

# **Computer Systems Performance Analysis and Benchmarking (37-235)**

**Analytic Modeling**

**Simulation**

**Measurements / Benchmarking**

**Lecture/Assignments/Projects:**

Dr. Christian Kurmann

**Textbook:**

Raj Jain, "The Art of Computer Systems Performance Analysis", 1991 Wiley & Sons, New York

**Topic of Today:**

- **Memory Systems Benchmarks (ECT-memperf)**
- **Modelling of an application (OPAL)**

# Memory System Performance Characterization for PCs, Workstations and Parallel Systems

*PDS Group ETH*



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*Intel Microprocessor Research Lab*

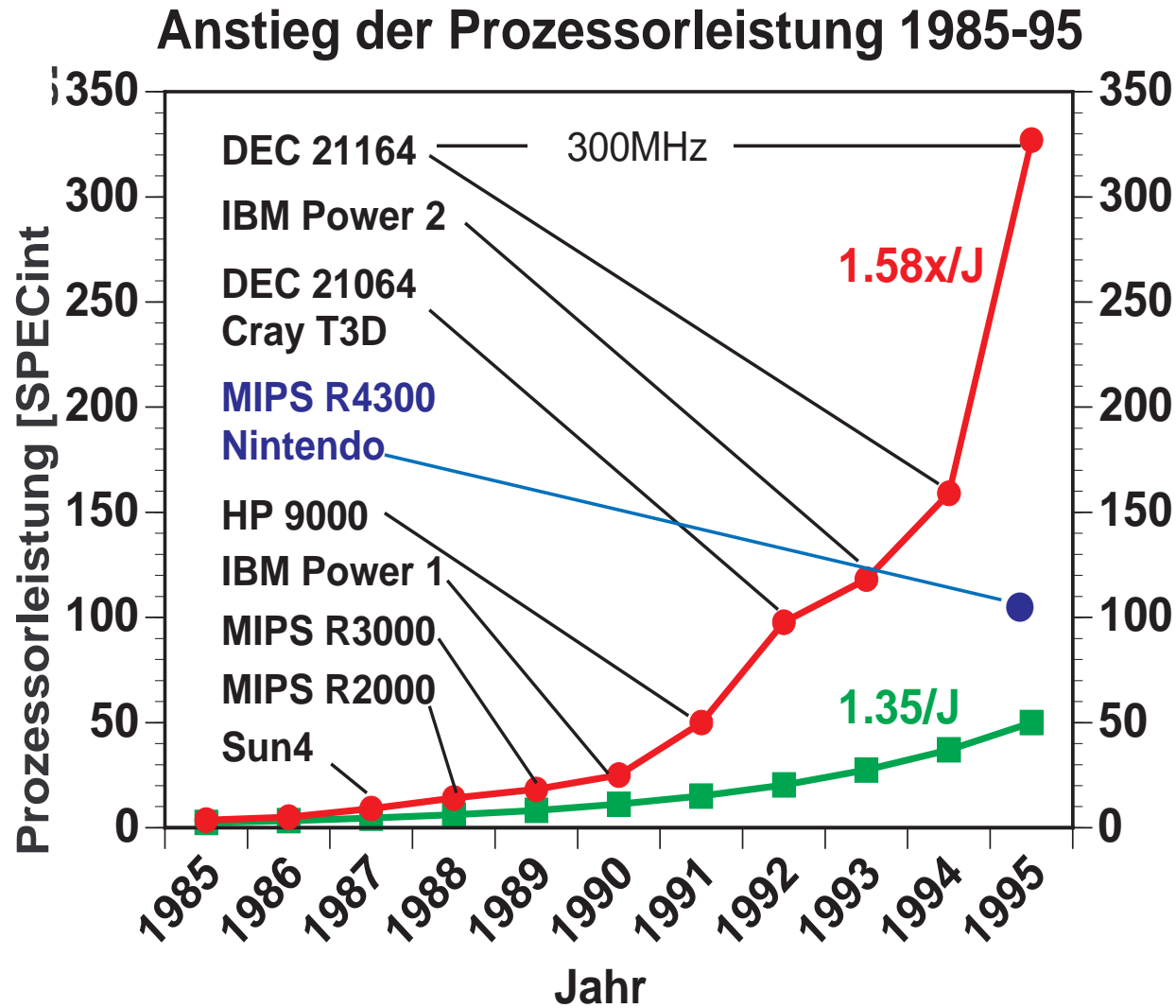
*February 10, 1997*

# Outline

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- **Notion of a global address space**
- **Extended copy transfer (ECT) characterization**
  - Bandwidth, spatial locality, temporal locality
- **Performance of local/remote memory accesses and transfers**
  - DEC8400, T3D, T3E
  - Intel P6, uni- and twin- Processor
- **High speed communication and the memory system**
- **Evaluation with an application kernel**

# Rechenleistung wächst explosionsartig!



# Extended Copy Transfer Characterizations

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**Contribution: New method to characterize the performance of memory systems:**

- **Categories**
  - **Access pattern, stride** (temporal locality)
  - **Working set** (spatial locality)
- **Value**
  - **Transfer bandwidth** (large amount of data)
- **Same chart resulting from one microbenchmark**
  - **Local** and **Remote** transfers

# Related work

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- **Trace based evaluation of a memory system**
- **Classic NUMA model**
- **A basic copy transfer model [ISCA95]**

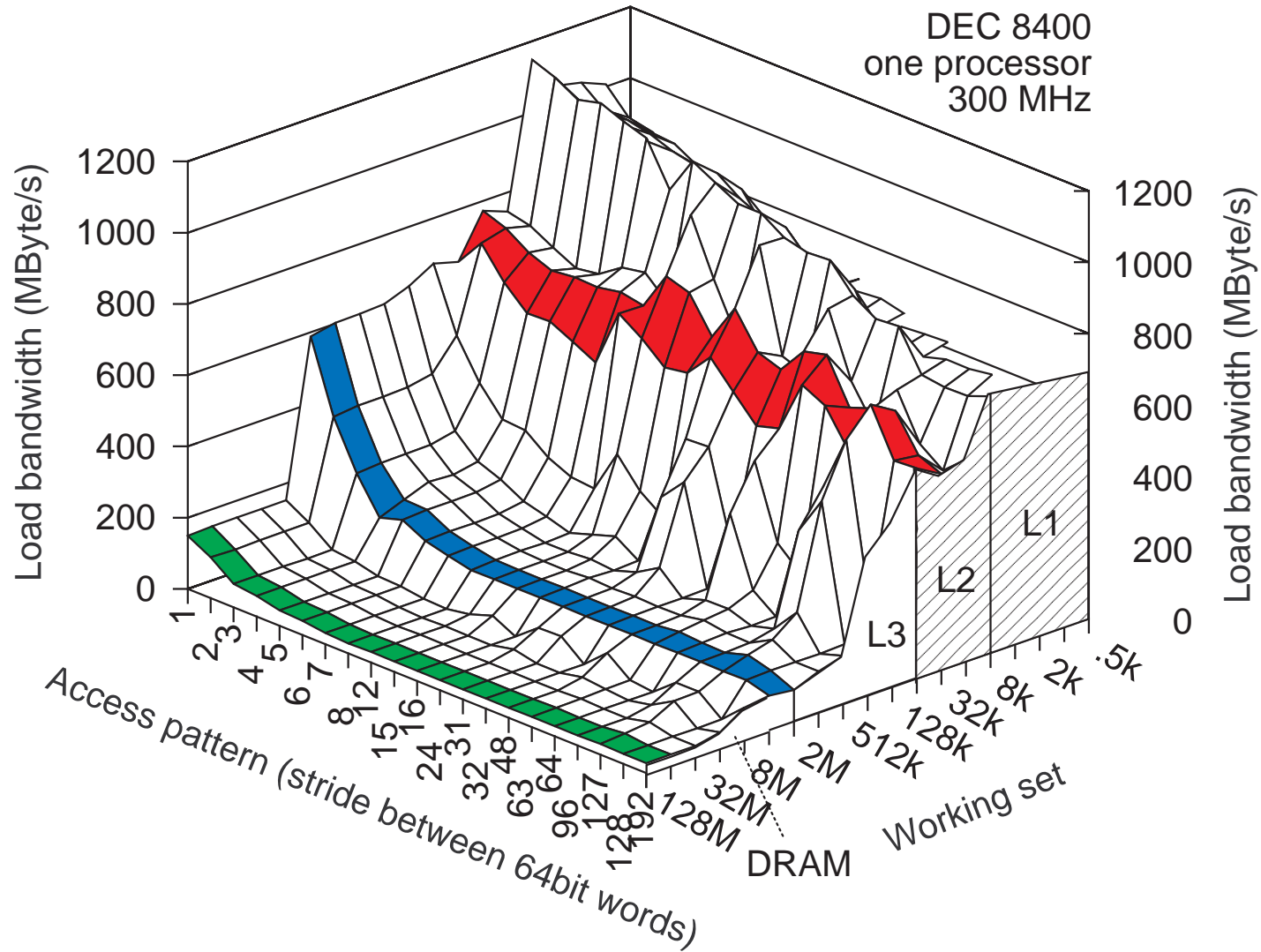
# Caveat

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**Some parameter combinations are hard to measure, even with carefully tuned C code:**

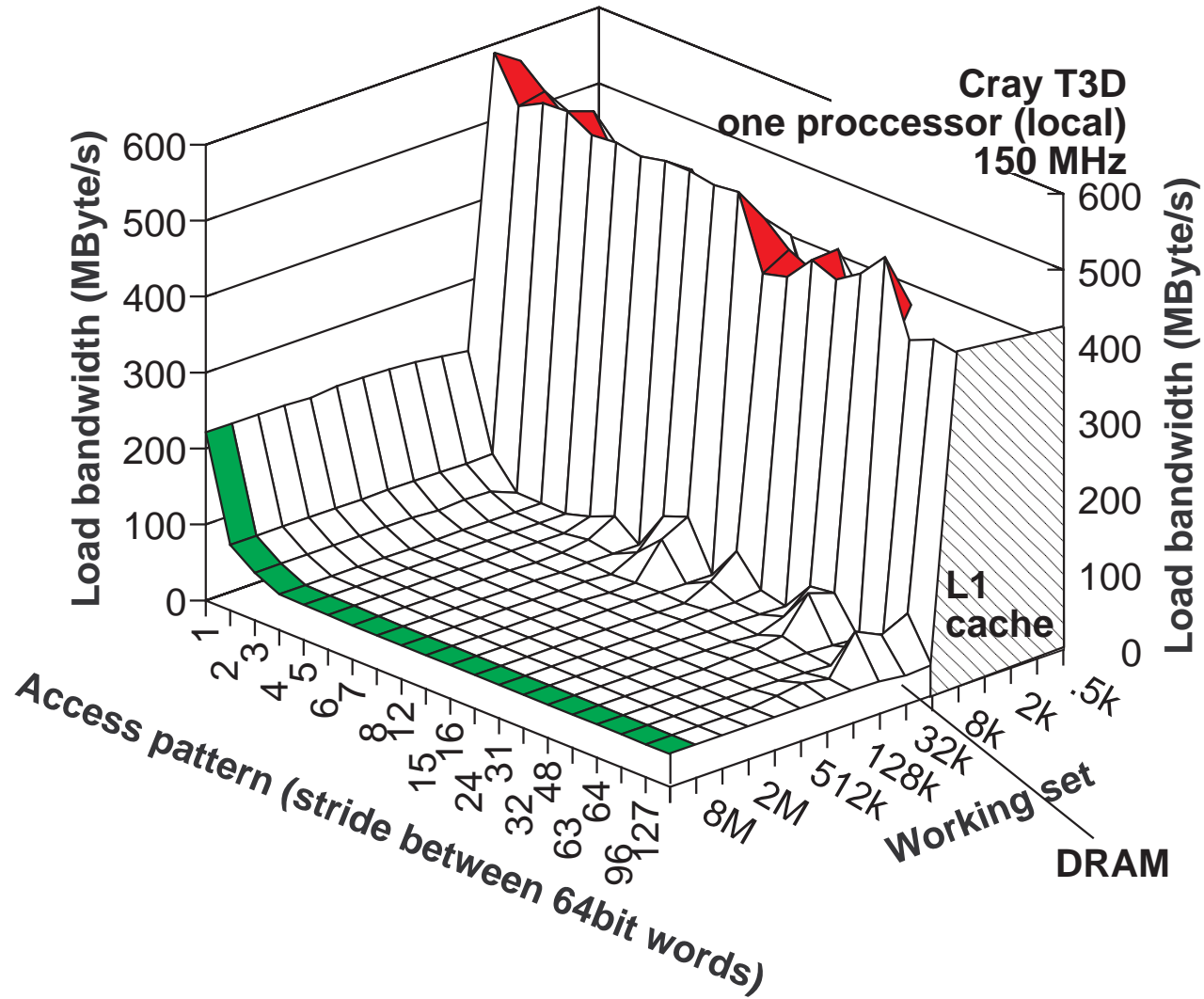
- **Reduced performance for *large strides* and *small working-sets* is a measurement artifact and not architecture related.**
- **Compilers occasionally generate suboptimal instruction schedules for loads/stores.**

# Local Load Access (DEC 8400)

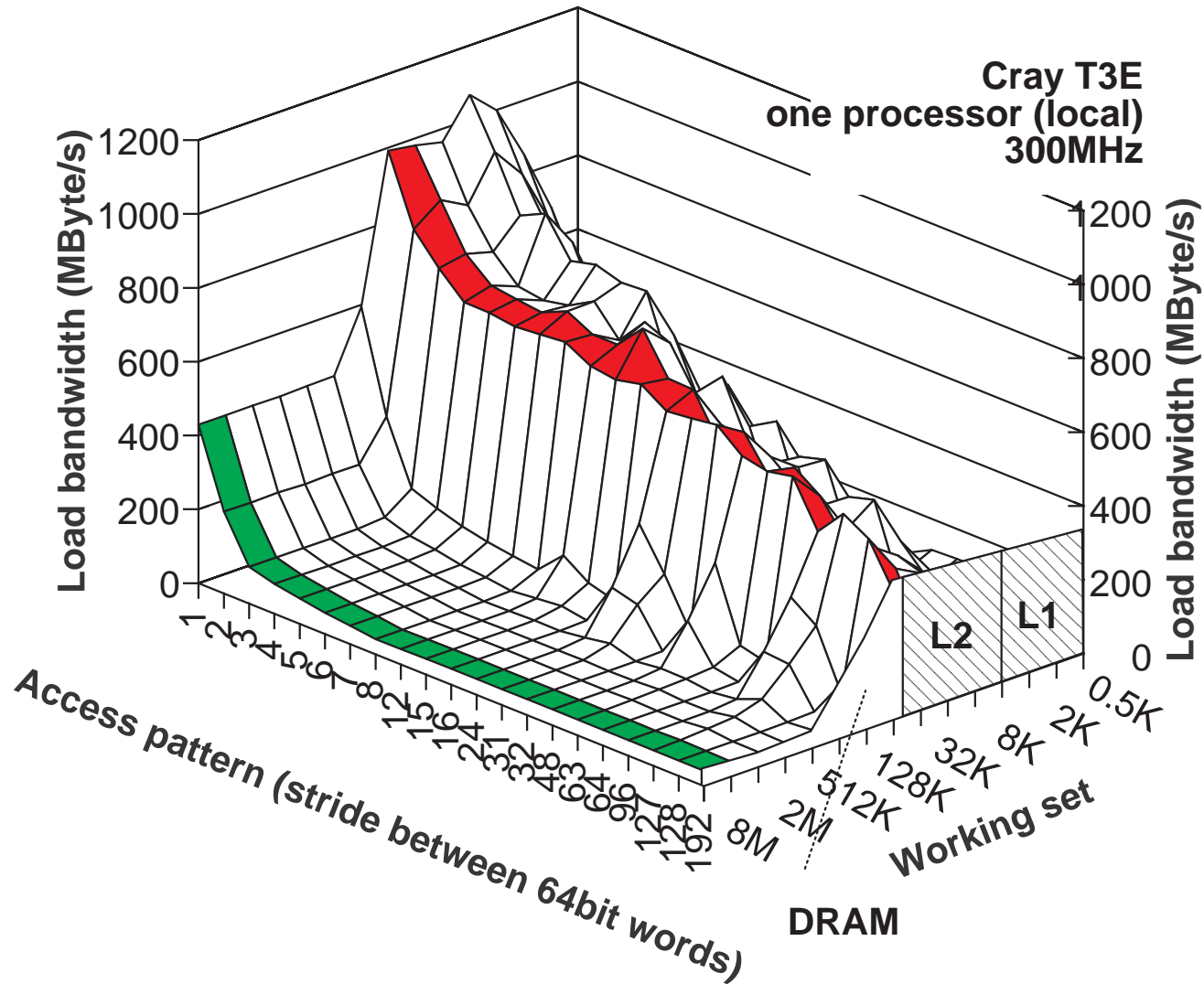




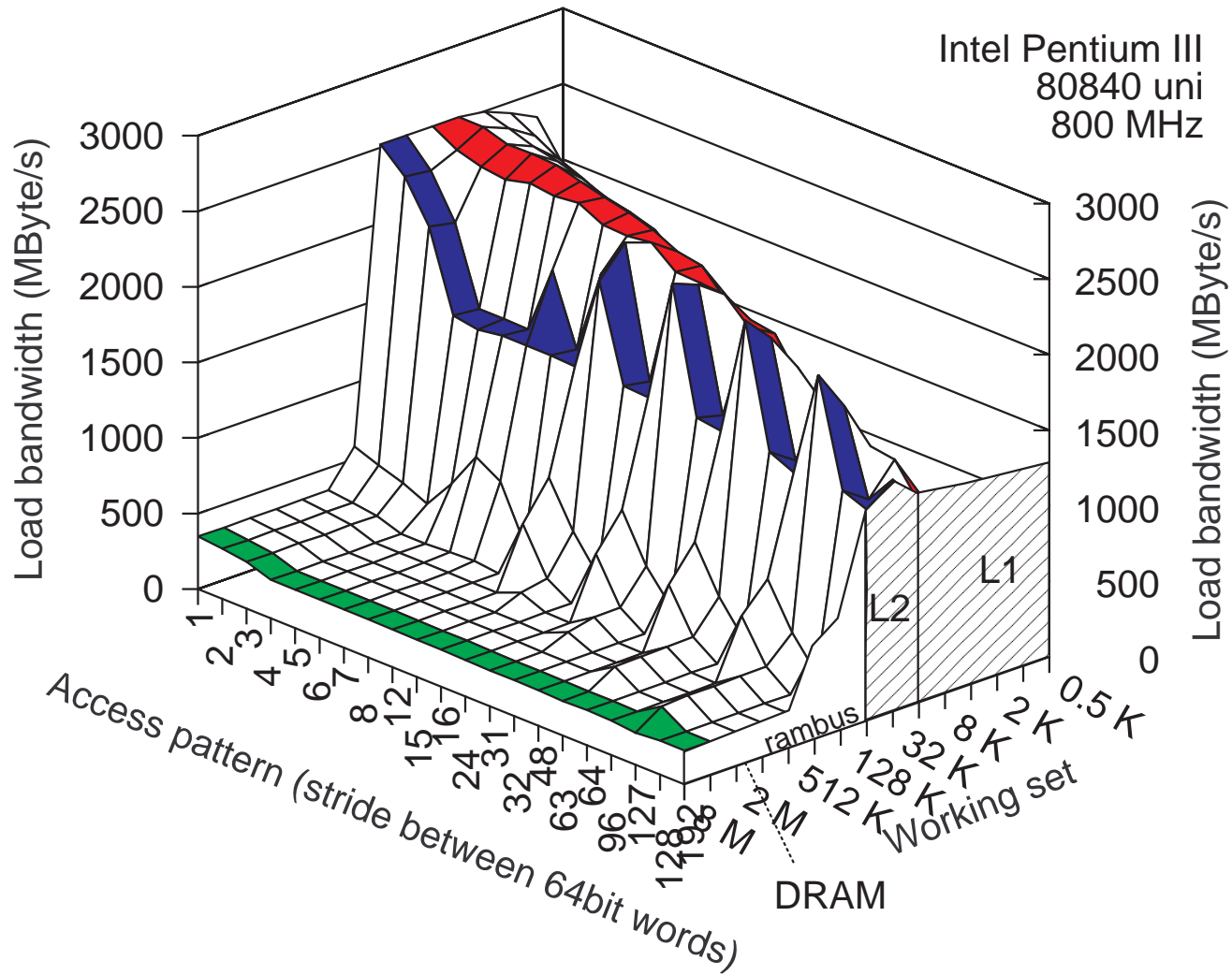
# Local Load Access (Cray T3D)



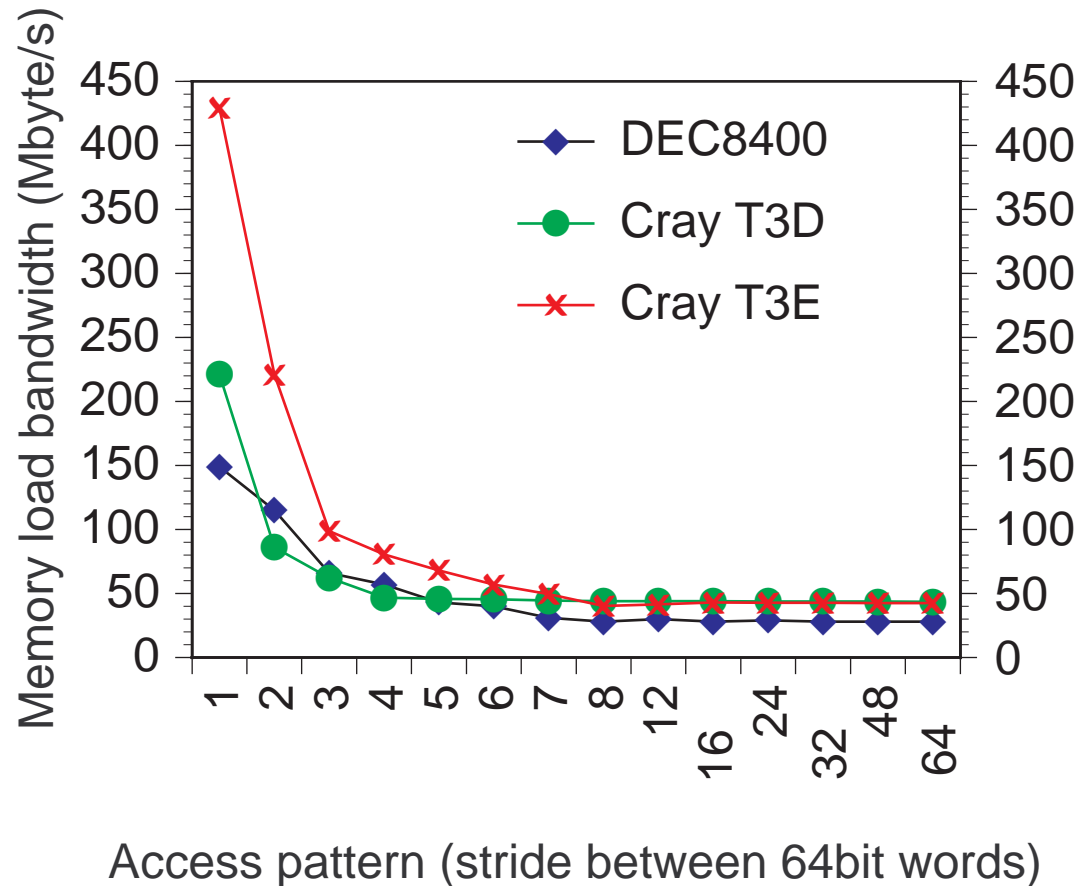
# Local Load Access (Cray T3E)



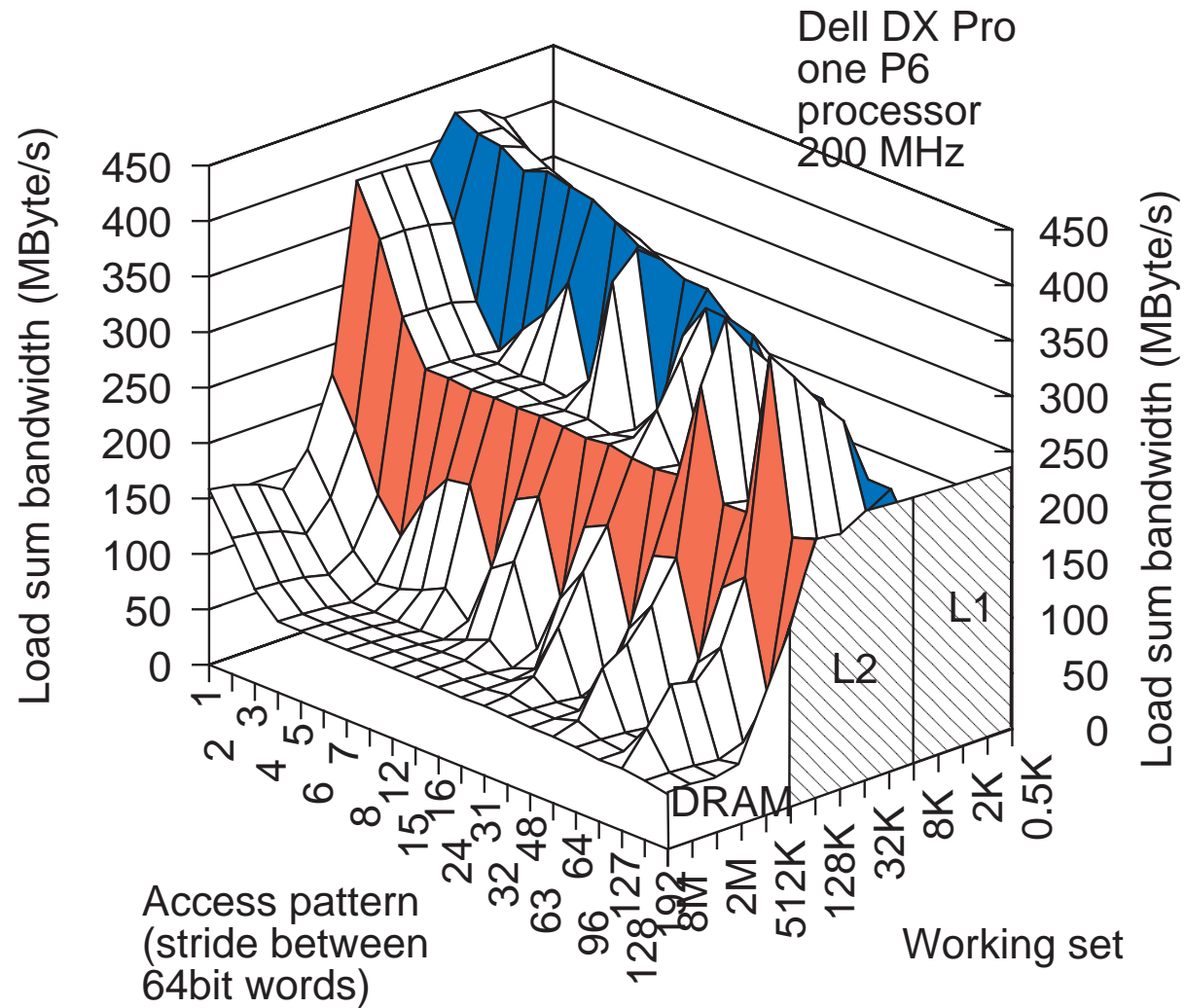
# Load Datenstrom Intel 80840 (800MHz)



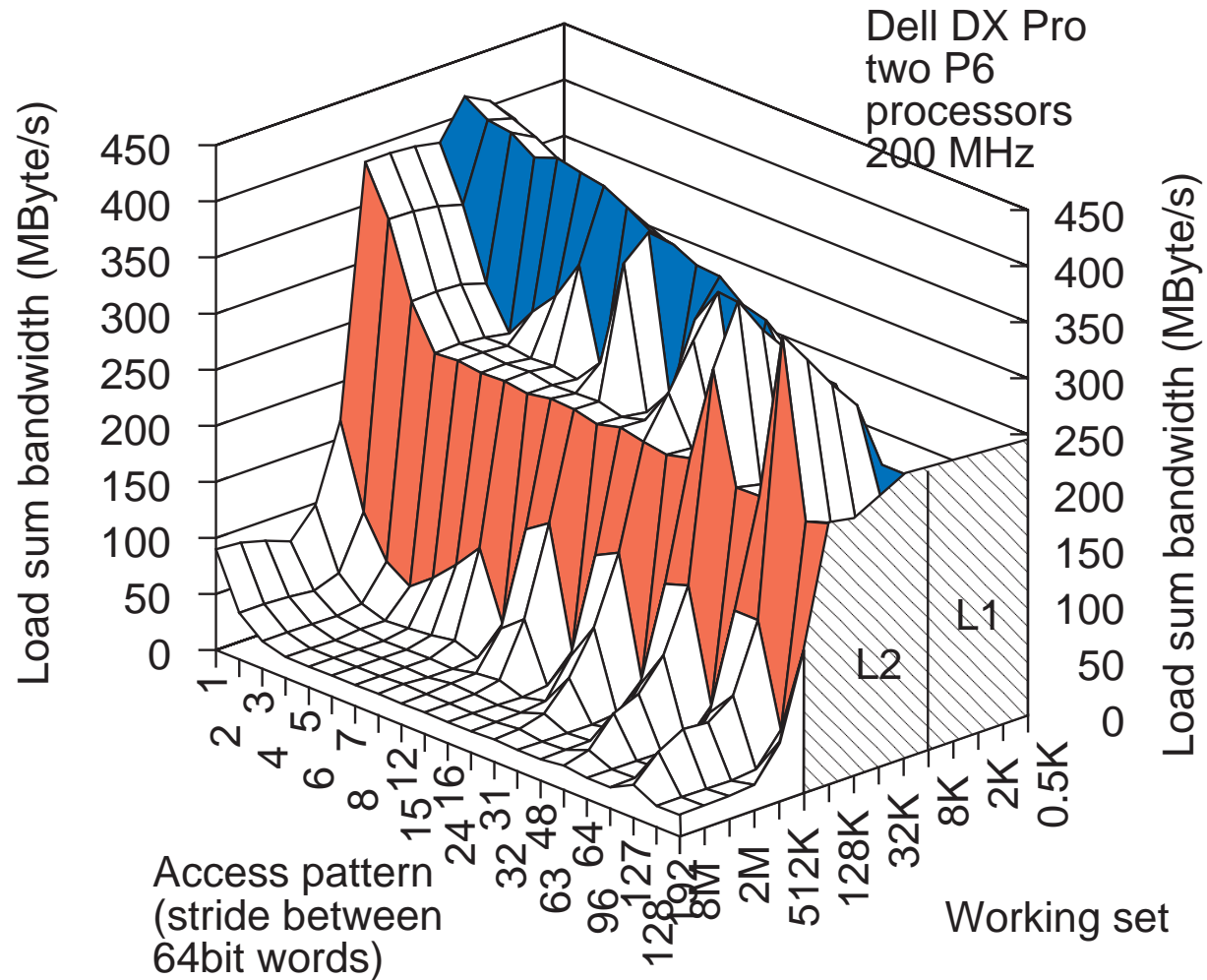
# Comparison - Local (Working Set: DRAM)



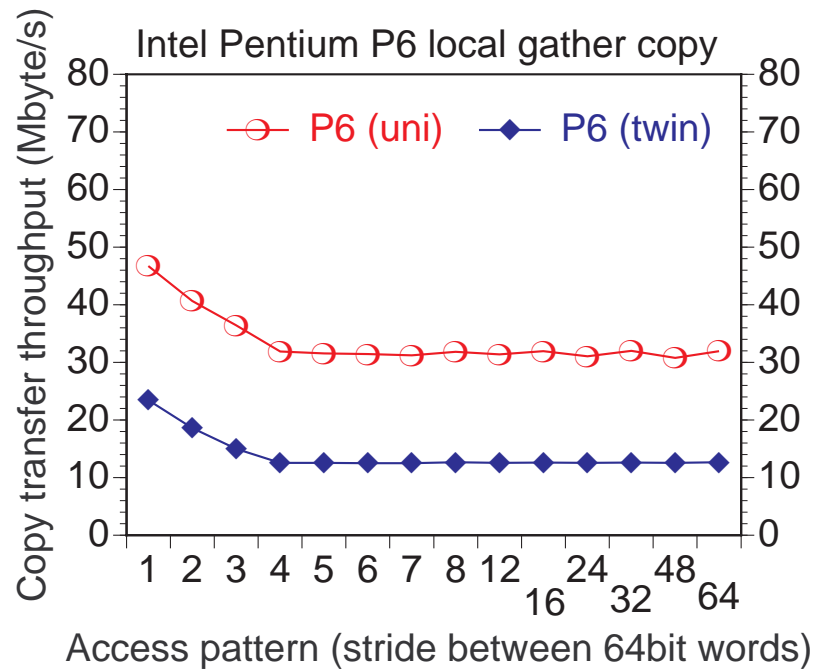
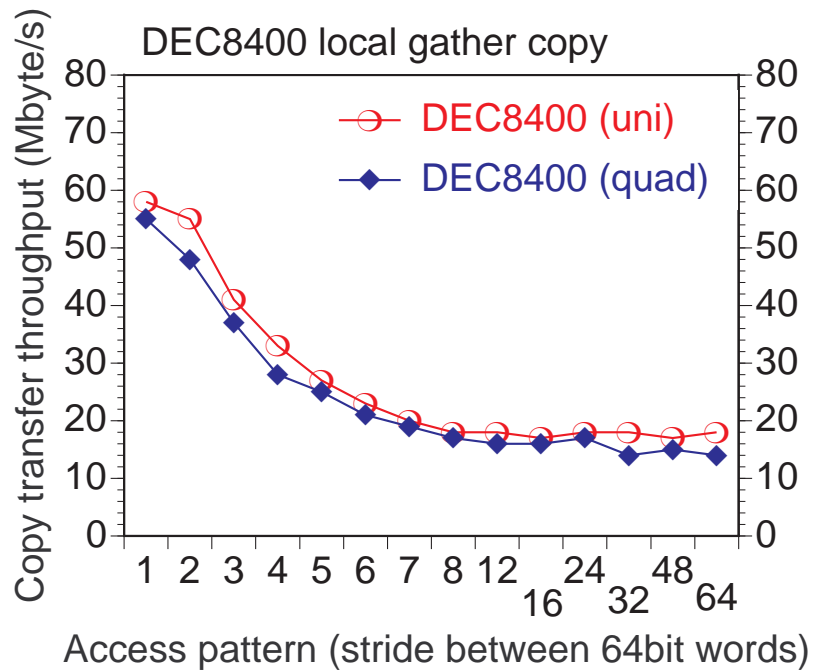
# Local Load Access (P6 single)



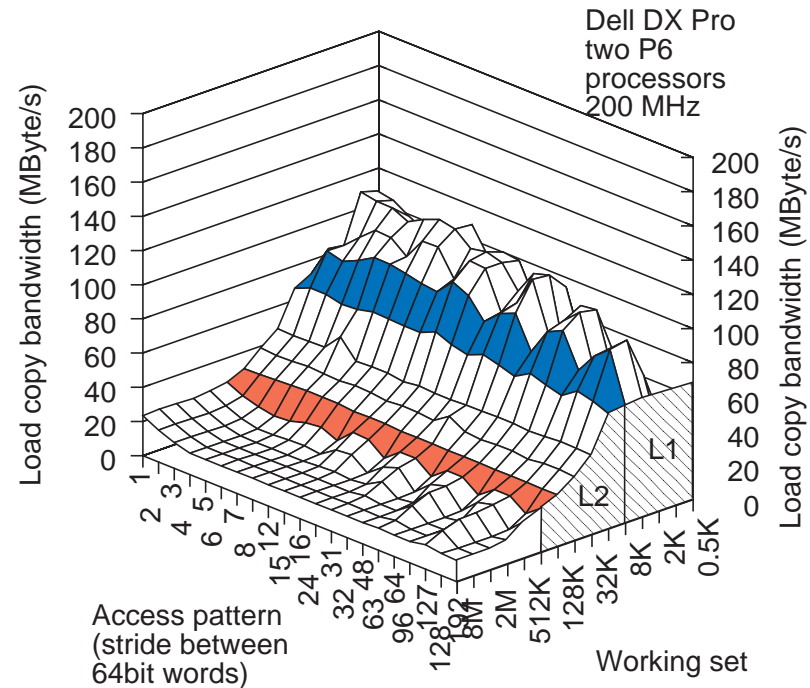
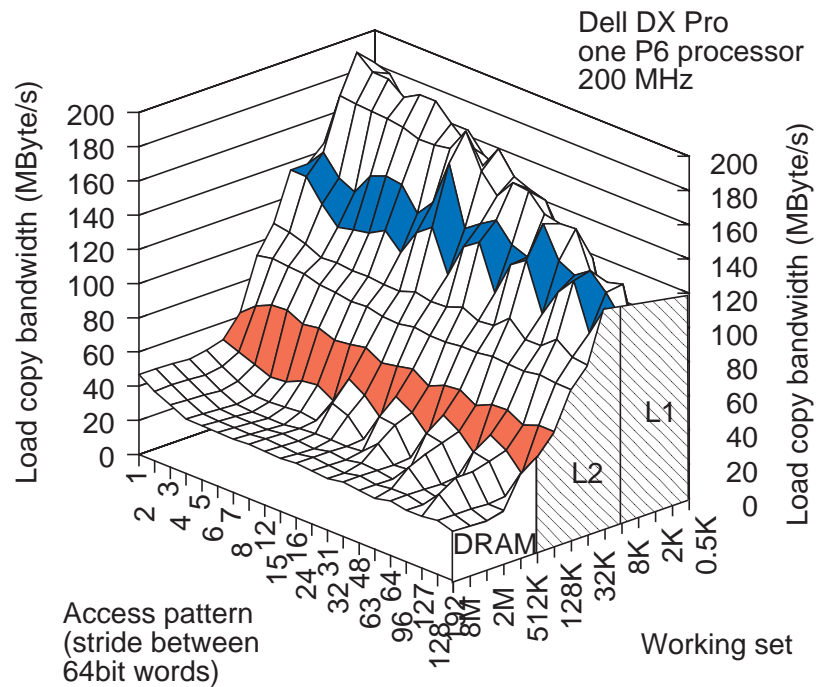
# Local Load Access (P6 twin)



# Comparison - Local Copy (Working Set: DRAM)

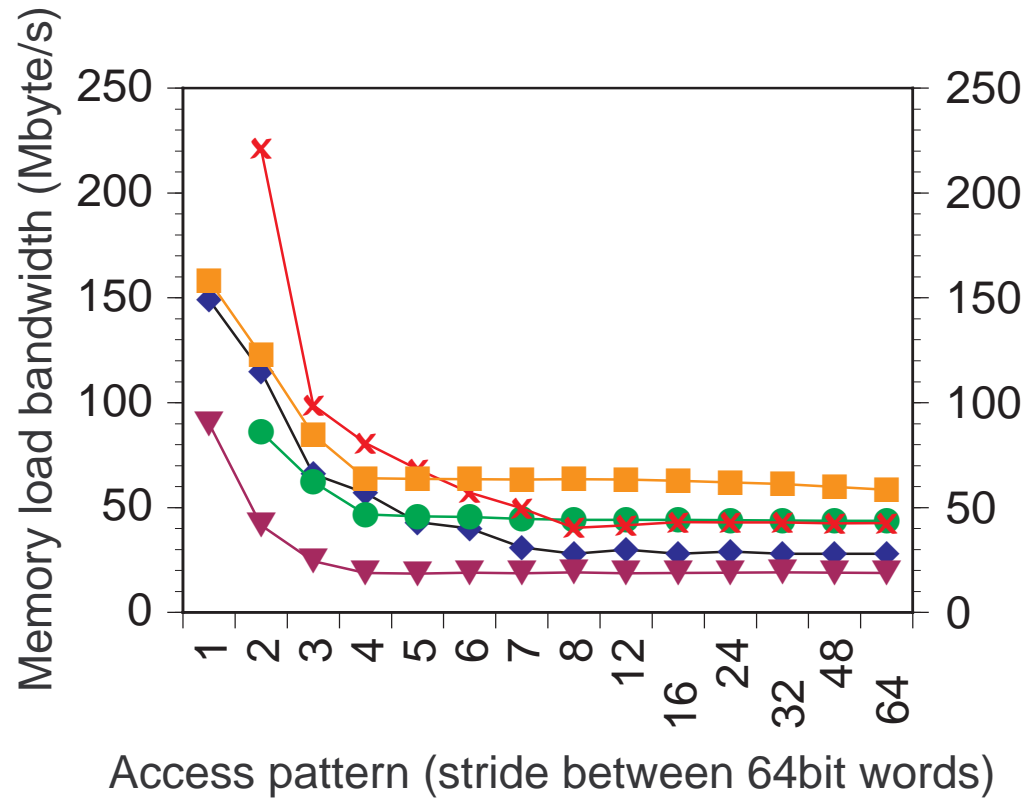


# Local Copy (P6 single/twin)



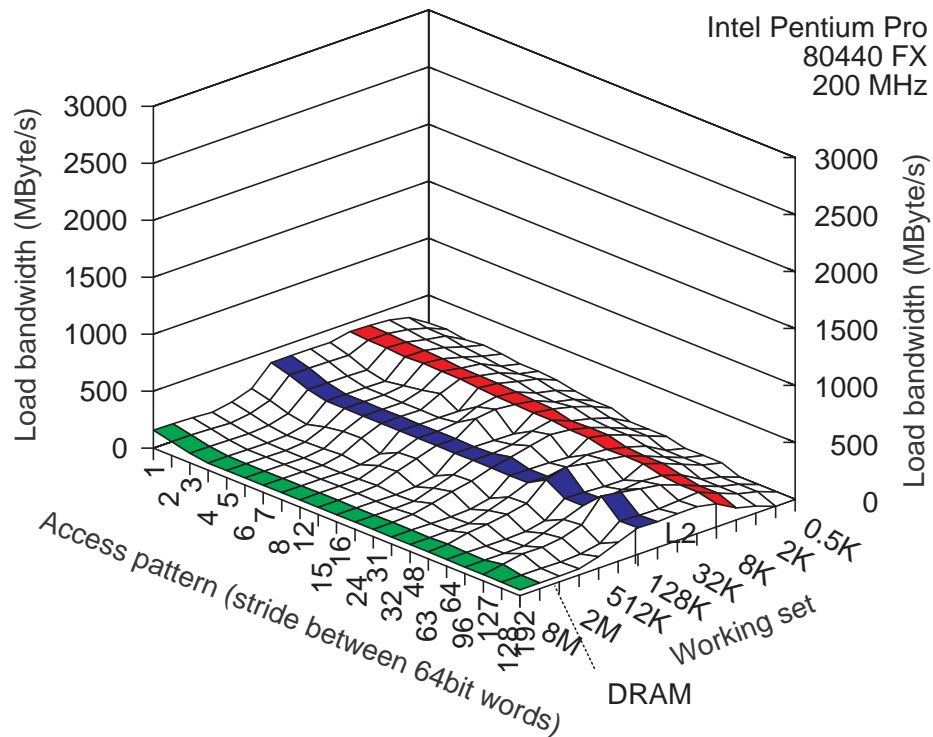


# Comparison - Local Access (Working Set: DRAM)

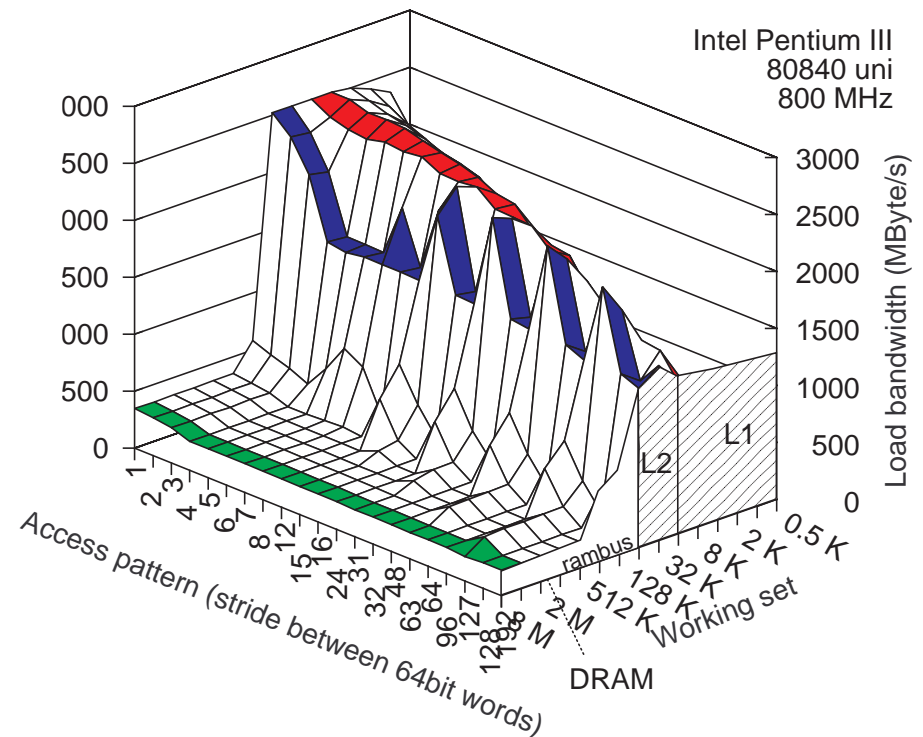


- ◆— DEC8400
- ×— Cray T3E
- ▼— P6 (twin)
- Cray T3D
- P6 (uni)

# Entwicklung 1996 to 2000

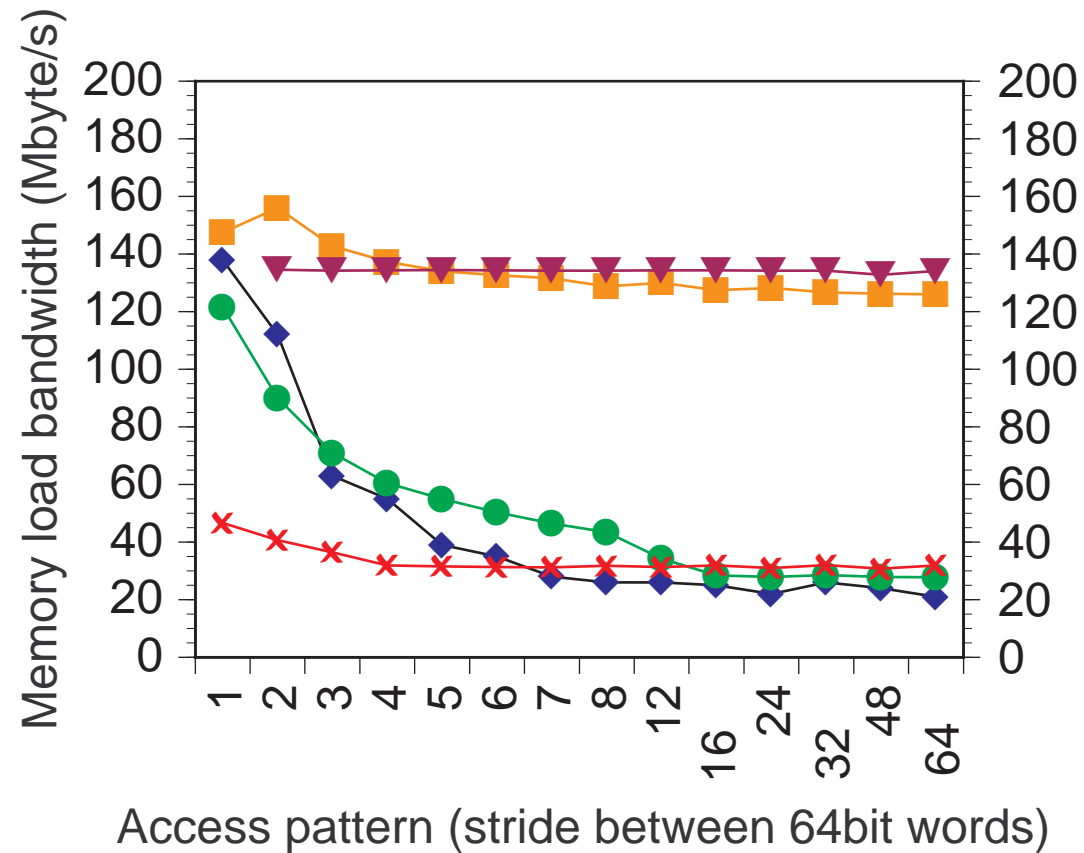


**80440FX (200MHz)**



**80840 (800MHz)**

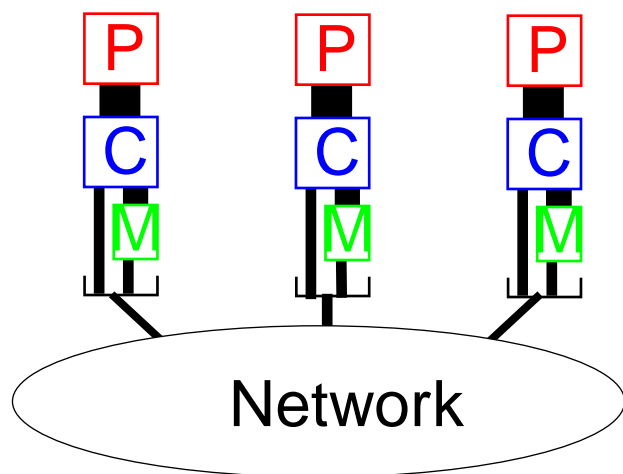
# Vergleich - Local Copy



- ◆ DEC8400
- ✕ Intel PPro
- ▼ CrayT3E
- SGI Origin
- Intel PII 840er

# Local/Remote: Parallel Computers

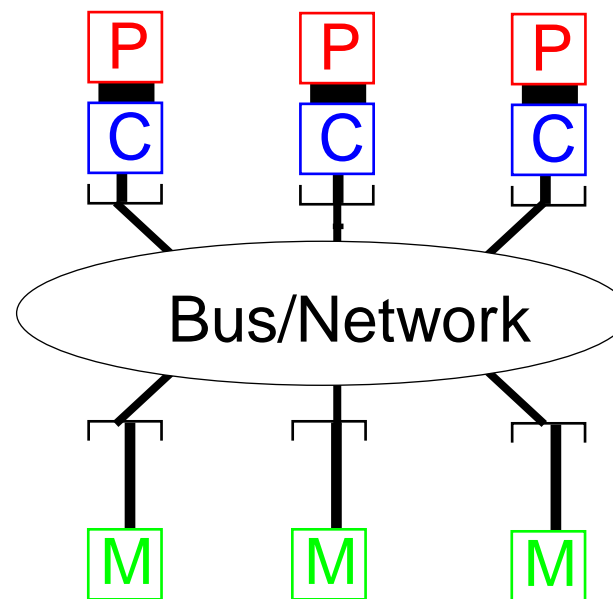
## Parallel & Network Computers



Nectar (Classic, Gigabit, Credit), SHRIMP  
Cray T3D/T3E, Intel Paragon, NEC Cenju

**P: Processor**    **M: Memory**

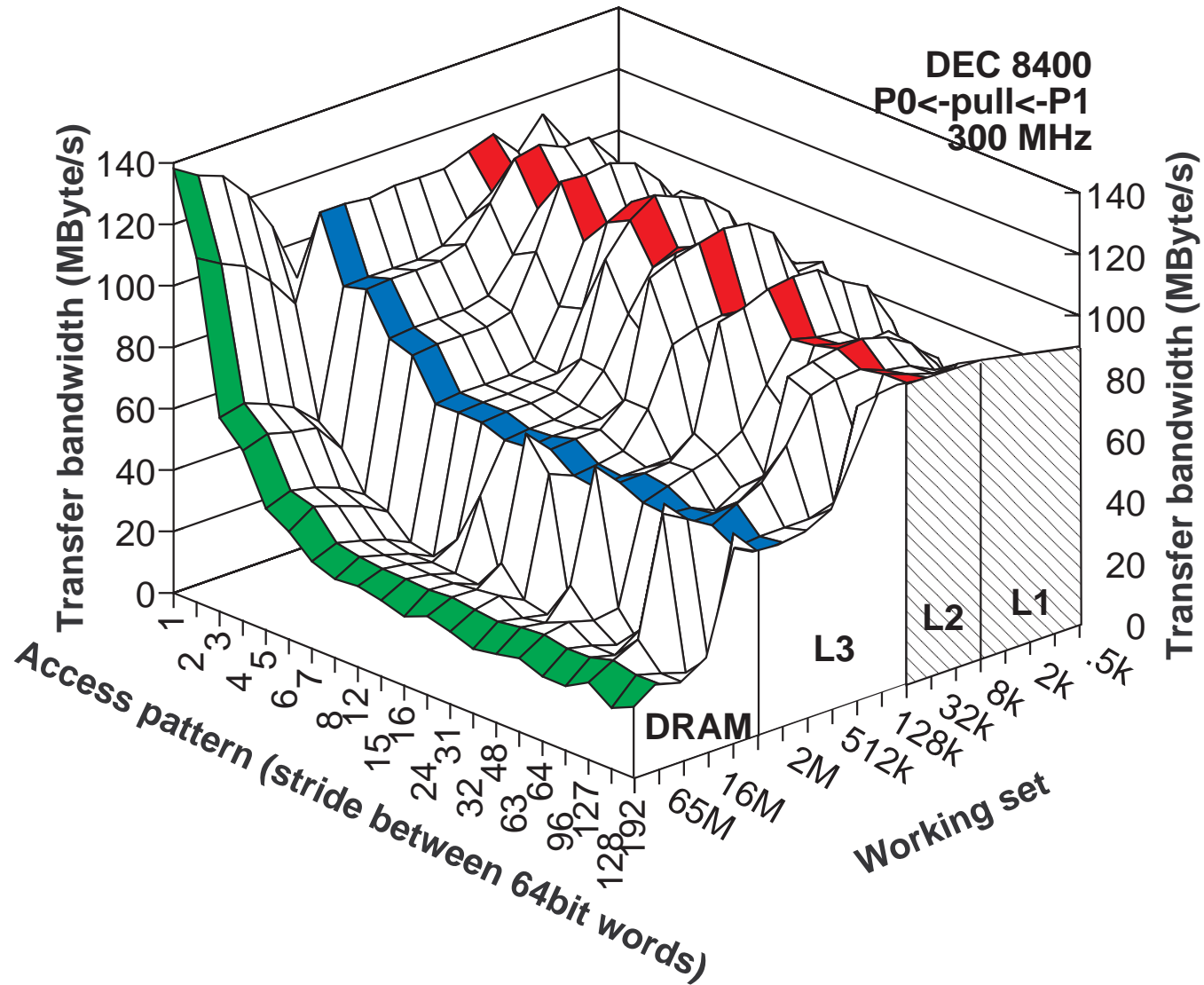
## Symmetric Multiprocessors



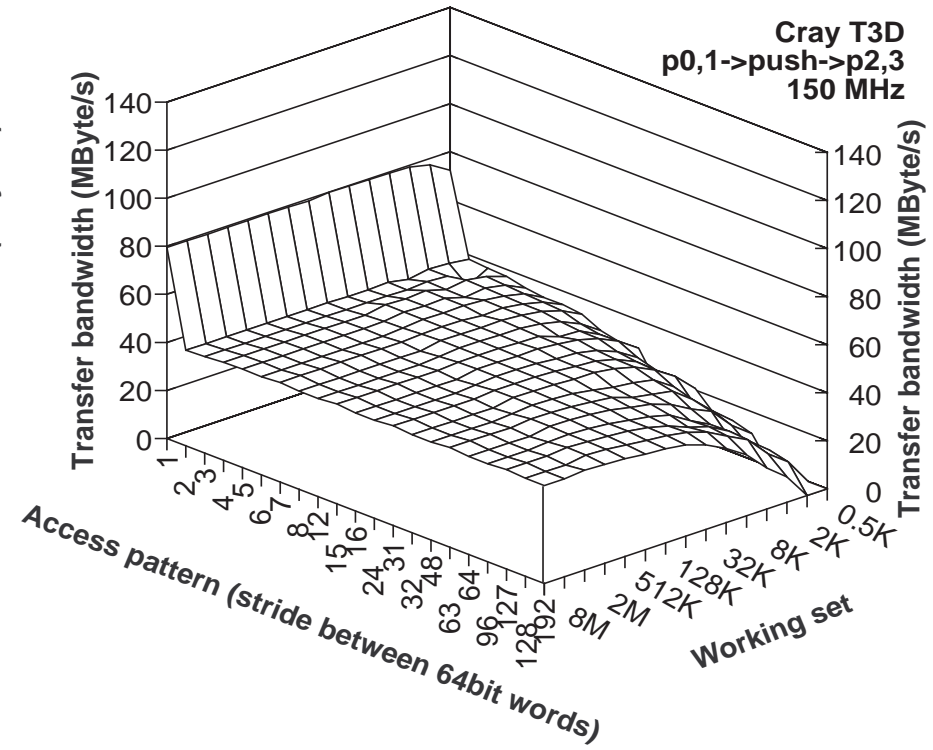
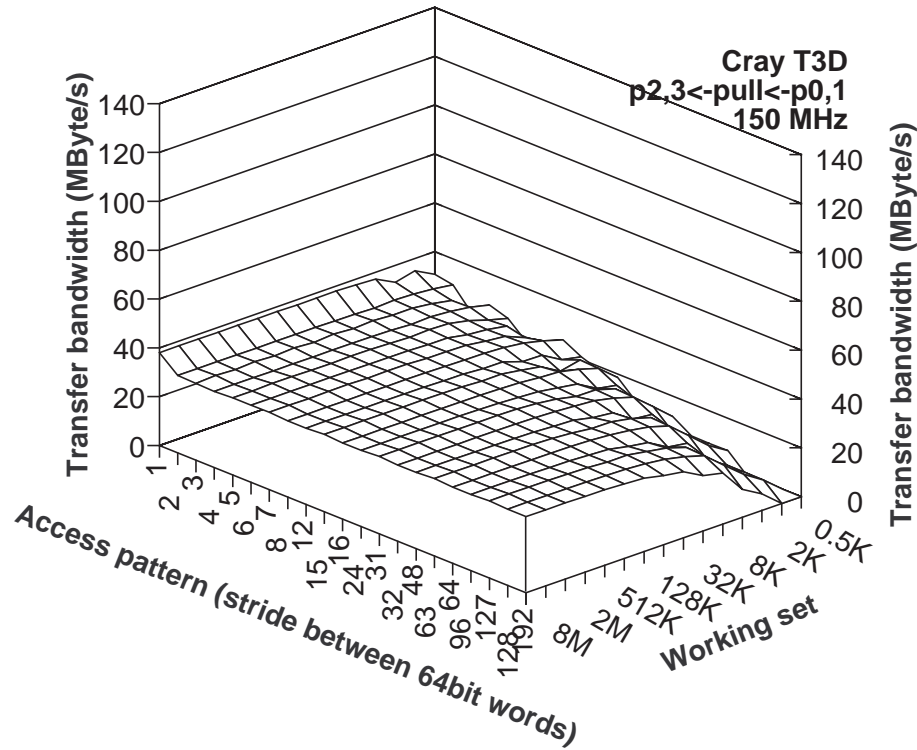
SGI Power Challenge, DEC 8400  
Cray J90, Pentium SMPs

**C: on-chip/on-board Caches**

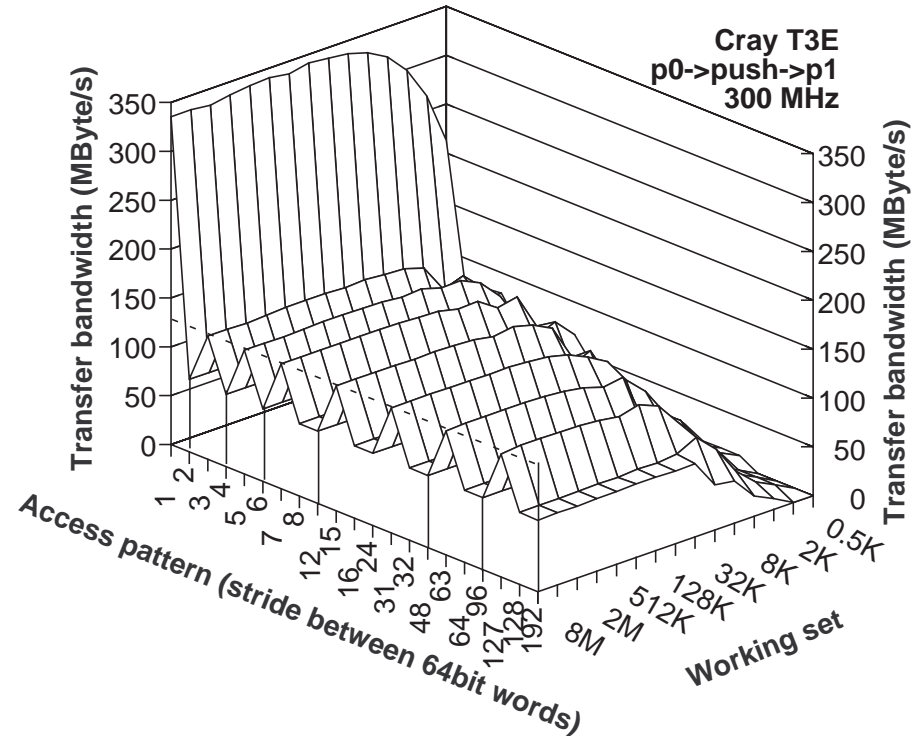
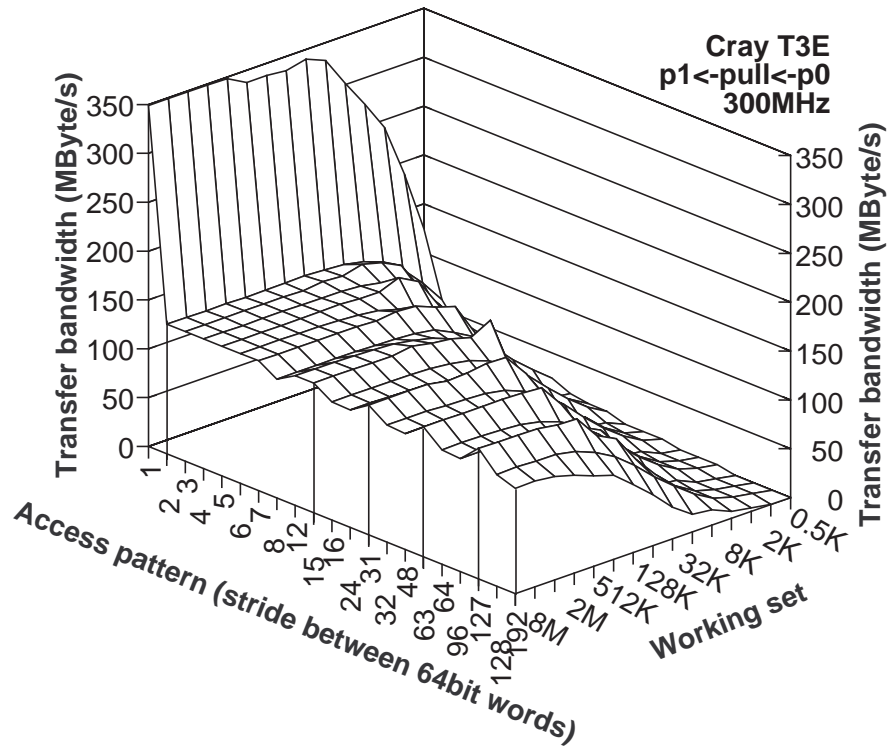
# Remote Copy Transfer (DEC 8400)



# Remote Copy Transfer on T3D (push/pull)

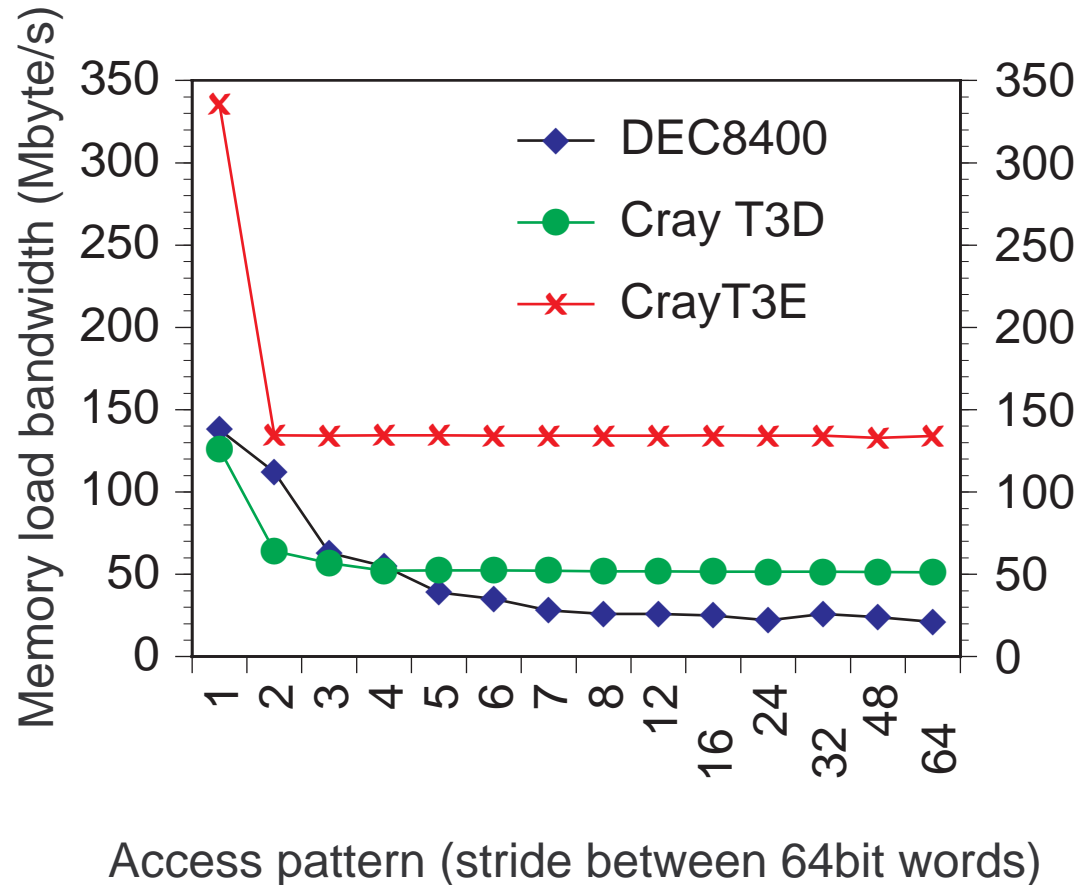


# Remote Copy on Cray T3E (push, pull)



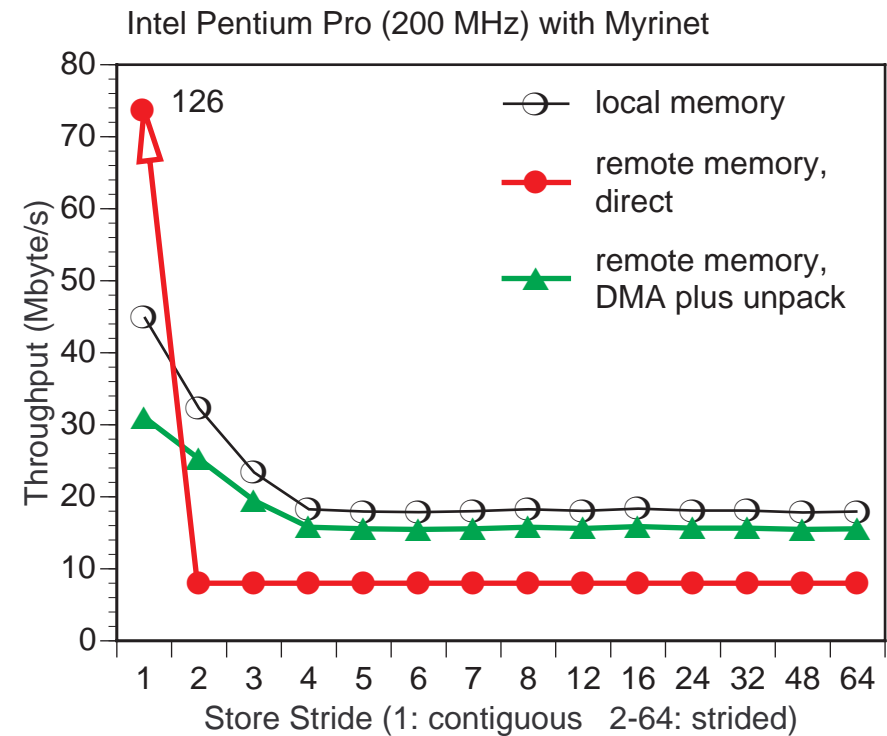
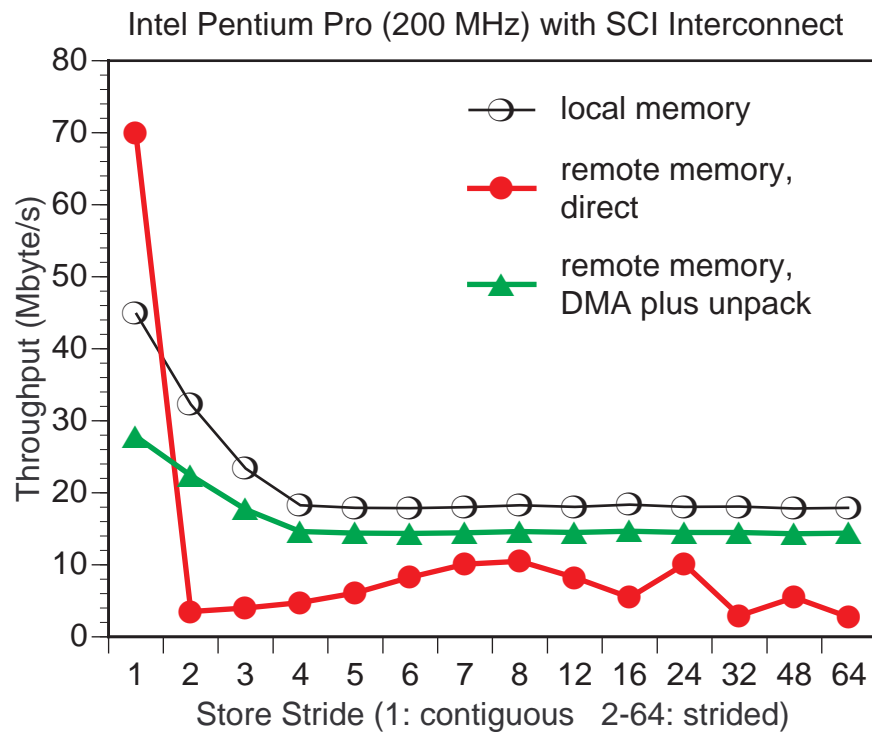
***Performance numbers on T3E are likely to improve  
New machine software not as mature as T3D***

# Comparison - Remote (Working Set: DRAM)





# Remote Transfer im Cluster (Working Set: DRAM)



# Conclusions

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- The introduction of a **global address space** asks for a new memory system **performance model**.
- Streaming support (MPPs) instead of L3 caches (SMPs) can result in **better memory systems** and **faster computation**.
- **Fast communication** puts a high demand on the memory system. Current PC platforms need some improvements.