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IoT Technologies

- Security
  - Access Control
  - Awareness and Training
  - Audit and Accountability
  - Security Assessment and Authorization
  - Configuration Management
  - Contingency Planning
  - Identification and Authentication
  - Incident Response
  - Maintenance
  - Media Protection
  - Physical and Environmental Protection
  - Planning
  - Personnel Security
  - Risk Assessment
  - System and Services Acquisition
  - System and Communications Protection
  - System and Information Integrity
  - Program Management
  - Privacy
    - Data-Driven Privacy
- Time Synchronization
  - Reference
    - Clock
      - Oscillator Type
        - Crystal (XT) Oscillator
          - Controlled
            - Free Running
            - Oven Controlled
            - Voltage Controlled
            - Temperature Controlled
            - Calibrated Dual Crystal
          - RC Oscillator
        - Mechanical (MEMS) Oscillator
        - Pendulum / Balance Wheel
        - Atomic Oscillator
      - Oscillator Properties
        - Frequency
        - Phase
        - Drift/Stability
      - Transmission Methods
        - Global Navigation Satellite System (GNSS)
        - Modem (Automated Computer Time Service (ACTS))
        - Optical Timecode Broadcast
        - Radio Timecode Broadcast
        - Internet
    - Local Reference Clock
      - Astronomical
        - Universal Time Coordinated (UTC)
        - Greenwich Mean Time (GMT)
      - Atomic
        - National Atomic Reference (NIST F-2, NPL Cesium, USNO Master Clock, etc.)
        - International Atomic Time (TAI)
    - Peers (Consensus)
    - Standards
  - Algorithms
    - Hardware
      - Frequency Locking (Synchronization)
      - Phase Locking (Synchronization)
      - Temperature Drift Compensation
    - Software
      - Reference Clock Selection
      - Clock Disciplining Algorithms
      - Anomaly Detection
      - Leap Second Compensation
      - System Management
      - Peer Management
  - Timestamp
    - Time Formats
      - Local/Customized
      - W3C Date Time Format
      - XML Schema Data Time
        - ISO 8601
        - RFC 822
      - Posix Time / Epoch Time
    - Traceability
    - Implementation
      - Hardware
      - Firmware
      - Software
    - Resolution
    - Epoch
  - Time Distribution Methods
    - Simple Network Time Protocol (SNTP)
    - Network Protocols
      - Network Time Protocol (NTP)
      - Precision Time Protocol (PTP)
        - White Rabbit
        - Telecom Profile
        - Power Profile
      - Reference Broadcast Time Synchronization (RBS)
      - Time Protocol, Daytime Protocol
    - 10 MHz Analog Reference Signal
    - Pulse-Per-Second (PPS) Signal
    - Mode Locked Optical Signal
    - Inter-Range Instrumentation Group (IRIG)
- Performance
  - Accuracy
    - Offset
    - Jitter
    - Convergence Rate
  - Availability
    - Local Area
    - Wide Area
    - Wireless
    - Wired
    - Interoperability
    - Oscillator Holdover
  - Security
    - Time Code Integrity
    - Reference Clock Authentication
    - Backup Reference Clock
- Complex Systems
  - Self Organization
    - Pattern Spreading
      - Principle of Least Action
        - Space
        - Time
        - Spatiotemporal
      - Adaptation
        - Short Term (Flexibility)
        - Long Term (Evolution)
      - Resilience
        - Short Term (Robustness)
        - Long Term (Survivability)
    - Measurement Signals
      - 1/f Noise
      - Long-Range Dependence
      - Auto-Correlation
      - Self Similarity
        - Fractals
      - Critical Slowing Down
        - Entropy
        - Minimum Description Length
        - Kolmogorov Complexity
      - Information Theory
    - Emergent Behaviors
      - Swarms
      - Stigmergy
      - Social Models
      - Biological Models
        - Self-Interest
        - Altruism
        - Socialism
        - Communism
        - Game Theory
        - Catallaxy
      - Economic Models
      - Equilibrium
        - Oscillation
        - Self-Organized Criticality
        - Punctured Equilibrium
        - Metastability
        - Chaos
      - Phase Transition
  - Self-Organizing Design
    - Physical & Chemical Models
      - Electromagnetism
      - Thermodynamics
      - Molecular Equilibrium
      - Diffusion
      - Phase-Transition Resistance
    - Data Layout
      - Data Compression
      - Data Encryption
      - Record and Block Layout
      - Deduplication
      - Extraction, Transformation, and Loading
      - Data Exchange
      - Data Cleaning
      - Wrappers (Data Mining)
      - Mediators and Data Integration
    - Data Access Methods
      - Multidimensional Range Reach
      - Data Scans
      - Point Lookups
      - Unidimensional Range Search
      - Proximity Search
    - Information Integration
      - Entity Resolution
      - Data Warehouses
      - Federated Databases
    - Middleware for Databases
      - Database Web Servers
      - Application Servers
      - Object-Relational Mapping Facilities
      - Data Federation Tools
      - Data Replication Tools
      - Distributed Transaction Monitors
      - Message Queues
      - Service Buses
      - Enterprise Application Integration Tools
      - Middleware Business Process Managers
    - Database Management System Engines
      - DBMS Engine Architectures
      - Database Query Processing
        - Query Optimization
        - Query Operators
        - Query Planning
        - Join Algorithms
      - Database Transaction Processing
        - Data Locking
        - Transaction Logging
        - Database Recovery
        - Record and Buffer Management
      - Parallel and Distributed DBMSs
        - Key-Value Stores
        - MapReduce-Based Systems
        - Relational Parallel and Distributed DBMSs
    - Theory
      - Data Exchange
      - Data Provenance
      - Data Modeling
      - Database Query Languages (Principles)
      - Database Constraints Theory
      - Database Interoperability
      - Data Structures and Algorithms for Data Management
      - Database Query Processing and Optimization (Theory)
      - Data Integration
      - Logic and Databases
      - Theory of Database Privacy and Security
      - Incomplete, Inconsistent, and Uncertain Databases
    - Design and Models
      - Graph-Based Database Models
        - Hierarchical Data Models
        - Network Data Models
      - Relational Database Model
      - Entity Relationship Models
      - Physical Data Models
      - Semi-Structured Data
        - Data Streams
        - Data Provenance
        - Incomplete Data
        - Temporal Data
        - Uncertainty
        - Inconsistent Data
      - Data Model Extensions
    - Database Administration
      - Database Utilities and Tools
      - Database Performance Evaluation
      - Autonomous Database Administration
    - Query Languages
      - Data Dictionaries
      - Relational Database Query Languages
        - Structured Query Languages
        - XPath
        - XQuery
      - XML Query Languages
        - MapReduce Languages
      - Query Languages for Non-Relational Engines
    - Call Level Interfaces
  - Discoverable Items
    - Service Descriptions
    - Repository Descriptions
    - Administrative Scopes
    - Service Types
  - Configuration Discovery and Monitoring
    - Lazy Discovery
    - Aggressive Discovery
    - Directed Discovery
    - Monitoring Discoveries
  - Registration and Extensions
    - Registration Types
    - Registration Process
    - Extension Process
      - Service-Description Discovery with Repositories
      - Service-Description Discovery without Repositories
      - Service-Description Monitoring without Repositories
      - Notification
      - Polling
  - Service-Description Discovery and Monitoring
    - Primary Discovery
      - Discovery Consistency
    - Secondary Discovery
      - Registration Consistency
      - Update Consistency
      - Discovery Discard
      - Description Discard
      - Registration Discard
      - Discard Consistency
  - Consistency Guarantees
    - Fixed Assignment
    - Random Assignment
    - Requested Assignment
    - Adaptive Assignment
    - Priority Assignment
    - Greedy Scheme
    - Partition Scheme
    - Weighted Scheme
    - Balanced Scheme
    - Balanced-Partition Scheme
    - Extension Policy
    - Replica Selection
  - Limitations and Open Issues
    - Limited Scalability
    - Incomplete Design of Logical Partitioning Schemes
    - Unsupported Notification of Changes to Repository Descriptions
    - Underspecified Interactions between Service Providers and Service Discovery Entities
    - Insufficient Specification of Relationship between Service Description and Evertable Variables
    - Failure to Consider Resource Constraints in Devices
  - Variable Discovery and Monitoring
    - Random Response Strategy
    - Timed Response Strategy
      - Probabilistic Response
      - Multicast Implosion Avoidance
    - Timed Response
  - Performance Considerations
  - Service Discovery
  - Databases
    - Theory
    - Database Management System Engines
    - Middleware for Databases
    - Information Integration
    - Data Access Methods
    - Data Structures
      - Data-Centric Consistency Models
      - Client-Centric Consistency Models
      - Consistency Protocols
        - Replica Placement
        - Update Propagation
        - Epidemic Protocols
        - Distributed Protocols
          - Primary-Base Protocols
          - Replica-Write Protocols
          - Cache-Coherent Protocols
      - Consistency and Replication
        - Failure Masking and Replication
        - Agreement in Faulty Systems
        - Remote Procedure Call Semantics in the Presence of Failures
        - Reliable Multicasting
        - Scalable Reliable Multicasting
        - Automatic Multicast
        - Process Resilience
        - Reliable Client-Server Communications
        - Reliable Group Communications
      - Fault Tolerance
        - Two-Phase Commit
        - Three-Phase Commit
        - Distributed Commit
          - Checkpointing
          - Message Logging
          - Recovery
      - Distributed Transactions
        - Models
        - Concurrency Control
        - Mutual Exclusion
        - Election Algorithms
        - Global State
        - Physical
        - Logical
        - Clocks
        - Naming
        - Locating
        - Garbage Collection / State Reference Removal
      - Synchronization
      - Services/Entities
      - Code Migration
    - Distributed Systems
      - Network Management
      - Device Management
      - Resource Management
      - Service Management
      - Security Management
      - Privacy Management
      - Safety Management
      - Business Management
      - Quality of Service (QoS) Management
      - System Monitoring
      - Cross-Layer Management
    - Management Functions / Risk Management
  - Cloud Computing
    - Service Models
      - SaaS
      - PaaS
      - IaaS
    - Deployment Models
      - Private
      - Community
      - Public
      - Hybrid
    - Characteristics
      - Self-Service
      - Broad Network Access
      - Pooled Resources
      - Elastic
      - Metered/Measurable
      - Interoperable
  - Big Data
    - Data Providers
      - Data Capture from Sources
      - Data Persistence
      - Data Annotation / Metadata Creation
      - Access Right Management
      - Access Policy Contracts
      - Data Distribution APIs
      - Capabilities Hosting
      - Data Availability Publication
    - Data Consumers
      - Search & Retrieve
      - Download
      - Analyze Locally
      - Reporting
      - Visualization
      - Use for Their Own Processes
    - System Orchestrator
      - Business Ownership Requirements and Monitoring
      - Governance Requirements and Monitoring
      - Data Science Requirements and Monitoring
      - System Architecture Requirements and Monitoring
    - Application Providers
      - Data Collection Processes
      - Data Curation Processes
      - Data Analytics Processes
      - Visualization
      - Access
    - Framework Providers
      - Infrastructures
      - Platforms
      - Processing Frameworks
    - System Management
      - Provisioning
      - Configuration
      - Package Management
      - Software Management
      - Backup Management
      - Capability Management
      - Resource Management
      - Data Management
      - Performance Management
      - Security & Policy Management
    - Security and Privacy
      - Policy Requirements
      - Monitoring
    - Data Scrubbing
      - For Personally Identifiable Information (PII)
      - For Randomization (For Implicit PI)
  - Computing
- Networking
  - Transmission Medium
    - Wired
      - Cables
        - Optical Fiber
        - Power Line Communications (PLC)
      - Wireless
        - Radio Frequency (RF)
          - Network Variety
            - Cellular Telephony (3G/4G Wireless)
            - Wireless Local Area Networks (WLAN)
            - Wireless Personal Area Networks (WPAN)
            - Satellite Communications (SATCOM)
          - Spectrum Allocation
            - Licensed
            - Unlicensed
            - Opportunistic Spectrum Access (OSA) / Cognitive Radio (CR)
        - Infrared
        - Free Space Optical
  - Communication Protocols
    - OSI Protocol Stack
      - Physical Layer
        - Modulation
        - Coding
        - Channel Equalization
      - Data Link Layer
        - Medium Access Control (MAC)
        - Logical Link Control
      - Network Layer
        - IPv4
        - IPv6
        - X.25
      - Transport Layer
        - Transmission Control Protocol (TCP)
        - User Datagram Protocol (UDP)
      - Session Layer
      - Presentation Layer
      - Application Layer
        - Session Initiation Protocol (SIP)
        - Real-Time Transport Protocol (RTP)
    - Other Protocol Stacks
  - Quality of Service (QoS)
  - Widely-Used Standards
    - Wired
    - Wireless
  - Topology
    - Point-to-Point
    - Bus
    - Star
    - Ring
    - Daisy Chain
    - Mesh
    - Tree
    - Ad Hoc
- Situation-/Context-Awareness
  - Sensors
    - Motion
      - Accelerometer
      - Gyroscope
    - Magnetometer
    - Environmental
      - Temperature
      - Humidity
      - Barometric Pressure
      - Wind Speed
      - Seismic
      - Light/Photometer
      - Gravimeter
    - Acoustic
      - Audio
      - Sound
      - Ultrasound
        - Photographic
        - Infrared
      - Still/Video Imagery
        - Light Detection and Ranging (LiDAR)
      - Biologic
      - Range Finder
    - Global Navigation Satellite System (GNSS)
      - Global Positioning System (GPS)
      - Globalnaya Navigatsionnaya Sputnikovaya Sistema (GLONASS)
      - Galileo
  - Actuators
    - Hydraulic
    - Pneumatic
    - Electric
    - Mechanical
    - Piezoelectric
    - ElectroActive Polymers (EAP)
  - Controls
  - Applications
    - At Data Centers and in the Cloud
    - At Mobile Devices and Wireless Sensor Nodes
      - Data Fusion
        - Kalman Filtering
        - Particle Filtering
        - Graphical Models
        - Distributed Inference
      - Data Services
        - Storage
        - Archiving
        - Transformation
        - Indexing
        - Data Aging
        - Query Interface
        - Visualization
        - Tools and Libraries
      - Distributed Signal Processing
        - Sampling and Data Collection
        - Compression
        - Detection
        - Classification
        - Localization
        - Tracking
        - Array Signal Processing
        - Direction of Arrival Estimation
          - Beamforming
      - Sensor Tasking and Control
        - Information Utility and Cost Functions
        - In-Network Aggregation
        - Multi-Scale Summarization
        - Query Optimization and Processing
      - Collaborative Infomation Processing
        - Cluster and Leader Election Protocols
        - Distributed Routing
        - Fault Tolerance
      - Sensor Group Management
    - Data Analytics
  - Energy Consumption
    - Energy Efficiency
      - Energy Efficiency at Various Layers of OSI Protocol Stack
        - Data Link Layer
          - Need to be low power in order to last for a long time.
          - Smart battery discharge schedule can lead to natural recharging and longer battery life.
          - Sensing Schedule
            - On a Continuous Basis
            - Periodic On/Off
            - Event-Based (Use a lower power, less precise sensor to detect an event of interest and wake up the higher precision sensor.)
          - Data Processing Techniques, e.g. Clustering Algorithms and Data Aggregation
          - Radio Power Consumption Modes
            - Off
            - Tx
            - Rx
            - Standby
            - Circuitry Start-Up
          - Switching Cost (If possible, transmit for many time slots and then receive for many time slots.)
          - Reducing energy consumption at one layer may result in increased energy consumption at another.
          - If possible, use cross-layer design (e.g., by setting Tx power, ARQ/FEC, scheduling, and routing (in case of ad hoc networks) together and preferably using a distributed algorithm) to achieve optimum tradeoff between QoS and energy efficiency.
          - Be mindful of packet header overhead (long vs. short packets).
        - PHY Layer
          - Energy-Efficient Coding anf Modulation Schemes
          - Channel Equalization
        - Network Layer
          - Take channel conditions into account. No sense in transmitting when the channel conditions are poor.
          - Reduce chances of packet collisions, because they may lead to retransmissions, which consume more energy.
          - One may schedule transmissions and receptions, e.g. to avoid receiving a packet that does not belong to you. The cost is the need to compute the schedule and communicate it to all.
          - Whenever possible, schedules should be computed by base stations.
          - Scheduling algorithm may consider remaining battery energy of a node in addition to connection priority.
          - Mobile device can rearrange time slots allocated to it among its flows.
          - Mobile device should request for multiple time slots in one reservation request.
          - Keep radio in standby mode or even let it go to sleep when not needed.
          - Take advantage of the broadcast nature of wireless transmissions for broadcast/multicast traffic.
          - Combined FEC/ARQ for Energy Conservation
          - ARQ Probing Method as a Means for Energy Conservation
          - In ad hoc networks, the routing protocol should not simply minimize energy consumption, but it should maximize network lifetime.
          - Ensure all nodes run out of battery energy at roughly the same time.
          - Avoid routing through nodes with low battery energy.
          - Select frequency of routing table updates judiciously.
          - What route to use depends also on the nature of traffic (unicast/broadcast/multicast).
          - Use transmit power as a means for topology control.
        - Transport Layer
          - It is important to distinguish between network congestion and loss due to wireless links (deep fades, handoff).
          - Split Connection
            - Link-Layer
            - End-to-End
          - Protocols to Mitigate TCP Problems over Wireless Links
        - Application Layer
          - Load Partitioning Between Mobile and Base Station
          - Cloud Computing
          - Proxies – Middleware that adapts applications to changes in battery energy and bandwidth.
          - Energy-Efficient Query Optimization in Database Systems
          - Power-Aware Video Processing
      - Operating System (OS) Level Energy Efficiency
        - Dynamically control power consumption by varying supply voltage. This affects CPU operating speed, but techniques such as pipelining and parallelism can be used to increase processing speed.
        - Suspend operation of disk, memory, or display when prolonged inactivity is detected.
        - Predictive Shutdown of CPU / Power-Aware CPU Scheduling
        - Memory Page Allocation
        - Appropriate Performance Metric: Energy-Delay Product
    - Energy Harvesting
      - Energy Source Classification
        - Uncontrollable but predictable, e.g. solar energy
        - Uncontrollable and unpredictable, e.g. vibrations
        - Fully controllable, e.g. self-powered flashlights that can be operated by continuously squeezing a hand lever
        - Partially controllable, e.g. when RFID tags get the necessary RF energy from an RFID reader
      - Environmental Energy Sources
        - Solar Cells
        - Wind Turbines
        - Piezoelectric
        - Biochemical
        - Vibrations
        - Motion-Based
      - Spatiotemporal Model for Variability of Harvested Power (e.g. a Solar Cell)
      - Methods for Learning the Spatiotemporal Variability of Harvested Power
      - Power Consumption Model for Network Node (e.g. a Sensor Node) Powered by Energy Harvesting
      - The operational load in a distributed network may be redistributed among network nodes to match the spatiotemporal profile of available harvested power to maximize network lifetime.
      - Power Management Algorithms
        - Energy Harvesting as a Supplement to Battery Energy: Maximize the lifetime of the network node while meeting its functional requirements.
        - Obtain the best possible performance from the network node that can be supported with the available harvested energy.
      - Energy Storage
        - Devices
          - Modes of Usage
            - Energy Neutral Systems (Relying on Energy Harvesting Only)
              - May have to settle for lower performance for the network node than otherwise could be achieved if energy consumption was not an issue.
              - The network node can potentially function forever.
            - Either mode may use a device for buffering/storing energy.
          - Rechargeable Batteries, e.g. Li-Ion, NiCd, NiMH
          - Ultracapacitors
      - Performance-Limiting Factors
        - Inefficiency: Energy stored is always less than the energy supplied.
        - Leakage
        - Required charging current and/or voltage is high for certain batteries.
        - Battery storage capacity degrades with multiple charge-discharge cycles.
  - Localization and Tracking
    - Modeling
      - Types of Context
        - Control Actions in Response to Context
        - Personal Experience
        - Accessibility Support
          - Matching to Context
            - Content Guidelines
            - Product Design Requirements and Guidelines
            - Roles and Permissions
            - Assistive Technologies
            - Adaptive Devices
            - General
            - Sector-Specific
          - Personal Needs, Preferences, and Requirements
        - Operating Environment
          - Outdoor
            - GPS/GNSS
            - Star Tracker
          - Both
            - Inertial Navigation System (INS)
            - Tower-Based (Cellular Telephony)
            - Still/Motion Imagery
            - Signals of Opportunity (e.g. TV and Radio Stations)
          - Indoor
            - RF-Based
              - Received Signal Strength (RSS) Based
              - Proximity-Based (e.g. RFID-Based)
              - Time of Arrival (TOA) / Time Difference of Arrival (TDOA)
              - Angle of Arrival
              - Range/Pseudo-Range Finder
              - Altimeter
              - Acoustic Sensor
              - Ultrasound Sensor
          - Sensor Types Used
            - Unimodal Systems
            - Multimodal/Hybrid Systems
        - Human User Context
          - Computing Context
            - Network Connectivity
            - Communications Cost/Bandwidth
            - Nearby Resources
          - User Profile
          - Social Situation
          - Human Activity
        - Physical Context
          - Location Context
            - Semantic (Home, Office, Theatre, Hospital, Airport, etc)
            - 3D Global Coordinates
          - Time Context
            - Time of the Day
            - Day of the Week
            - Month/Season
            - Year
          - Environmental Hazards
            - Lighting
            - Background Noise
            - Traffic Conditions
            - Weather Conditions (Temperature/Humidity/Rain/Snow)
            - Presence of People and Animals
            - Air Quality
            - Gaseous Conditions
            - Dust/Particulates
        - IoT Device Context
          - Device/Service State
            - On
            - Off
            - Dormant/Listening
            - Paging/Polling
          - Personal Device
            - Display
              - Size
              - Resolution
              - Dynamic Range
              - Refresh/Frame Rate
            - Sound
            - Sensor Specifications
            - Actuator Specifications
    - Methodologies
      - Automotive
        - Cruise Control
        - Engine Control
        - Electric and Hybrid-Electric Vehicles
        - Powertrain Control
        - Transmission Control
        - Vehicle Dynamics Control
        - Automated Highway Control
      - Aerospace
        - Aircraft Flight Control
        - Air Traffic Management (ATM)
        - Satellite Control
        - Control of UAVs
        - Launch Vehicle Control
        - Flocking and Swarm Stability
      - Industrial
        - Process Control in Semiconductor Manufacturing
        - Statistical Process Control for Discrete Manufacturing
        - Control of Machine Tools and Machining Processes
        - Control of Polymerization Processes
        - Control of Porous Thin Film Growth
        - Scheduling of Batch Plants
        - MPC for Batch Processes
        - Programmable Logic Controllers
        - Flat Strip Metal Processing
        - Control of Micro and Nano Structures
        - PID Control
        - Control in Printing as a Feedback System
      - Robotics
        - Flexible Robots
        - Parallel Robots
        - Underactuated Robots
        - Walking Robots
        - Robot Force Control
        - Robot Grasp Control
        - Robot Motion Control
        - Robot Teleoperation
        - Robotic Surgery
      - Power and Electric Energy Systems
        - Control of Brushless DC Motors
        - Hybrid MPC of the Boost Converter
        - Active Power Control of Wind Power Plants
        - Control of Distributed Energy Resources
        - MPC for Power Networks
        - Power System Voltage Stability and Control
        - Singular Perturbations and Coherency in Power Graid Dynamics
        - Electric Energy Transfer and Control
        - Fast Detection and Localization of Power Grid Blackouts
        - Demand Response Management
      - Biological and Medical
        - Control of Biotechnological Processes
        - Model-Based Control of Biochemical Reactors
        - Drug Discovery and Delivery
        - Biochemical Networks
        - Synthetic Biology
      - Marine and Submarine Vessels
        - Control of Networks of Underwater Vehicles
        - Dynamic Positining Control Systems for Ships and AUVs
        - Underactuated Marine Control Systems
        - Motion Planning for Marine Control Systems
        - Control of Ship Roll Motion
        - Collision Avoidance for Maritime Traffic
        - Control for Deep Underwater Sampling
      - Economics and Finance
        - Stochastic Control for Construction of Portfolios of Financial Assets
        - Modeling of Consumer Investment
        - Modeling of Financial Markets
        - Optimal Inventory Theory
        - Option Theory
        - Cash Management
    - Nonlinear Control
      - Zero Dynamics
      - Output Regulation
      - Feedback Linearization
      - Differential Geometric Methods
      - Lie-Algebraic Methods
      - Controllability and Observability
      - Observer Design
      - Time-Scale Separation and Singularly Purturbed Systems
      - Control of Non-Holonomic and Underactuated Systems
      - Variable Structure & Sliding Mode Control Design
      - Control of Chaotic Motion
      - Hybrid Observers
      - Hybrid Feedback Control
    - Decentralized and Distributed Control
      - Decoupling by Decentralized Feedback
      - Control of Networked and Multi-Agent Systems
      - Passivity for Network Stability and Distributed Control
      - Distributed Optimization
      - Intelligent Control
      - Averaging Algorithms and Consensus
      - Team Solutions Under Decentralized Information
      - Non-Classical Information Patterns
      - Flow Control Over Communication Networks
    - Quantized, Digital Control
      - Control Over Digital Networks
      - Design Under Data Rate Constraints
      - Sampled Data Control
      - Optimum Quantization
      - Performance Limitations
      - Control Over Lossy Networks
      - Symbolic Control
    - Control of Distributed Parameter Systems
      - Control of Heat Equations
      - Control and Stabilization of Fluid Flows
      - Control of Schrodinger Systems
      - Boundary Control of PDEs via Backstepping
      - Control of Systems with Delays
    - Adaptive Control and Learning
      - Model Reference Adaptive Control
      - Self-Tuning Regulator
      - Switching-Adaptive Control
      - Robust Adaptive Control
      - Stochastic Adaptive Control
      - Extremum Seeking
      - Iterative Learning
    - Robust Control
      - Kalman-Yakubovich-Popov Lemma
      - Fundamental Limitations
      - Gap Metric
      - Structured Singular Values
      - H-Infinity Control
      - Robust Servomechanism Design
      - Robustness with Real Parametric Uncertainty
      - Multivariable Poles, Zeros, and Pole-Zero Cancellation
      - Stability Robustness to Unstructured Uncertainty
      - Balanced Realizations and Model Order Reduction
      - Fault Tolerant Control
    - Model-Predictive Control (MPC)
      - Moving Horizon Estimation and Control
      - Distributed MPC
      - Explicit MPC
      - Robust MPC
    - Game Theory
      - Auction Theory
      - Mechanism Design
      - Nash Equilibrium
      - Hierarchical (Stackleberg) Equilibrium
      - Evolutionary Stable Equilibrium
      - Correlated Equilibrium
      - Sub-Game Perfect Policies
      - Mean Field Games
    - Computational Algorithms
      - Gradient Methods
      - Conjugate Gradient Methods
      - LMI Methods
      - Approximate Dynamic Programming
      - Neuro Dynamic Programming
      - Neutral-Net Based Approximations
    - Optimal Control
      - Calculus of Variations
      - Dynamic Programming
      - Maximum Principle
      - Linear Quadratic Regulator Control
      - Discrete- and Continuous-Time Riccati Equations
      - H-Infinity Optimal Control
      - Linear Matrix Inequalities
      - Quantitative Feedback Theory (QFT)
      - Spectral Factorization
    - Estimation and Filtering
      - Least Squares Estimation
      - Wiener Filtering
      - Kalman Filtering
      - Extended Kalman Filter
      - Nonlinear Filters
      - Particle Filters
    - Identification
      - Non-Parametric Techniques
      - Frequency Domain Methods
      - Time Domain Methods
      - Subspace Techniques
      - Coverification, Regularization, and Relaxation
    - Stability
      - Lyapunov Stability
      - Input-Output Stability
      - Input-to-State Stability
    - Stochastic Control
      - Linear-Quadratic-Gaussian Control
      - Separation and Certainty Equivalence
      - Dynamic Programming and HJB Equation
      - Stochastic Maximum Principle
      - Stability of Stochastic Systems
      - Risk-Sensitive Stochastic Control
      - Supervisory Control of Discrete Event Systems
      - Perturbation Analysis of Discrete Event Systems
    - Linear Systems
      - [no text]
      - Time Domain
      - Frequency Domain
      - Polynomial and Matrix Fraction Descriptions
    - Nonlinear Systems
      - Discrete Time
      - Continuous Time
      - Variable Structure
    - Distributed Parameter Systems
      - Hyperbolic Systems
      - Parabolic Systems
      - Linear Systems
      - Nonlinear Systems
    - Stochastic Systems
      - Discrete Time Markov Processes
      - Finite State Markov Chains
      - Discrete Event Systems, Petri Nets
      - Stochastic Differential Equations
      - Linear Gaussian Systems
      - Nonlinear Systems
    - Networked Systems
      - Graphs and Neighborhoods
      - Multi-Agent Systems
      - Communication Networks
      - Mobile Ad Hoc Networks
    - Hybrid and Switching Systems
      - Dynamical Systems
      - Event-Triggered Systems
      - Self-Triggered Systems
  - Games
    - Cooperative Games
    - Non-Cooperative Games
    - Static Games
    - Dynamic Games
    - Stochastic Games
- Unique Identification
  - "Things" Needing Identification
    - Objects
      - Physical Objects
      - Network Elements (Cyber Objects)
      - Software/Content/Data (Virtual Objects)
    - Events
    - Persons
      - Real
      - Legal
    - Locations of "Things" and Events
      - Global Coordinate System
      - Local Coordinate System
      - Relative Coordinate System
      - Civic Coordinate System
      - Database Reference System (e.g., DUNS, ZIP, GLN)
      - Internet Address (e.g., DNS, URL, IP Address)
    - Time Instance of Occurence of Events
      - Global Time (e.g., UTC)
      - Local Time
    - Optically Readable Media
      - Linear Bar Code Symbols
      - 2D Symbols
      - OCR
    - RFID
      - 433 MHz
      - 860 - 960 MHz
      - 2450 MHz
      - UHF
      - 13.56 MHz (ISO/IEC 18000-3)
      - 13.56 MHz (NFC)
      - 13.56 MHz (Smart Card)
      - HF
      - LF
    - Technologies/Media
  - Database Reference for Persons
  - Biometrics and Identity Management
    - Biometrics Modalities
      - Friction Ridge
      - Finger
        - Finger Geometry
        - Finger Skeleton
      - Face
      - Iris
      - Eye
        - Retina
      - Hand Geometry
      - Palm
      - DNA
      - Voice
      - Vein Pattern
      - Keystroke
      - Gait
      - Ear Shape
      - Dynamic Signature
    - System Components
      - Data Capture
      - Data Storage
      - Signal and Image Processing
        - Enhancement and Segmentation
        - Feature Extraction
        - Quality Assessment
      - Comparison
      - Decision
      - Administration
      - Interfaces
      - Enrollment
      - Functions
        - Verification
        - Identification
        - Quality
        - Liveness
        - Template Protection
        - Recognition
        - Processing
  - Interface Devices
    - Fixed Position Devices
      - Symbol Reader
      - RFID Reader
      - IC Card Reader
    - Mobile Devices
      - Mobile Phones
        - IC Card Interface
        - Symbol Interface
        - RFID Interface
      - Handheld Symbol Reader
      - Handheld RFID Reader
    - Localization and Tracking Devices

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