Chapter 1
Ubiquitous Computing–Enabled Intelligent Control of Discrete Event Systems:
A Cyber–Physical and Data–Driven Approach

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ABSTRACT

Ubiquitous computing (UbiComp) has fundamentally transformed modern computing paradigms by enabling seamless integration of sensing, computation, and communication across distributed and heterogeneous environments (Weiser, 1991). In parallel, Discrete Event Systems (DES) provide a powerful modeling framework for complex systems whose dynamics evolve asynchronously through the occurrence of discrete events, such as manufacturing systems, logistics networks, and intelligent transportation systems (Cassandras & Lafortune, 2009). However, conventional DES control approaches are largely model-driven and rule-based, limiting their adaptability under uncertainty, environmental variability, and partial observability.This study proposes a ubiquitous computing–enabled

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intelligent control framework for DES, grounded in cyber-physical systems (CPS) and data-driven methodologies. The proposed framework integrates pervasive sensing infrastructures, real-time data acquisition, and machine learning–based analytics to enable context-aware and adaptive control decisions.

1. INTRODUCTION

Discrete Event Systems (DES) constitute a fundamental modeling and control paradigm for systems in which state transitions occur as a result of discrete events rather than continuous time evolution. Such systems are widely encountered in manufacturing and production lines, communication and computer networks, transportation systems, healthcare operations, and autonomous robotic platforms (Cassandras & Lafortune, 2009). In DES, events such as machine breakdowns, task completions, or message transmissions trigger state changes, making system behavior inherently asynchronous and often highly complex. Due to their event-driven nature, DES are particularly sensitive to uncertainties, disturbances, and variations in operating conditions.

Conventional control strategies for DES are largely grounded in model-based and rule-driven approaches, including supervisory control theory, Petri nets, and finite automata (Wonham, 2011). While these methods have demonstrated effectiveness in structured and predictable environments, they often rely on predefined system models and static event sequences. As a result, their applicability becomes limited in dynamic, large-scale, or partially observable environments where system conditions evolve rapidly and unpredictably. In modern application domains, DES increasingly operate under conditions characterized by high variability, distributed decision-making, and real-time constraints, exposing the limitations of traditional control mechanisms.

In parallel with the evolution of DES, ubiquitous computing (UbiComp) has emerged as a transformative computing paradigm. Originally envisioned by Weiser (1991), UbiComp emphasizes the seamless embedding of computational capabilities into everyday objects and environments, enabling continuous sensing, pervasive communication, and intelligent