DRUID-NET

eDge computing ResoUrce allocatIon for Dynamic NETworks

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DRUID-NET Consortium

- National Technical University of Athens, Greece

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- Université catholique de Louvain, Belgium

- École de technologie supérieure (ETS), Montreal, Canada

Scientific Background

- IoT-based applications and Cyber-Physical Systems
  - Interplay between end-devices, sensors and actuators
  - Limited energy and computing capacity of local nodes
  - Time and mission constraints

- Edge Computing
  - Low network latency
  - Virtualization
  - Limited computing resources
  - Dynamic Resource Allocation

DRUID-NET Key Challenges

- Workload Estimation
  - Types of devices
  - Characteristics of network traffic
  - User's mobility behavior

- Application Performance Modeling
  - Mapping of QoS metrics to computing resources
  - Resource heterogeneity

- Resource Allocation
  - Resource Scheduling & Scaling
  - Task Offloading
  - Application Migration
  - Co-design with CPS control algorithms

DRUID-NET Impact

Theoretical Results

- Accurate context-aware estimation for IoT applications
- Accurate MIMO application performance models
- Smart Allocation Strategies with guaranteed properties (Stability, Robustness)
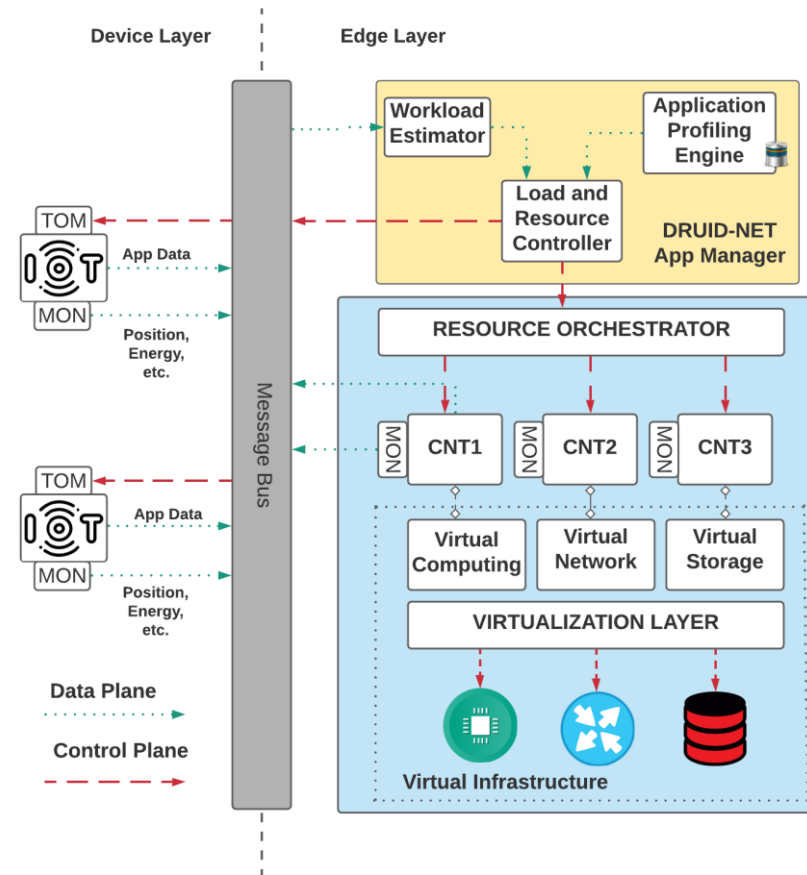- Novel Controllers for CPS

Practical Results

- Architecture Design
- Actual Implementation with well-known cloud and IoT orchestration platforms
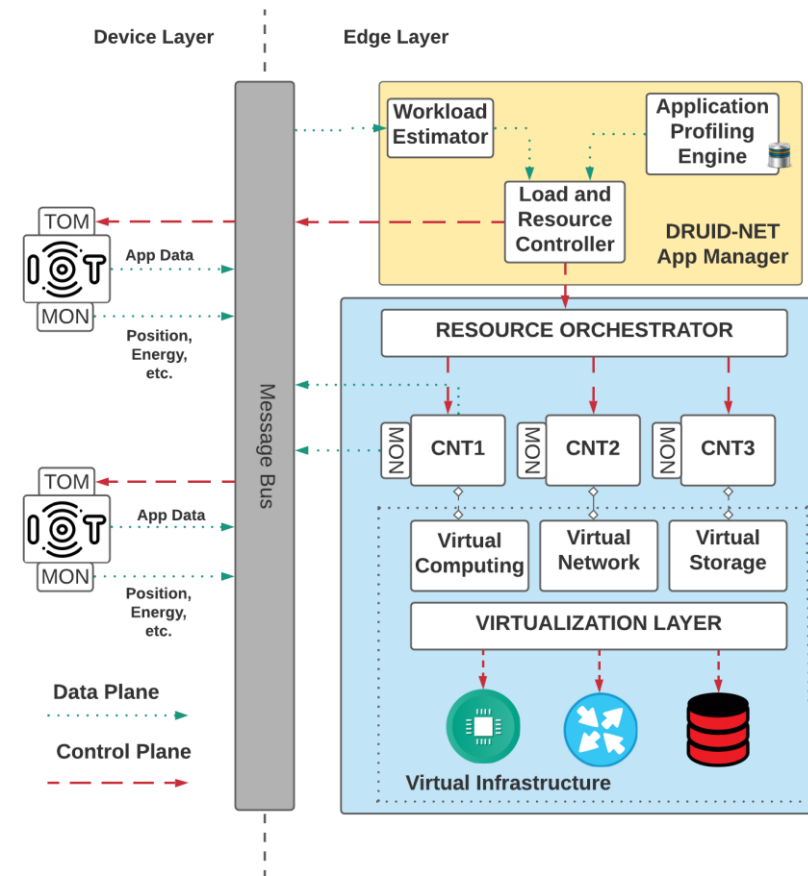- Open reproducible data sets.

DRUID-NET Architecture

- Workload Estimator:
  - Accurate Classifier for device profiling.
  - Application Profiling
    - Creation of real data sets for 6 IoT applications in smart-building environment
    - 5 tested regression-based machine learning algorithms for predicting QoS metrics per application
  - Mobility profiling
    - ML- based mobility prediction
    - ARIMA-based request rate prediction

- Performance Modeling
  - ML-based application performance models

DRUID-NET Architecture

- Resource Allocation
  - Design of an AIMD-based (additive increase multiplicative decrease) resource scheduling and scaling algorithm
  - Implementation with Kubernetes features
  - Task-offloading decision is incorporated with the control algorithms of CPS

Dissemination

Journal Publications

1. Hameed, A., Violos, J., & Leivadeas, A. (2022). A deep learning approach for IoT traffic multi-classification in a smart-city scenario. IEEE Access, 10, 21193-21210.

2. Avgeris, M., Spatharakis, D., Dechouniotis, D., Leivadeas, A., Karyotis, V., & Papavassiliou, S. (2022). ENERDGE: Distributed Energy-Aware Resource Allocation at the Edge. Sensors, 22(2), 660

3. Spatharakis, D., Avgeris, M., Athanasopoulos, N., Dechouniotis, D., & Papavassiliou, S. (2022). Resource-aware Estimation and Control for Edge Robotics: a Set-based Approach. IEEE Internet of Things Journal, Early Access

4. Saeik, F., Avgeris, M., Spatharakis et al. (2021). Task offloading in Edge and Cloud Computing: A survey on mathematical, artificial intelligence and control theory solutions. Computer Networks, 195, 108177.

5. Santi, N., & Mitton, N. (2021). A RESOURCE MANAGEMENT SURVEY FOR MISSION-CRITICAL AND TIME-CRITICAL APPLICATIONS IN MULTIACCESS EDGE COMPUTING. International Telecommunication Union journal (ITU Journal).

6. Dechouniotis D, Athanasopoulos N, Leivadeas A, Mitton N, Jungers RM, Papavassiliou S. Edge Computing Resource Allocation for Dynamic Networks: The DRUID-NET Vision and Perspective. Sensors. 2020 Jan;20(8):2191

Conference Publications

1. Hameed, A., Violos, J., Santi, N., Leivadeas, A., & Mitton, N. (2021, December). A Machine Learning Regression approach for Throughput Estimation in an IoT Environment. In iThings-2021: The 14th IEEE International Conference on Internet of Things.

2. Saeik, F., Violos, J., Leivadeas, A., Avgeris, M., Spatharakis, D., & Dechouniotis, D. (2021, September). User Association and Behavioral Characterization during Task Offloading at the Edge. In 2021 IEEE International Mediterranean Conference on Communications and Networking (MeditCom) (pp. 70-75).

3. Tsanakas, S., Hameed, A., Violos, J., & Leivadeas, A. (2021, November). An Innovative Neuro-Genetic Algorithm and Geometric Loss Function for Mobility Prediction. In Proceedings of the 19th ACM International Symposium on Mobility Management and Wireless Access (pp. 25-32).

4. Santi, N., Foubert, B., & Mitton, N. (2021, May). Comment générer des traces applicatives avec FIT IoT-LAB pour la science ouverte. In CORES 2021–6ème Rencontres Francophones sur la Conception de Protocoles, l'Évaluation de Performance et l'Expérimentation des Réseaux de Communication.

5. Santi, N., Grünblatt, R., Foubert, B., Hameed, A., Violos, J., Leivadeas, A., & Mitton, N. (2021, November). Automated and reproducible application traces generation for IoT applications. In Proceedings of the 17th ACM Symposium on QoS and Security for Wireless and Mobile Networks (pp. 17-24).

6. Vlahakis, E., Athanasopoulos, N., & McLoone, S. (2021). AIMD scheduling and resource allocation in distributed computing systems. *arXiv preprint arXiv:2109.02589*.

7. Ren, W., Calbert, J., & Jungers, R. (2021). Zonotope-based Controller Synthesis for LTL Specifications. arXiv preprint arXiv:2108.00704.

8. Debauche, V., Della Rossa, M., & Jungers, R. M. (2021). Template-Dependent Lifts for Path-Complete Stability Criteria and Application to Positive Switching Systems. IFAC-PapersOnLine, 54(5), 151-156.

9. A. Hameed and A. Leivadeas, "IoT Traffic Multi-Classification Using Network and Statistical Features in a Smart Environment," 2020 IEEE 25th International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD), Pisa, Italy, pp. 1-7.

Dissemination

- Tutorials
    - ECC 2020 - "Control co-design and resource allocation in edge computing and dynamic networks"

- Special Issues
    - Special Issue "Performance, Simulation and Modelling of Sensors Networks in the Context of IoT, Edge Computing, and AI", MDPI Sensors. 3 published articles. **DEADLINE: 20 MAY 2022**

Sustainability/Exploitation

- Synergies with industrial partners
  - Cisco Systems (Canada)
  - Rakuten (Japan)

- Demonstration use-cases
  - Collaborative Robotics
  - Rapid Resource Deployment for Disaster Relief
  - Mobility-aware Edge Computing

- Open Datasets
  - IoT Applications (to be published soon!!!)
  - User Mobility (to be published soon!!!)

Stay tuned on DRUID-NET

Website: https://druidnet.netmode.ntua.gr/

Zenodo Community: https://zenodo.org/communities/chist-era_druid-net/?page=1&size=20

Questions