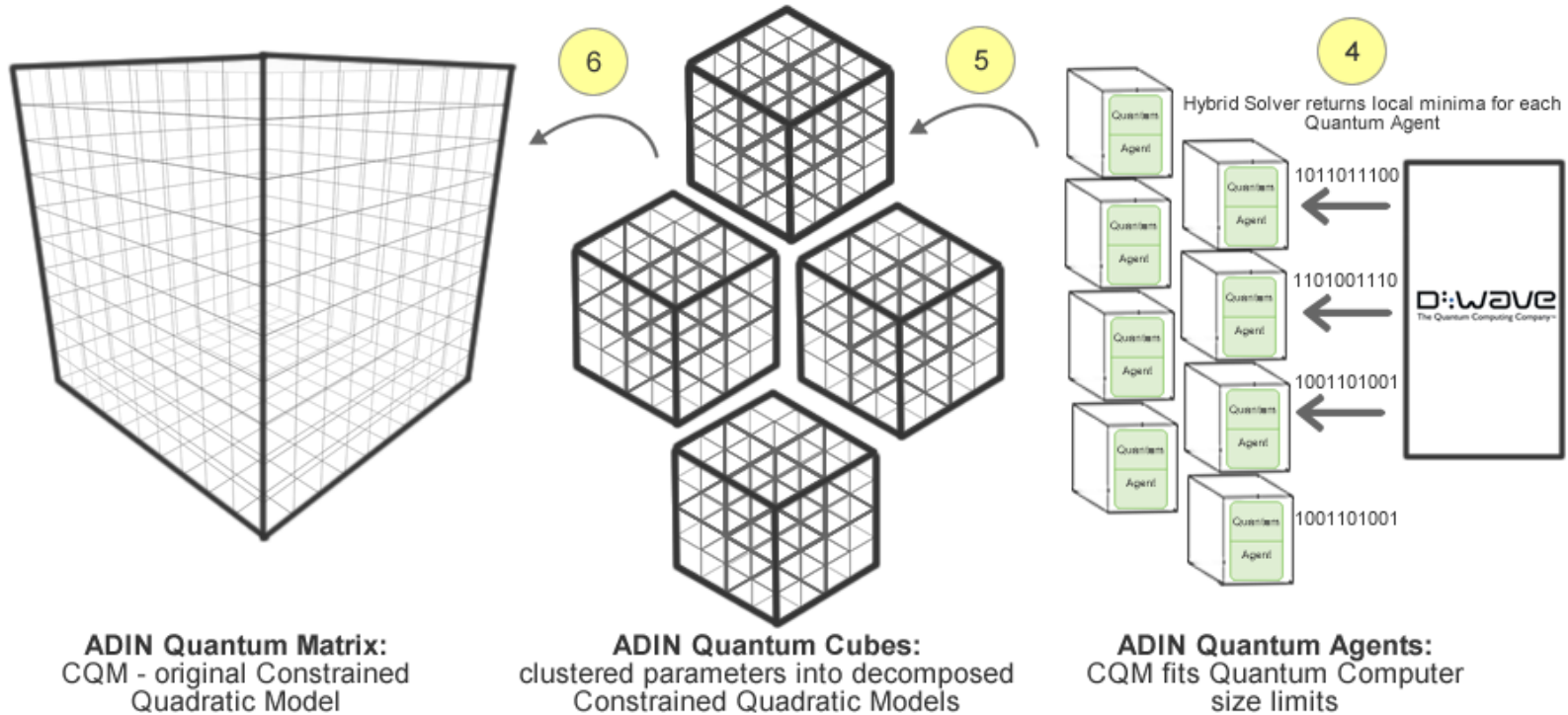
ADIN User Interface allows for introspection at all levels
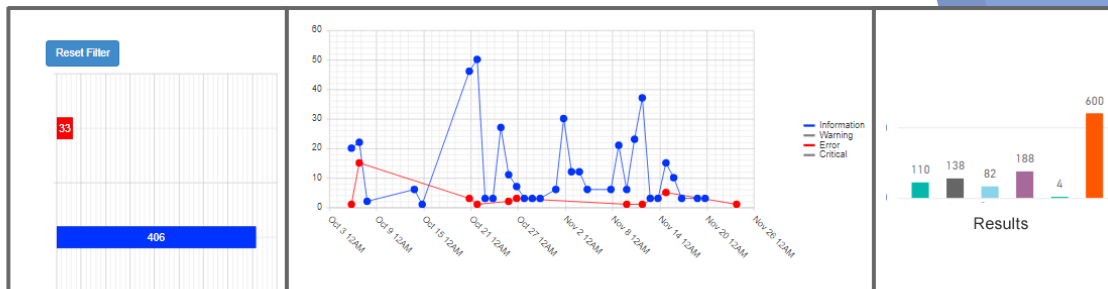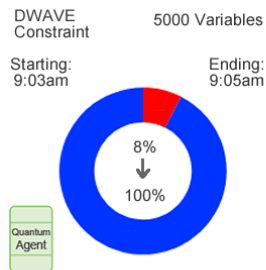
Events (past 60 minutes)	Agents Per Type	Agent Type - MIRA Trackable Events	Events (past 60 minutes)	Agents Per Type	1	2	3	4	5	6	7	8	9
50	6	Mental Emotional Stress - Work	50	6	0	0	0	0	0	0	0	0	0
81	10	Mental Emotional Stress - Parenting	81	10	0	0	0	0	0	0	0	0	0
93	11	Mental Emotional Stress - Traffic	93	11	0	0	0	0	0	0	0	0	0
31	4	Mental Emotional Stress - Relationship	31	4	0	0	0	0	0	0	11638	0	0
84	11	Mental Emotional Stress - Fear	84	11	0	0	0	0	15497	0	0	0	0
27	4	Mental Emotional Stress - Anxiety	27	4	0	0	21169	0	0	0	0	0	0
92	11	Mental Emotional Stress - Financial	92	11	0	0	0	0	0	0	0	0	0
95	11	Illness - No Fever	95	11	0	0	0	0	0	0	0	0	0
85	10	Illness - Fever	85	10	0	0	0	0	0	0	0	0	0
71	9	Pain	71	9	0	0	0	0	0	0	0	0	0
52	6	Pain - Menstrual	52	6	0	0	0	0	0	0	0	0	0
88	10	Pain - Grief	88	10	0	0	0	0	0	0	0	0	0
91	11	Pain - Headaches	91	11	0	0	0	0	0	18309	0	0	0
53	7	O2	53	7	0	0	0	0	0	0	0	0	0
46	6	Glucose Regulation	46	6	0	0	0	0	0	0	0	0	0
91	11	Sleep States - NREM	91	11	0	0	0	0	0	0	0	0	17769
40	5	Sleep States - REM	40	5	0	12184	0	0	0	0	0	13168	0
15	2	Wake State	15	2	0	0	0	0	0	0	0	0	0
19	3	Cell Recycling	19	3	0	0	0	0	0	0	0	0	0
22	3	Temperature Regulation	22	3	0	0	0	0	0	0	0	0	0
79	9	Digestive - Food intake Calories	79	9	0	0	0	0	0	0	0	0	0
75	9	Digestive - Fluid intake	75	9	0	0	0	18429	0	0	0	0	0
100	12	Ovulation	100	12	14127	0	0	0	0	0	0	0	0
78	9	Brain Waves	78	9	0	0	0	0	0	0	0	0	0
80	10	Respiratory Rate	80	10	0	0	0	0	0	0	0	0	0
399	200	TOTALS:	1638	200									

Conclusion: Use proven Agent-based technology to leverage power of quantum and classical computing

- Interfaces to Quantum Computers are challenging and early-stage, limited to large research centers/corporations.

- Constraint Satisfaction Problems (CSP) are common, involving optimization, resource allocation, scheduling and routing.

- ADIN™ provides access to building applications where CSP problems can be solved using quantum agents, along with traditional agents for classical computing.

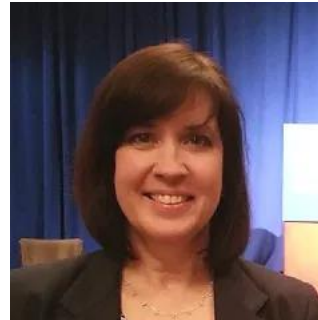- Building the best of both quantum and classical computing worlds.