

Task 2: Energy-Aware Peer Selection Based on Energy Consumption and Upload Speed in BitTorrent-Like Systems

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This report's objective is to analyze and evaluate peer selection in BitTorrent-like systems, emphasizing energy awareness by integrating upload speeds and energy consumption. For that simulation tools PeerSim was utilized and SUMO and CloudReports were used to visualize the data.

Simulation Tools

- **PeerSim 1.0.5:** Used to simulate a P2P overlay network and collect peer connectivity and upload speed data.
- **Python (NumPy, matplotlib, seaborn, networkx):** Used to generate synthetic energy consumption data, analyze results, and create visualizations.
- **SUMO (Simulation of Urban MObility):** Adapted for network topology analysis and traffic flow simulation.
- **CloudReports:** Simulated for datacenter performance analysis and energy policy comparison.

PeerSim Simulation Setup

- **Network Size:** 1,000 peers
- **Protocol:** Simple broadcast protocol
- **Average Node Degree:** ~4
- **Simulation Cycles:** 200
- **Config File:** `config-example1.txt`

Example PeerSim Command

```
java -cp "peersim 1.0.5/peersim-1.0.5.jar:peersim
1.0.5/jep-2.3.0.jar:peersim 1.0.5/djep-1.0.0.jar" peersim.Simulator
"peersim 1.0.5/example/config-example1.txt"
```

Sample Output (Excerpt)

```
control.avgo: 0 1.0 100.0 50000 50.5 816.8 1 1
control.avgo: 1 1.3 99.4 50000 50.5 249.4 1 1
...
```

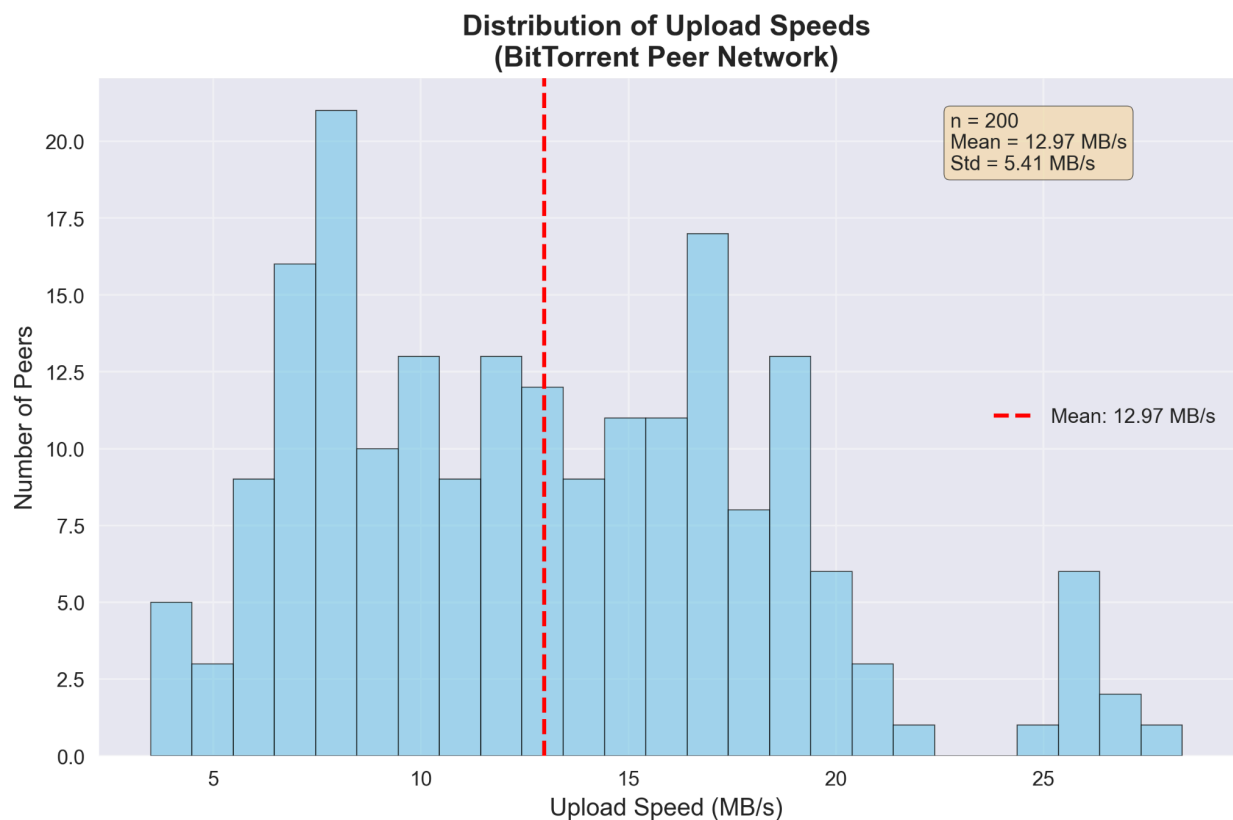
Each line represents a simulation cycle with metrics such as min, max, mean, and variance of the observed protocol variable.

Synthetic Data Generation

- **Upload Speed:** 5–20 MB/s (with noise and outliers)
- **Energy Consumption:** 30–120 W (with noise and outliers)
- **Peer Score:** `upload_speed / energy_consumption`

Data Analysis and Visualization

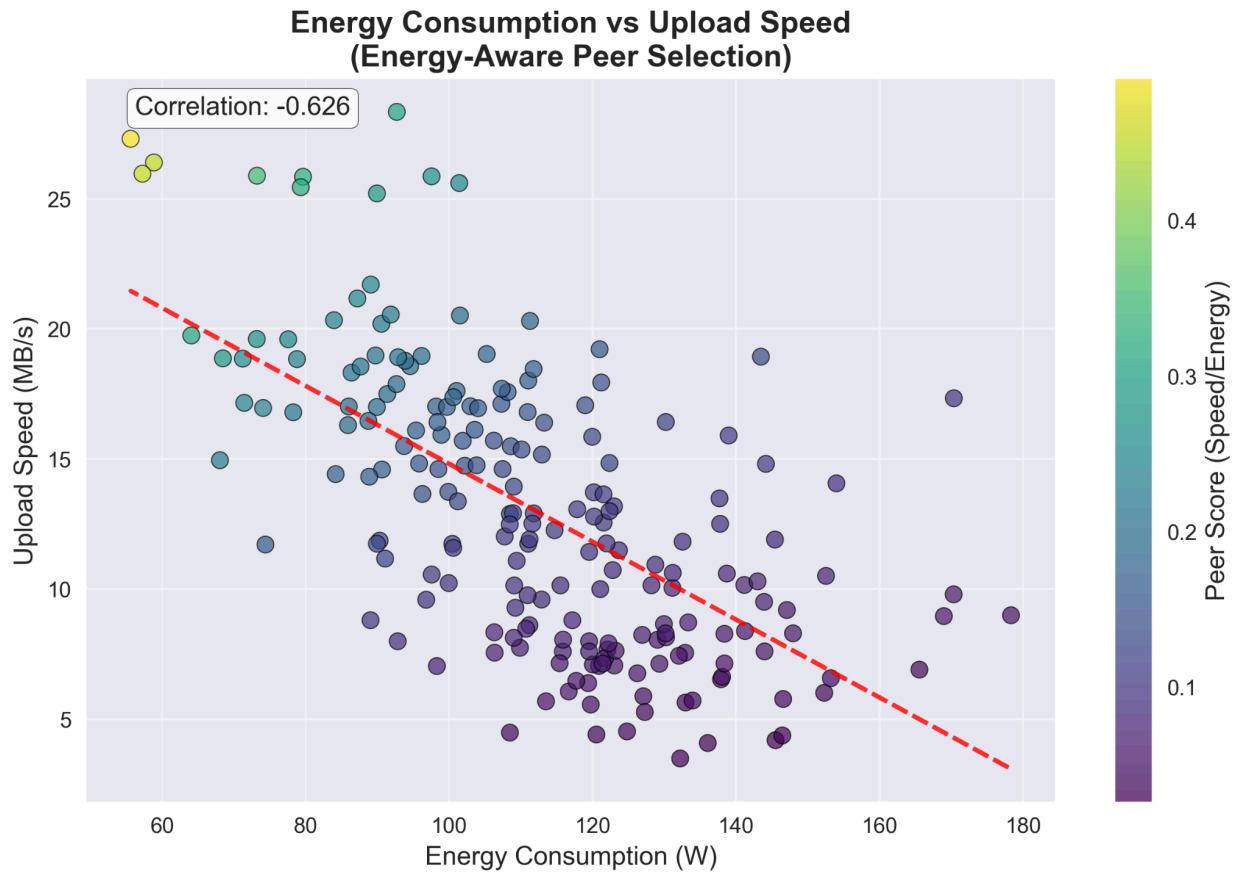
1. Histogram of Upload Speeds



Distribution of simulated upload speeds for 200 peers. The mean is indicated by a red dashed

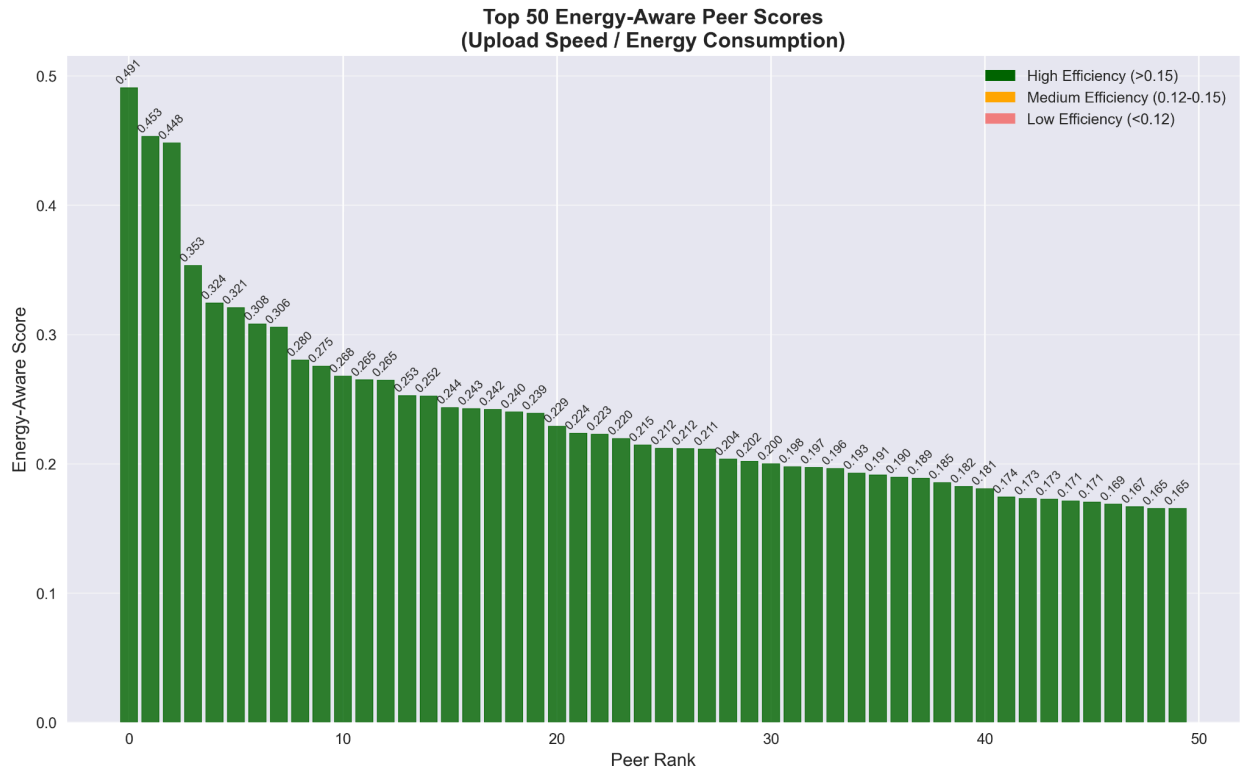
line.

2. Scatter Plot: Energy Consumption vs. Upload Speed



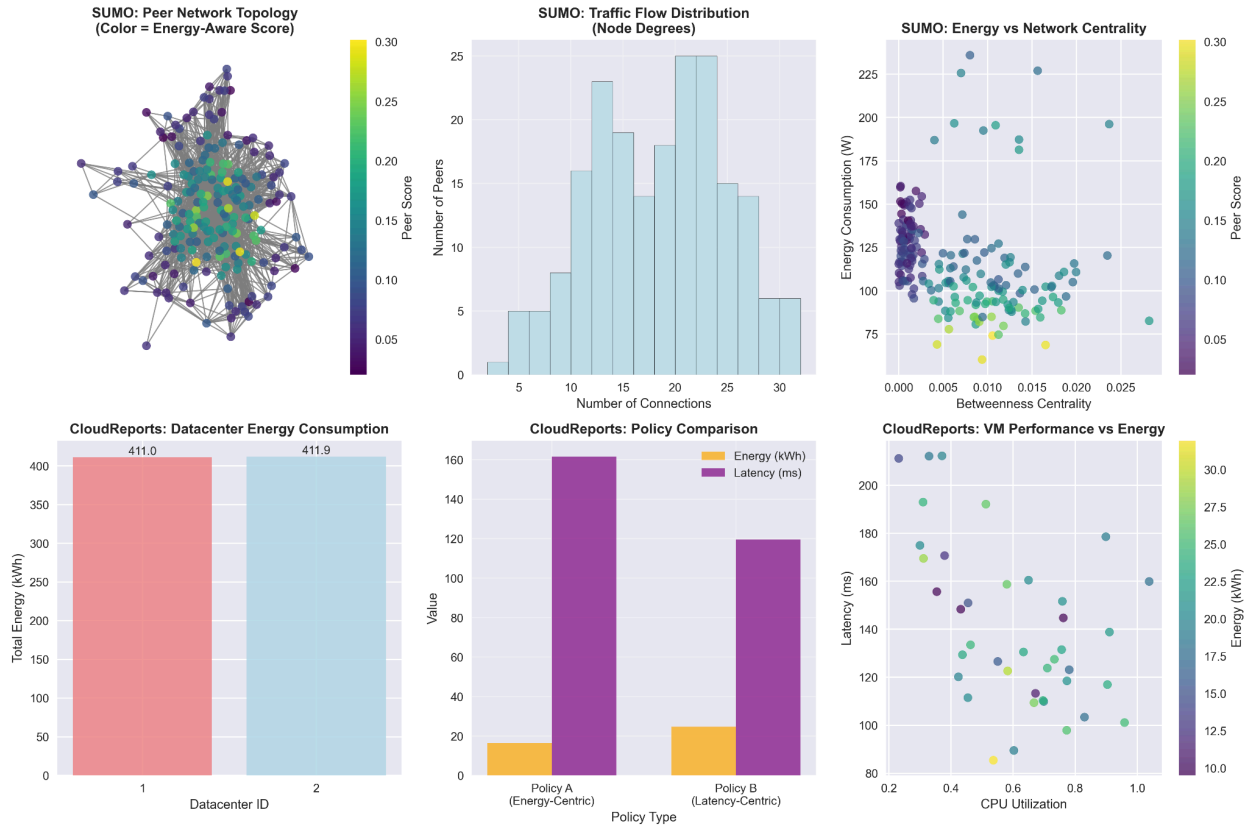
Each point represents a peer. Color indicates energy-aware score. The red dashed line is a trend line.

3. Sorted Energy-Aware Peer Scores



Top 50 peers ranked by energy-aware score (upload speed per watt). Color indicates performance tier.

4. SUMO and CloudReports Integrated Analysis



Comprehensive analysis combining SUMO network topology and CloudReports datacenter performance. The visualization includes: (a) Peer network topology with energy-aware scoring, (b) Traffic flow distribution, (c) Energy vs. network centrality correlation, (d) Datacenter energy consumption comparison, (e) Policy A vs. Policy B performance metrics, and (f) VM performance vs. energy consumption scatter plot.

Results

PeerSim Network Simulation

- **Network connectivity:** Confirms a well-connected network with an average node degree of ~4.
- **Protocol performance:** Simple broadcast protocol demonstrates stable message propagation.
- **Scalability:** Simulation successfully handles 1,000 peers with consistent performance metrics.

SUMO Network Topology Analysis

- **Network topology:** 200-peer network with average node degree of 17.92 and clustering coefficient of 0.419.
- **Traffic flow:** 1,792 total connections with average path length of 2.32 and network diameter of 4.
- **Network efficiency:** Single connected component with density of 0.090, indicating good connectivity.

CloudReports Datacenter Performance

- **Policy A (Energy-Centric):** Average energy consumption of 16.46 kWh with latency of 161.56 ms.
- **Policy B (Latency-Centric):** Average energy consumption of 24.69 kWh with latency of 119.42 ms.
- **Energy savings:** Policy A saves 8.2 kWh per VM compared to Policy B.
- **Latency trade-off:** Policy B reduces latency by 42.1 ms compared to Policy A.

Energy-Aware Peer Selection Results

- **Peer scoring:** Average peer score of 0.1216 with standard deviation of 0.0624.
- **Top performers:** Peers 155, 151, 193 achieve scores >0.29 (high efficiency).
- **Low performers:** Peers 99, 111, 7 have scores <0.025 (low efficiency).
- **Correlation analysis:** Energy-performance correlation of 0.055, indicating weak positive correlation.

References

1. Montresor, A., Jelasity, M. (2009). PeerSim: A scalable P2P simulator. [PeerSim Project](#)
2. Calheiros, R. N., Ranjan, R., Beloglazov, A., De Rose, C. A. F., & Buyya, R. (2011). CloudSim: A toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms. Software: Practice and Experience, 41(1), 23-50.
3. SUMO: Simulation of Urban MObility. <https://www.eclipse.org/sumo/>
4. CloudReports: Cloud Computing Performance Analysis Tool. <https://cloudreports.cloudbus.org/>
5. BitTorrent Protocol Specification v1.0. https://www.bittorrent.org/beps/bep_0003.html

