INTEL 1ST GEN. DCPMM MEMORY CONFIGURATION FOR THE INTEL PURLEY PLATFORM

USER'S GUIDE

Revision 1.0a

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Preface

This user's guide is written for system integrators, IT technicians and knowledgeable end users. It provides information for the installation and use of 1st Generation Intel® Optane™ DC Persistent Memory Modules (DCPMMs) in a system based on the Intel Purley Platform.

About This User's Guide

This user's guide provides an introduction to Intel 1st Gen. DC Persistent Memory Modules (DCPMMs). It also provides detailed instructions on how to install and configure 1st Gen. DCPMMs on Supermicro serverboards.

User's Guide Organization

Chapter 1 describes the features, specifications and performance of Intel 1st Gen. DCPMM memory modules.

Chapter 2 provides detailed instructions on how to install DCPMM memory in a Supermicro computer system based on the Intel Purley platform

Chapter 3 provides DCPMM configuration instructions using ipmctl and ndtcl. Read this chapter when you want to configure the DCPMM settings using the open source utilities available on the market.

Chapter 4 provides detailed instructions on how to configure DCPMM settings using the BIOS utility.

Conventions Used in the User's Guide

Special attention should be given to the following symbols to ensure proper installation and to avoid damaging system components or causing bodily injury to yourself:

Important: Important information given to ensure proper system installation or to relay safety precautions.

Note: Additional Information given to provide information for proper system setup.

Important Links

For your system to work properly, please follow the links below to download all necessary drivers/utilities and the user's guide for your system.

- Supermicro product manuals: http://www.supermicro.com/support/manuals/
- Product drivers and utilities: https://www.supermicro.com/wftp/driver
- Product safety info: http://www.supermicro.com/about/policies/safety_information.cfm
- If you have any questions, please contact our support team at: support@supermicro.com

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Chapter 1

Introduction

Congratulations on purchasing your motherboard or your system from an industry leader. Supermicro products are designed to provide you with the highest standards in quality and performance.

1.1 Introduction to Intel 1st Gen. DCPMM Memory Modules

Intel® 1st Gen. Optane™ DC Persistent Memory Module (DCPMM), the latest memory innovation, provides a new data-centric architecture that offers increased storage capabilities for higher performance computing platforms with flexible configuration options at lower cost. Utilizing the unique disruptive technology, DCPMM utilizes memory as storage to operate as system memory, which allows the DCPMM to have memory-like performance with the storage capacity of a solid state drive. In addition, DCPMM can also function as storage, providing memory-like performance with persistence and high-capacity while operating at much lower latency at an affordable cost.

DCPMM memory supports two modes: Memory Mode and App Direct Mode. Optimized for volatile use, Memory Mode provides a high-capacity main memory solution with higher power efficiency at lower operational cost. Featuring byte-addressability and cache-coherence, App Direct Mode allows memory space to be provisioned as persistent memory where software can "talk directly to" the persistent memory in the "byte-addressable" manner without any modifications needed. DCPMM also offers Mixed Memory Mode, a combination of Memory Mode and App Direct Mode, which will allow a portion of the DCPMM to be used for the Memory Mode operations, while the remaining portion is used for the App Direct Mode operations. In this Mode, all installed DDR4 DIMMs are hidden from the operating system and act as the caching layer for the portion of the DCPMMs in Memory Mode. This is especially instrumental for the applications that use system RAM for in-memory databases. With DCPMM memory used in the system, there is no need for the system RAM to copy data from disk to memory, and thus effectively eliminate in-memory database initialization delays at bootup, further enhancing system performance.

1.2 DCPMM Modes

This section provides additional details on DCPMM modes. Please refer to the information below to configure your DCPMM memory settings.

Memory Mode (volatile memory)

In Memory Mode, the system treats DCPMM modules as system memory, and DCPMMs will act as large-capacity DDR4 memory modules. The installed DDR4 DIMMs will become a caching layer for the DCPMMs and will be hidden from the operating system. This mode does not require applications that support DCPMMs to operate.

App Direct Mode (non-volatile memory)

In App Direct Mode, DCPMM modules provide all persistent memory features to the operating system and to the applications that support them. The DDR4 DIMMs will act as system memory and DCPMMs will act as persistent storage.

Mixed Mode

DCPMMs can be configurated in Mixed Memory Mode with a portion of their capacity used for Memory Mode operations, and the remaining capacity as persistent memory for App Direct Mode operations. All DDR4 DIMMs discovered in the system are hidden from the operating system and act as a caching layer for the DCPMMs Memory Mode portion.

Memory Ratio

In Memory Mode and Mixed Mode configurations, the required ratio of system memory to DCPMMs is between 1:16 and 1:4 gigabytes. In order to achieve the best performance, a ratio of 1:4 is recommended. In Mixed Mode, this ratio requirement applies to system memory and only the volatile portion of the DCPMMs. The ratio requirement does not apply to App Direct Mode.

1.3 Specifications

Operating Speed

1st Gen. DCPMMs operate at 2666 MHz DDR4 memory bus speed, and any installed 2933 MHz DDR4 memory will also operate at 2666 MHz.

Capacity

1st Gen. DCPMM modules are offered in capacities of 128GB, 256GB, and 512GB.

Additional Specifications

When set to App-Direct Mode, DCPMM provides optional data security support, including secure-erasing and data-encryption. DCPMM encrypts data using AES 256-bit encryption and it supports the following memory functions:

ECC

ECC (Error-Correcting Code) memory, a type of computer data storage, can detect and correct most-common internal data corruptions and errors. ECC memory is usually used in computers that cannot tolerate data corruptions or memory errors such as computers used for scientific or financial purposes. Normally, ECC memory maintains a memory system that is immune to single-bit errors so that the data that is read from each word is always the same as the data that had been written to it. ECC memory will protect against any additional memory failure caused by a ‘single-bit’ error in the same memory rank.

SDDC

SDDC (Single Device Data Correction) checks and corrects single-bit or multiple-bit (4-bit max.) memory corruptions and errors that affect an entire single x4 DRAM device. SDDC Plus One is the enhanced feature to SDDC. Using this enhanced feature will spare the faulty DRAM device out after an SDDC event has occurred. After the event, ECC mode will be activated to further protect the system against any additional memory failure caused by a ‘single-bit’ error in the same memory rank.

DDDC

DDDC (Double Device Data Correction) provides memory-error checking and correction and it also prevents the system from issuing a performance penalty before a device fails. Please note that virtual lockstep mode might be affected until a faulty DRAM module is spared.

Patrol scrubbing

Patrol Scrubbing is a process that allows the CPU to correct correctable memory errors detected on a memory module and send the correction to the requestor (the original source). When Patrol Scrubbing is activated, the IO hub will read and write back one cache line every 16K cycles if there is no delay caused by internal processing. By using this method, roughly 64 GB of memory behind the IO hub will be scrubbed every day.

Demand scrubbing

Demand Scrubbing is a process that allows the CPU to correct correctable memory errors found on a memory module. When the CPU or I/O issues a demand-read command, and the read data from memory turns out to be a correctable error, the error is corrected and sent to the requestor (the original source). In the meantime, system memory is updated as well.

Operating System Support

1st Gen. DCPMM modules support the following operation systems:

- Microsoft Windows Server 2019
- Red Hat Enterprise Linux 7.6
- SUSE Linux Enterprise Server 12.4
- SUSE Linux Enterprise Server 15
- VMware vSphere Hypervisor (ESXi) 6.7 U1
- Ubuntu LTS 18.04

Platform Support

- 1st Gen. DCPMM memory is supported by the Intel Purley Platform

Chapter 2

DCPMM Memory Installation

2.1 Static-Sensitive Devices

Electrostatic Discharge (ESD) can damage electronic components. To avoid damaging your motherboard, it is important to handle it very carefully. The following measures are generally sufficient to protect your equipment from ESD.

Precautions

- Use a grounded wrist strap designed to prevent static discharge.
- Touch a grounded metal object before removing the motherboard from the antistatic bag.
- Handle the motherboard by its edges only; do not touch its components, peripheral chips, memory modules or gold contacts.
- When handling chips or modules, avoid touching their pins.
- Put the motherboard and peripherals back into their antistatic bags when not in use.
- For grounding purposes, make sure that your computer chassis provides excellent conductivity between the power supply, the case, the mounting fasteners and the motherboard.
- Use only the correct type of onboard CMOS battery. Do not install the onboard battery upside down to avoid possible explosion.

Unpacking

Supermicro's motherboards are shipped in antistatic packaging to avoid static damage. When unpacking a motherboard , make sure that the person handling it is static protected.

2.2 Installing DCPMM Memory Modules

Important: Exercise extreme care when installing or removing DIMM modules to prevent any possible damage.

Memory Population Requirements

For proper memory installation, please pay close attention to the following instructions:

1. Intel 1st Generation DCPMM is supported by the Intel Purley Platform.
2. Memory speeds are dependent upon the processors used in your system.
3. All DCPMMs installed on your motherboard must be of the same size, and the DDR4 DIMMs that are installed in conjunction with DCPMMs must be of the same size and the same type as well.
4. Be sure to install your DCPMM modules in standard memory slots. When installing a memory module, be sure to install the DIMM module in the first channel slot (i.e. DIMMA1), and then, in the second channel slot (i.e. DIMMA2).
5. Please use balanced configuration to achieve maximum performance. Supermicro does not recommend unbalanced memory configuration since it will reduce memory performance.
6. Mixing different DIMM types or using 1Rx8 DIMMs in conjunction with DCPMMs is not supported.
7. A total of six DCPMMs can be supported per processor (one in each memory channel), and a minimum of two DDR4 DIMMs are required per processor (one per memory controller).
8. For Memory Mode, a minimum of two DCPMMs are required per processor (one per memory controller). For App Direct Mode, a minimum of one DCPMM is required per processor (any processor).
9. Check the Supermicro website for recommended memory modules.

Maximum Memory Capacity Supported on a Platform

The maximum memory capacity that is supported on a platform is dependent on the suffix of the Second Generation Xeon Scalable Processor used in your system:

- Processors with an L suffix (i.e. 8280L): 4.5 TB maximum per processor
- Processors with an M suffix (i.e. 8280M): 2 TB maximum per processor
- Processors with no suffix (i.e. 8280): 1 TB per processor

Restrictions on Memory Configuration Settings

When configuring memory mirroring and memory sparing settings, please note the following restrictions:

1. Only the DRAM DIMM installed in the system will be mirrored; DCPMMs do not support memory mirroring.
2. Memory mirroring is only supported when DCPMMs are configured in App-Direct Mode.
3. Memory sparing is not supported when DCPMMs are installed in the system.

DCPMM Population Tables

Symmetric Population within 1 CPU Socket									
Modes	**P1-DIMMF1**	**P1-DIMME1**	**P1-DIMMD1**	**P1-DIMMD2**	**P1-DIMMA2**	**P1-DIMMA1**	**P1-DIMMB1**	**P1-DIMMC1**	**Channel Config.**
AD	DRAM1	DRAM1	DRAM1	***DCPMM***	***DCPMM***	DRAM1	DRAM1	DRAM1	**2-1-1**
MM	DRAM2	DRAM2	DRAM2	***DCPMM***	***DCPMM***	DRAM2	DRAM2	DRAM2	**2-1-1**
AD + MM	DRAM3	DRAM3	DRAM3	***DCPMM***	***DCPMM***	DRAM3	DRAM3	DRAM3	**2-1-1**
AD	***DCPMM***	DRAM1	DRAM1	-	-	DRAM1	DRAM1	***DCPMM***	**1-1-1**
MM	***DCPMM***	DRAM1	DRAM1	-	-	DRAM1	DRAM1	***DCPMM***	**1-1-1**
AD + MM	***DCPMM***	DRAM3	DRAM3	-	-	DRAM3	DRAM3	***DCPMM***	**1-1-1**

Asymmetric Population within 1 CPU Socket									
Modes	**P1-DIMMF1**	**P1-DIMME1**	**P1-DIMMD1**	**P1-DIMMD2**	**P1-DIMMA2**	**P1-DIMMA1**	**P1-DIMMB1**	**P1-DIMMC1**	**Channel Config.**
AD	DRAM1	DRAM1	DRAM1	-	***DCPMM***	DRAM1	DRAM1	DRAM1	**2-1-1**
AD*	DRAM1	DRAM1	DRAM1	-	***DCPMM***	DRAM1	DRAM1	DRAM1	**2-1-1**

Legend (for the two tables above)					
DDR4 Type					**Capacity**
DRAM1	RDIMM	3DS RDIMM	LRDIMM	3DS LRDIMM	Refer to Validation Matrix (DDR4 DIMMs validated with DCPMM) below.
DRAM2	RDIMM	-	-	-	
DRAM3	RDIMM	3DS RDIMM	LRDIMM	-	

Note: DDR4 single rank x8 is not available for DCPMM Memory Mode or App-Direct Mode.

Legend (for the first two tables above)	
Capacity	
DCPMM	Any Capacity (Uniformly for all channels for a given configuration)

- * 2nd socket has no DCPMM DIMM
- Mode definitions: AD=App Direct Mode, MM=Memory Mode, AD+MM=Mixed Mode
- For MM, general DDR4+DCPMM ratio is between 1:4 and 1:16. Excessive capacity for DCPMM can be used for AD.
- For each individual population, rearrangements between channels are allowed as long as the resulting population is compliant with the PDG rules for the 2nd Gen Intel Xeon Scalable-SP (82xx/62xx/52xx/4215 series) processors.
- For each individual population, please use the same DDR4 DIMM in all slots.
- For each individual population, sockets are normally symmetric with exceptions for 1 DCPMM per socket and 1 DCPMM per node case. Currently, DCPMM modules operate at 2666 MHz.
- No mixing of DCPMM and NVMDIMMs within the same platform is allowed.
- This DCPMM population guide targets a balanced DCPMM-to-DRAM-cache ratio in MM and MM + AD modes.

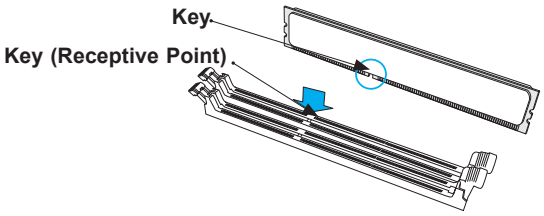
Validation Matrix (DDR4 DIMMs Validated w/DCPMM)			
DIMM Type	**Ranks Per DIMM & Data Width (Stack)**	**DIMM Capacity (GB)**	
		DRAM Density	
		4Gb	**8Gb**
RDIMM	1Rx4	8GB	16GB
	2Rx8	8GB	16GB
	2Rx4	16GB	32GB
LRDIMM	4Rx4	N/A	64GB
LRDIMM 3DS	8Rx4 (4H)	N/A	128GB

DIMM Module Installation

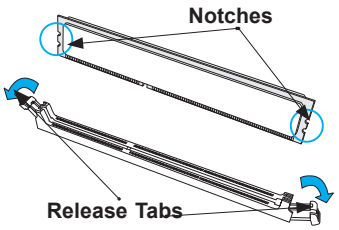
1. Insert the desired number of DIMMs into the memory slots based on the recommended DIMM population tables on the previous page.

2. Push the release tabs outwards on both ends of the DIMM slot to unlock it.

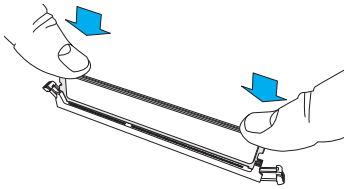
3. Align the key of the DIMM module with the receptive point on the memory slot.



4. Align the notches on both ends of the module against the receptive points on the ends of the slot.



5. Press both ends of the module straight down into the slot until the module snaps into place.



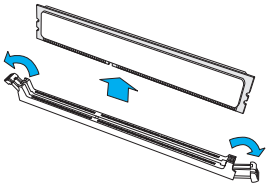
Push both ends straight down into the memory slot.

6. Press the release tabs to the lock positions to secure the DIMM module into the slot.

Note: All graphics included in this user's guide are for illustration only. Your system components may or may look exactly the same as the graphics shown in this user's guide.

DIMM Removal

Press both release tabs on the ends of the DIMM module to unlock it. Once the DIMM module is loosened, remove it from the memory slot.



Warning! Please do not use excessive force when pressing the release tabs on the ends of the DIMM socket to avoid causing any damage to the DIMM module or the DIMM socket. Please handle DIMM modules with care. Carefully follow all the instructions given on Page 1 of this chapter to avoid ESD-related damages done to your memory modules or components.

Chapter 3

Configuring DCPMM Settings Using Open Source Utilities

3.1 DCPMM Configuration

Introduction to ipmctl and ndtcl

ipmctl is an open source utility used to configure and manage Intel Optane DC memory modules for memory performance enhancement. This utility, created and maintained by Intel, is available for download from GitHub. It supports the following features:

- Discovery
- Configuration
- Firmware management
- Security functionality management
- Health monitoring
- Performance tracking
- Debug and troubleshooting

Introduction to ndtcl

Ndctl is an open source utility used for managing the Linux LIBNVDIMM kernel subsystem. It is designed to work with various non-volatile memory devices (NVDIMMs) from different vendors. **Ndctl** supports the following features:

- Provisioning Namespaces
- Enumerating Devices
- Enabling and Disabling DCPMM, Regions and Namespaces
- Managing DCPMM Labels

Some Important Concepts for Persistent Memory Provisioning

Region

A region is a group of one or more DCPMMs. A DCPMM region can be created in either a non-interleaved or n-way interleaved format. In a interleaved region, all DCPMMs are seen as one single monolithic space, which is similar in concept to RAID-0 in storage. In a non-interleaved region, each DCPMM is seen as a separate space, which is similar in concept to JBOD in storage.

DCPMM Region

DCPMM regions can only be created or modified by using ipmctl. DCPMMs support the following three types of regions:

- PMEM: Persistent memory devices allow for byte-addressable access.
- BLK: Block devices allow sector atomicity similar to traditional storage devices.
- NVDIMM: NVDIMM modules simultaneously support PMEM and BLK mode access.

Namespace

Namespace defines a contiguously addressed range of non-volatile memory, which is similar in concept to a hard disk partition, SCSI Logical Unit (LUN), or an NVM Express namespace. It is a persistent memory storage unit that cannot be used for input/output. Namespaces will appear as a device in **ndctl** (**/dev**). Creating namespaces can be achieved by using **ndctl** (Non-volatile Device Control) in a Linux system.

DCPMM Namespace

DCPMMs can appear as one of the two types of namespaces depending on the operating system and UEFI BIOS settings.

- **Direct Access (DAX)**

  DAX, which functions as a byte-addressable storage, requires an API (Application programming interface) to access. In order to utilize the DCPMM features, applications must be DCPMM-aware and use the published APIs.

- **Block Storage:**

  Block Storage is persistent memory that is seen as a block storage device by applications. In order to utilize the DCPMM features, the operating system needs to be DCPMM-aware.

3.2 Ipmctl Configuration

The full list of commands can be seen by running **ipmctl help** from the command line.

Show Topology

Use the **ipmctl sudo show- topology** command to display the DCPMMs and DDR DIMMs discovered in the system by enumerating the SMBIOS Type 17 tables.

```
[root@localhost ~]# ipmctl show -topology

 DimmID | MemoryType                  | Capacity  | PhysicalID| DeviceLocator
================================================================================
 0x0001 | Logical Non-Volatile Device | 502.6 GiB | 0x0015    | P1-DIMMA2
 0x0101 | Logical Non-Volatile Device | 502.6 GiB | 0x0019    | P1-DIMMD2
 0x1001 | Logical Non-Volatile Device | 502.6 GiB | 0x001d    | P2-DIMMA2
 0x1101 | Logical Non-Volatile Device | 502.6 GiB | 0x0021    | P2-DIMMD2
 N/A    | DDR4                        | 16.0 GiB  | 0x0014    | P1-DIMMA1
 N/A    | DDR4                        | 16.0 GiB  | 0x0016    | P1-DIMMB1
 N/A    | DDR4                        | 16.0 GiB  | 0x0017    | P1-DIMMC1
 N/A    | DDR4                        | 16.0 GiB  | 0x0018    | P1-DIMMD1
 N/A    | DDR4                        | 16.0 GiB  | 0x001a    | P1-DIMME1
 N/A    | DDR4                        | 16.0 GiB  | 0x001b    | P1-DIMMF1
 N/A    | DDR4                        | 16.0 GiB  | 0x001c    | P2-DIMMA1
 N/A    | DDR4                        | 16.0 GiB  | 0x001e    | P2-DIMMB1
 N/A    | DDR4                        | 16.0 GiB  | 0x001f    | P2-DIMMC1
 N/A    | DDR4                        | 16.0 GiB  | 0x0020    | P2-DIMMD1
 N/A    | DDR4                        | 16.0 GiB  | 0x0022    | P2-DIMME1
 N/A    | DDR4                        | 16.0 GiB  | 0x0023    | P2-DIMMF1
```

A.1. Show Topology (CentOS)

```
Select Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl show -topology

DimmID  MemoryType      Capacity        PhysicalID      DeviceLocator
0x0001  Unknown         502.5 GiB       0x0015          P1-DIMMA2
0x0101  Unknown         502.5 GiB       0x0019          P1-DIMMD2
0x1001  Unknown         502.5 GiB       0x001d          P2-DIMMA2
0x1101  Unknown         502.5 GiB       0x0021          P2-DIMMD2
N/A     DDR4            16.0 GiB        0x0014          P1-DIMMA1
N/A     DDR4            16.0 GiB        0x0016          P1-DIMMB1
N/A     DDR4            16.0 GiB        0x0017          P1-DIMMC1
N/A     DDR4            16.0 GiB        0x0018          P1-DIMMD1
N/A     DDR4            16.0 GiB        0x001a          P1-DIMME1
N/A     DDR4            16.0 GiB        0x001b          P1-DIMMF1
N/A     DDR4            16.0 GiB        0x001c          P2-DIMMA1
N/A     DDR4            16.0 GiB        0x001e          P2-DIMMB1
N/A     DDR4            16.0 GiB        0x001f          P2-DIMMC1
N/A     DDR4            16.0 GiB        0x0020          P2-DIMMD1
N/A     DDR4            16.0 GiB        0x0022          P2-DIMME1
N/A     DDR4            16.0 GiB        0x0023          P2-DIMMF1
```

A.2. Show Topology (Windows)

Show DIMM Information

Use the **ipmctl show -dimm** command to display the persistent memory modules discovered in the system and the communication status between applications and memory modules. This command also displays DIMM IDs, capacities, health state, and firmware version.

```
[root@localhost ~]# ipmctl show -dimm

 DimmID | Capacity  | HealthState | ActionRequired | LockState | FWVersion
==============================================================================
 0x0001 | 502.6 GiB | Healthy     | 0              | Disabled  | 01.02.00.5360
 0x0101 | 502.6 GiB | Healthy     | 0              | Disabled  | 01.02.00.5360
 0x1001 | 502.6 GiB | Healthy     | 0              | Disabled  | 01.02.00.5360
 0x1101 | 502.6 GiB | Healthy     | 0              | Disabled  | 01.02.00.5360
```

B.1. Show DIMM Information (CentOS)

```
Select Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl show -dimm

DimmID  Capacity        HealthState     ActionRequired  LockState       FWVersion
0x0001  502.5 GiB       Healthy         0               Disabled        01.02.00.5360
0x0101  502.5 GiB       Healthy         0               Disabled        01.02.00.5360
0x1001  502.5 GiB       Healthy         0               Disabled        01.02.00.5360
0x1101  502.5 GiB       Healthy         0               Disabled        01.02.00.5360
```

B.2. Show DIMM Information (Windows)

Show Provisioned Capacity

Use the **ipmctl show -memoryresources** command to display the provisioned capacity under different DCPMM mode configurations. If memory capacity is displayed as 0 GiB, it indicates the current mode is set to App Direct; otherwise, it is set to Memory Mode.

```
[root@localhost ~]# ipmctl show -memoryresources

Capacity=2010.4 GiB
MemoryCapacity=0.0 GiB
AppDirectCapacity=0.0 GiB
UnconfiguredCapacity=2010.4 GiB
InaccessibleCapacity=0.0 GiB
ReservedCapacity=0.0 GiB
```

C.1. Show Provisioned Capacity (CentOS)

```
Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl show -memoryresources

Capacity=2010.3 GiB
MemoryCapacity=0.0 GiB
AppDirectCapacity=1856.0 GiB
UnconfiguredCapacity=154.2 GiB
InaccessibleCapacity=0.0 GiB
ReservedCapacity=0.1 GiB
```

C.2. Show Provisioned Capacity (Windows)

Provisioning

During provisioning process, a **goal** is specified and configured into Memory Mode, App Direct Mode, or both(Mixed Mode). This goal will be applied after the system has been reset.

Memory Mode Configuration

Use the **ipmctl create -goal MemoryMode=n** command to provision any percentage of DCPMM capacity on all sockets, where **n** represents the percentage number of capacity to be provisioned in Memory Mode. A reboot is required to process new memory allocation **goals**.

```
[root@localhost ~]# ipmctl create -goal MemoryMode=100

The following configuration will be applied:
 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
==================================================================
 0x0000   | 0x0001 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
 0x0000   | 0x0101 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
 0x0001   | 0x1001 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
 0x0001   | 0x1101 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
Do you want to continue? [y/n] y
Created following region configuration goal
 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
==================================================================
 0x0000   | 0x0001 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
 0x0000   | 0x0101 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
 0x0001   | 0x1001 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
 0x0001   | 0x1101 | 502.0 GiB  | 0.0 GiB        | 0.0 GiB
A reboot is required to process new memory allocation goals.
```

D.1. Memory Mode Configuration (CentOS)

```
Select Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl create -goal MemoryMode=100

The following configuration will be applied:

SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  502.0 GiB               0.0 GiB 0.0 GiB
0x0000          0x0101  502.0 GiB               0.0 GiB 0.0 GiB
0x0001          0x1001  502.0 GiB               0.0 GiB 0.0 GiB
0x0001          0x1101  502.0 GiB               0.0 GiB 0.0 GiB
Do you want to continue? [y/n] y
Created following region configuration goal
SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  502.0 GiB               0.0 GiB 0.0 GiB
0x0000          0x0101  502.0 GiB               0.0 GiB 0.0 GiB
0x0001          0x1001  502.0 GiB               0.0 GiB 0.0 GiB
0x0001          0x1101  502.0 GiB               0.0 GiB 0.0 GiB
A reboot is required to process new memory allocation goals.
```

D.2. Memory Mode Configuration (Windows)

App Direct Mode Configuration

In App Direct Mode, DCPMMs can be provisioned with either interleaved or non-interleaved enabled. In interleaved configurations, all DCPMMs are seen as one monolithic space, which is similar in concept to RAID-0 in traditional storage. In non-interleaved configurations, each DCPMM is seen as a separate space, which is similar in concept to JBOD in traditional storage. DCPMM interleaving increases the throughput of reads and writes to persistent memory.

Use the **ipmctl create -goal PersistentMemoryType=AppDirect**, or the default **ipmctl create -goal** command to set a **goal** that creates an interleaved region across all the DCPMMs discovered in the system. The two commands are equivalent in this action.

To create a **goal** that creates non-interleaved regions, use the **ipmctl create -goal PersistentMemoryType=AppDirectNotInterleaved** command (Please specify the **PersistentMemoryType** to be **AppDirectNotInterleaved**).

```
[root@localhost ~]# ipmctl create -goal PersistentMemoryType=AppDirect

The following configuration will be applied:
 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
==================================================================
 0x0000   | 0x0001 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB
 0x0000   | 0x0101 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB
 0x0001   | 0x1001 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB
 0x0001   | 0x1101 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB

The amount of mapped memory was limited based on the SKU resulting in un-mapped capacity.
Do you want to continue? [y/n] y
Created following region configuration goal
 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
==================================================================
 0x0000   | 0x0001 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB
 0x0000   | 0x0101 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB
 0x0001   | 0x1001 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB
 0x0001   | 0x1101 | 0.0 GiB    | 464.0 GiB      | 0.0 GiB
A reboot is required to process new memory allocation goals.
```

E.1. App Direct Mode Configuration (CentOS)

```
Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl create -goal PersistentMemoryType=AppDirect

The following configuration will be applied:

SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  0.0 GiB         464.0 GiB       0.0 GiB
0x0000          0x0101  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1001  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1101  0.0 GiB         464.0 GiB       0.0 GiB

The amount of mapped memory was limited based on the SKU resulting in un-mapped capacity.
Do you want to continue? [y/n] y
Created following region configuration goal
SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  0.0 GiB         464.0 GiB       0.0 GiB
0x0000          0x0101  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1001  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1101  0.0 GiB         464.0 GiB       0.0 GiB
A reboot is required to process new memory allocation goals.
```

E.2. App Direct Mode Configuration (Windows)

Mixed Mode Configuration

DCPMMs can be configured into Mixed Mode with part of the capacity assigned to Memory Mode and the remaining capacity to App Direct Mode as an interleaved region. When part or all of the capacity is set to Memory Mode, the DDR4 DRAM capacity is hidden from the applications and acts as a caching layer for DCPMMs.

Use the **ipmctl create -goal MemoryMode=n** command to set a **goal** that provisions any percentage of DCPMM capacity on all sockets, where **n** represents the number percentage (ie. 0~100) of capacity to be provisioned in Memory Mode.

```
[root@localhost ~]# ipmctl create -goal MemoryMode=60

The following configuration will be applied:
 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
==================================================================
 0x0000   | 0x0001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0000   | 0x0101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
Do you want to continue? [y/n] y
Created following region configuration goal
 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
==================================================================
 0x0000   | 0x0001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0000   | 0x0101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
A reboot is required to process new memory allocation goals.
```

F.1. Mixed Mode Configuration (CentOS)

```
Select Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl create -goal MemoryMode=60

The following configuration will be applied:

SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  310.0 GiB               192.0 GiB       0.0 GiB
0x0000          0x0101  310.0 GiB               192.0 GiB       0.0 GiB
0x0001          0x1001  310.0 GiB               192.0 GiB       0.0 GiB
0x0001          0x1101  310.0 GiB               192.0 GiB       0.0 GiB
Do you want to continue? [y/n] y
Created following region configuration goal
SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  310.0 GiB               192.0 GiB       0.0 GiB
0x0000          0x0101  310.0 GiB               192.0 GiB       0.0 GiB
0x0001          0x1001  310.0 GiB               192.0 GiB       0.0 GiB
0x0001          0x1101  310.0 GiB               192.0 GiB       0.0 GiB
A reboot is required to process new memory allocation goals.
```

F.2. Mixed Mode Configuration (Windows)

Create a Goal from a Configuration File

Use the **ipmctl load -source <file> -goal** command to load goals and special configurations from a configuration file. Use the **ipmctl dump -destination <file> -system -config** command to save the current configuration to a file.

```
[root@localhost ~]# ipmctl load -source /root/testfile -goal

Load the configuration goal from '/root/testfile' which will delete existing data and provision the capacity of the DIMMs on the
 next reboot.
Do you want to continue? [y/n] y
Loaded following pool configuration goal
 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
==============================================================
 0x0000   | 0x0001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0000   | 0x0101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
A reboot is required to process new memory allocation goals.
```

G.1. Create a Goal from a Configuration File (CentOS)

```
Select Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl load -source C:\Users\Administrator/ipmctl_config -goal

Load the configuration goal from 'C:\Users\Administrator/ipmctl_config' which will delete existing data and provision the capacity of the DIMMs
 on the next reboot.
Do you want to continue? [y/n] y
Loaded following pool configuration goal
SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  0.0 GiB         464.0 GiB       0.0 GiB
0x0000          0x0101  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1001  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1101  0.0 GiB         464.0 GiB       0.0 GiB
A reboot is required to process new memory allocation goals.
```

G.2. Create a Goal from a Configuration File (Windows)

```
[root@localhost ~]# ipmctl dump -destination /root/testfile -system -config

Successfully dumped system configuration to file: /root/testfile
NVM_DBG_LOGGER Debug NVDIMM-ERR:DumpGoalCommand.c::DumpGoal:132: Failed to process printer objects! (0x2)
Segmentation fault
```

H.1. Save current Goal Configuration to a File (CentOS)

```
Administrator: Windows PowerShell
PS C:\Users\Administrator> pwd

Path
----
C:\Users\Administrator


PS C:\Users\Administrator> ipmctl dump -destination C:\Users\Administrator/ipmctl_config -system -config

Successfully dumped system configuration to file: C:\Users\Administrator/ipmctl_config
```

H.2. Save current Goal Configuration to a File (Windows)

Show Current Goal

Use the **ipmctl show -goal** command to display the goal that is currently in place.

Delete Goal

A goal will not be executed until after a system reboot. Use the **ipmctl delete -goal** command to clear the goal that is currently in place.

```
[root@localhost ~]# ipmctl show -goal

 SocketID | DimmID | MemorySize | AppDirect1Size | AppDirect2Size
=============================================================================
 0x0000   | 0x0001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0000   | 0x0101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1001 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
 0x0001   | 0x1101 | 310.0 GiB  | 192.0 GiB      | 0.0 GiB
A reboot is required to process new memory allocation goals.
```

I.1. Show Current Goal (CentOS)

```
Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl show -goal

SocketID        DimmID  MemorySize      AppDirect1Size  AppDirect2Size
0x0000          0x0001  0.0 GiB         464.0 GiB       0.0 GiB
0x0000          0x0101  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1001  0.0 GiB         464.0 GiB       0.0 GiB
0x0001          0x1101  0.0 GiB         464.0 GiB       0.0 GiB
A reboot is required to process new memory allocation goals.
```

I.2. Show Current Goal (Windows)

```
[root@localhost ~]# ipmctl delete -goal

Delete memory allocation goal from DIMM 0x0001: Success
Delete memory allocation goal from DIMM 0x0101: Success
Delete memory allocation goal from DIMM 0x1001: Success
Delete memory allocation goal from DIMM 0x1101: Success
```

J.1. Delete Goal (CentOS)

```
Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl delete -goal

Delete memory allocation goal from DIMM 0x0001: Success
Delete memory allocation goal from DIMM 0x0101: Success
Delete memory allocation goal from DIMM 0x1001: Success
Delete memory allocation goal from DIMM 0x1101: Success
```

J.2. Delete Goal (Windows)

Confirm Mode Change

Use the **ipmctl show -memoryresources** command to confirm if the mode has been changed successfully after a system reboot. If the mode is changed from Memory Mode to App Direct Mode, a single region per socket will be created upon system reboot. No regions will be created when the mode is changed from App Direct Mode to Memory Mode. Use the **show -region** command to display the regions that were created.

```
[root@localhost ~]# ipmctl show -memoryresources

Capacity=2010.4 GiB
MemoryCapacity=1240.0 GiB
AppDirectCapacity=768.0 GiB
UnconfiguredCapacity=0.0 GiB
InaccessibleCapacity=2.4 GiB
ReservedCapacity=0.0 GiB
```

K.1. Confirm Mode Change (CentOS)

```
Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl show -memoryresources

Capacity=2010.3 GiB
MemoryCapacity=0.0 GiB
AppDirectCapacity=1856.0 GiB
UnconfiguredCapacity=154.2 GiB
InaccessibleCapacity=0.0 GiB
ReservedCapacity=0.1 GiB
```

K.2. Confirm Mode Change (Windows)

```
[root@localhost ~]# ipmctl show -region

 SocketID | ISetID             | PersistentMemoryType | Capacity  | FreeCapacity | HealthState
=================================================================================================
 0x0000   | 0x94d0eeb83d732444 | AppDirect            | 384.0 GiB | 384.0 GiB    | Healthy
 0x0001   | 0x6f14eeb858752444 | AppDirect            | 384.0 GiB | 384.0 GiB    | Healthy
```

L.1. Display Region (CentOS)

```
Select Administrator: Windows PowerShell
PS C:\Users\Administrator> ipmctl show -region

SocketID             ISetID    PersistentMemoryType  Capacity FreeCapacity HealthState
       0 0xf3feda9037358a22 AppDirectNotInterleaved 464.0 GiB    464.0 GiB     Healthy
       0 0x0a4eda90063d8a22 AppDirectNotInterleaved 464.0 GiB    464.0 GiB     Healthy
       1 0x1e26da9088398a22 AppDirectNotInterleaved 464.0 GiB    464.0 GiB     Healthy
       1 0xee3ada90d03b8a22 AppDirectNotInterleaved 464.0 GiB    464.0 GiB     Healthy
```

L.2. Display Region (Windows)

Create Namespaces with ndctl

Follow the instructions below to properly create namespaces using the **ndctl** commands:

- **ndctl create-namespace [--mode | fsdax, sector]**
- Example: ndctl create-namespace --mode fsdax
- Repeat the same step to create a namespace for each region

```
[root@localhost ~]# ndctl create-namespace
{
  "dev":"namespace5.0",
  "mode":"fsdax",
  "map":"dev",
  "size":"988.31 GiB (1061.19 GB)",
  "uuid":"2a44c6f8-94ee-455f-a625-251067deb7cf",
  "raw_uuid":"26c04045-7fb6-44ea-ad83-430d4c77b7b7",
  "sector_size":512,
  "blockdev":"pmem5",
  "numa_node":1
}
```

M.1. Create Namespaces with ndctl

Check if Namespace is Successfully Created

To check if the namespace is successfully created, please use the **ndctl** command below:

- **ls -| /dev/ | grep pmem**

```
[root@localhost ~]# ls -l /dev/|grep pmem
brw-rw----.  1 root disk    259,   1 Dec 27 08:28 pmem4
brw-rw----.  1 root disk    259,   0 Dec 27 08:26 pmem5
```

M.2. Check if Namespace Successfully Created

List Active Namespaces

Use the **ndctl list -N** command to display the active namespaces list.

Delete Configuration

Deleting the current configuration can be done in two steps. First, namespaces need to be disabled and destroyed. After successfully destroying namespaces, disable the active regions to delete the configuration.

Disable Namespace

Use the **ndctl disable-namespace X** command to disable the namespace of the user's choice. **X** represents the namespace on the active namespaces list.

Note: It is imperative to stop applications and unmount used namespaces before disabling the namespace.

Destroy Namespace

Use the **ndctl destroy-namespace X** command to destroy the namespace of the user's choice. **X** represents the namespace on the active namespaces list.

List Active Regions

Use **ndctl list -R** to display the active regions list.

Delete Region

Use the **ndctl disable-region X** command to delete the region of the user's choice. **X** represents the region on the active regions list.

```
[root@localhost ~]# ndctl list -N
[
  {
    "dev":"namespace1.0",
    "mode":"fsdax",
    "map":"dev",
    "size":405872312320,
    "uuid":"cdcb9948-0b08-4c63-963d-8b8a4e9e0b91",
    "blockdev":"pmem1"
  },
  {
    "dev":"namespace0.0",
    "mode":"fsdax",
    "map":"dev",
    "size":405872312320,
    "uuid":"1c9f4c49-ce37-4573-91b6-85a0a18d62dd",
    "blockdev":"pmem0"
  }
]
```

N.1. List Active Namespaces (CentOS)

```
[root@localhost ~]# ndctl disable-namespace namespace0.0
disabled 1 namespace
```

O.1. Disable Namepace namespac0.0 (CentOS)

```
[root@localhost ~]# ndctl destroy-namespace namespace0.0
destroyed 1 namespace
```

O.2. Destroy Namepace namespac0.0 (CentOS)

Chapter 4

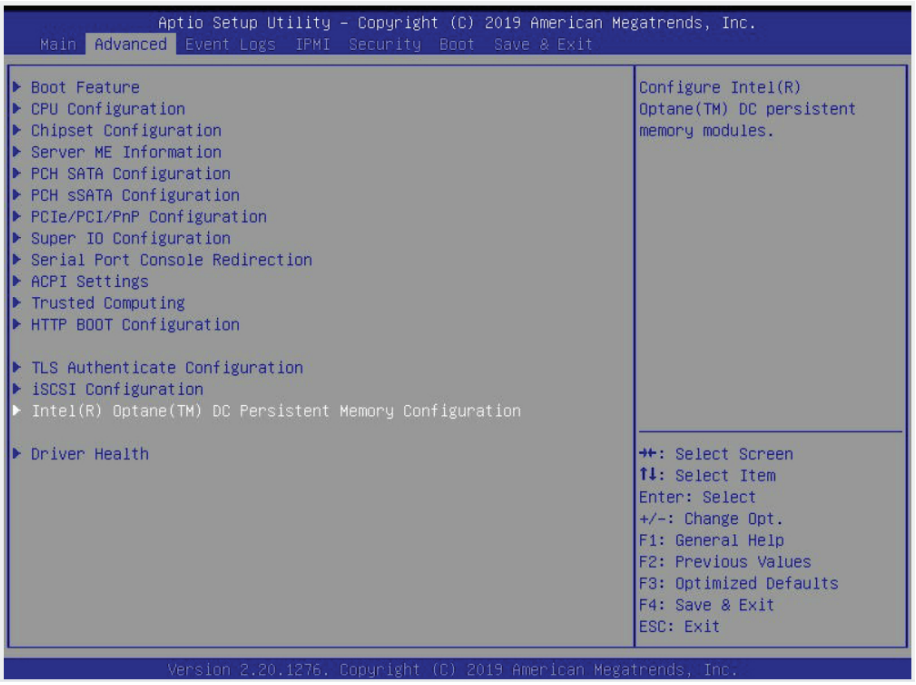
Configuring DCPMM Settings Using BIOS

This chapter describes how to configure DCPMM setting using the BIOS Setup utility.

4.1 To Enter the BIOS Setup Utility

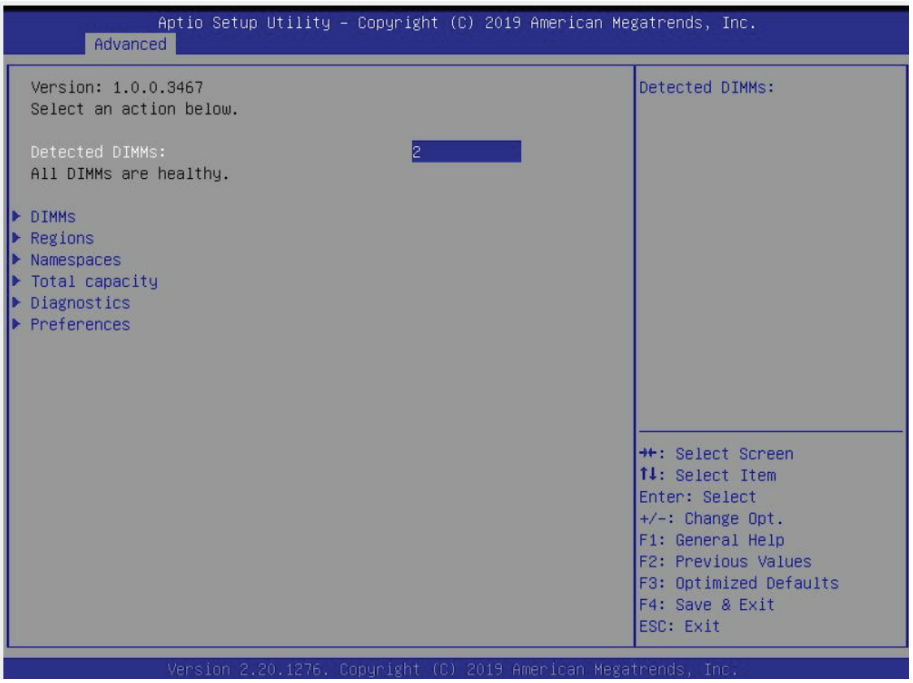
To enter the BIOS setup utility, please follow the instructions below.

- Press the <del> key continuously during system boot to enter the BIOS setup utility
- After the system enters the BIOS setup utility, use the arrow keys to select the Advanced tab on the top of the menu bar and press <Enter> to select it.
- Use the down-arrow key to select I**ntel(R) Optane(TM) DC Persistent Memory Configuration** and press <**Enter**>, the following screen will display:



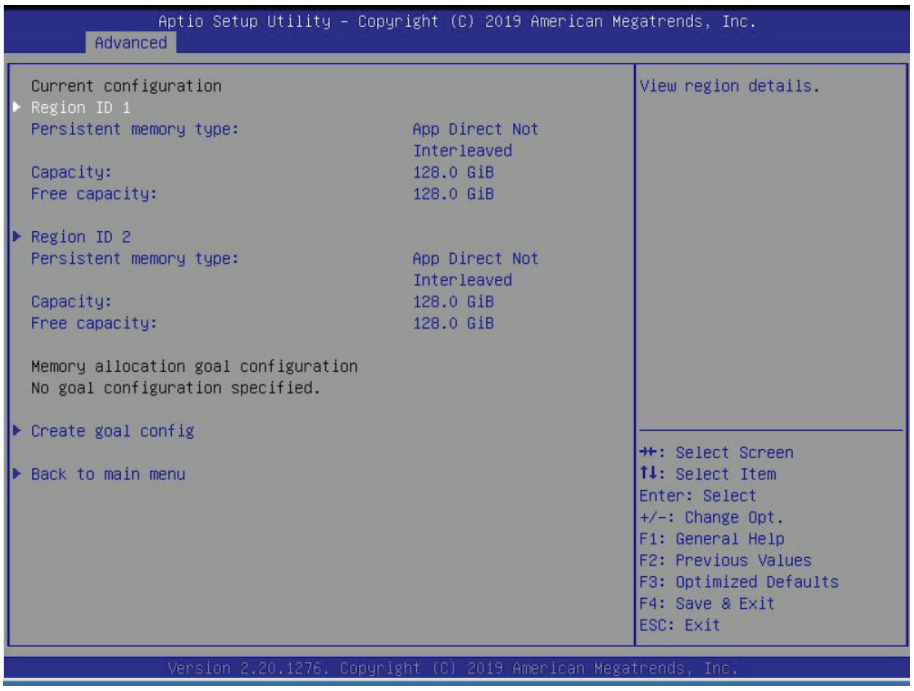
A.1. Intel DCPMM Configuration Settings

- Use the down arrow key to select **Region** and hit <**Enter**>. The following screen will display:



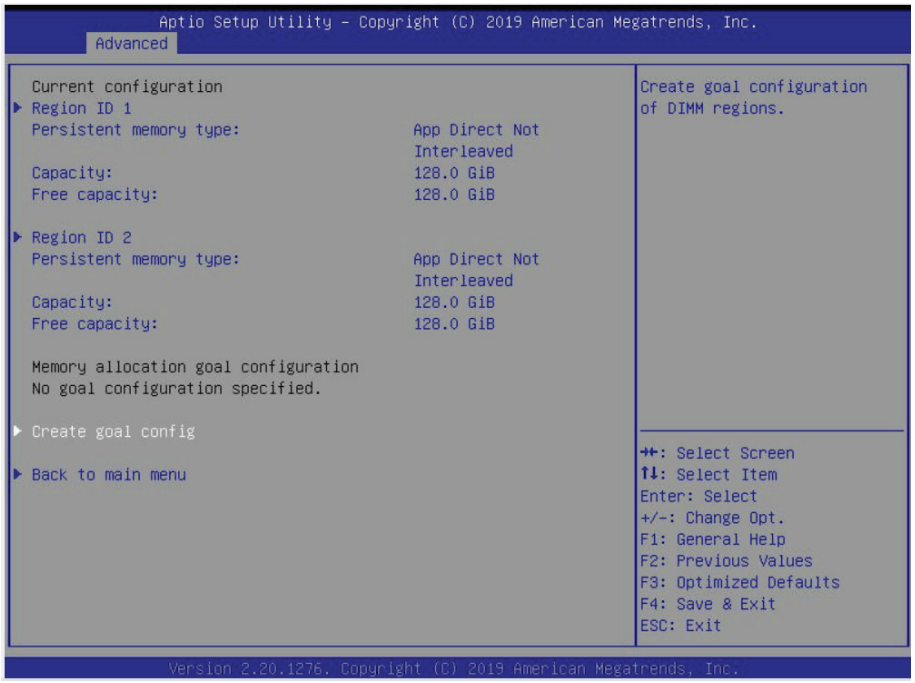
A.2. DCPMM Configuration Main Screen

- Scroll down to select **Create goal config** in the screen as shown below:



A.3. DCPMM Region ID

- When the screen above displays, select **Create goal config** and press <**Enter**>.

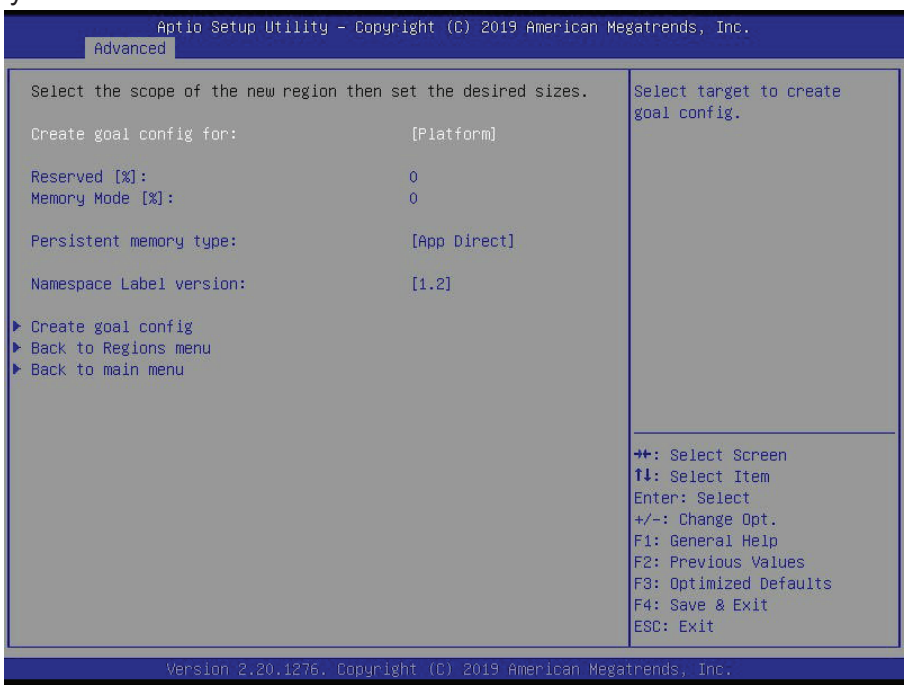


A.4. Create Goal Config. Entry

- The screen on the top of the next page will display which allow you to configure DCPMM memory as App Direct Mode, Memory Mode, and Mixed Memory Mode using the BIOS utility.

4.2 To Configure DCPMM Memory as App Direct Mode

Please complete all steps listed in Section 4.1 (pages 26-29). When the screen shown on the previous page displays, select **Create goal config** and press <**Enter**>, the following screen will display.



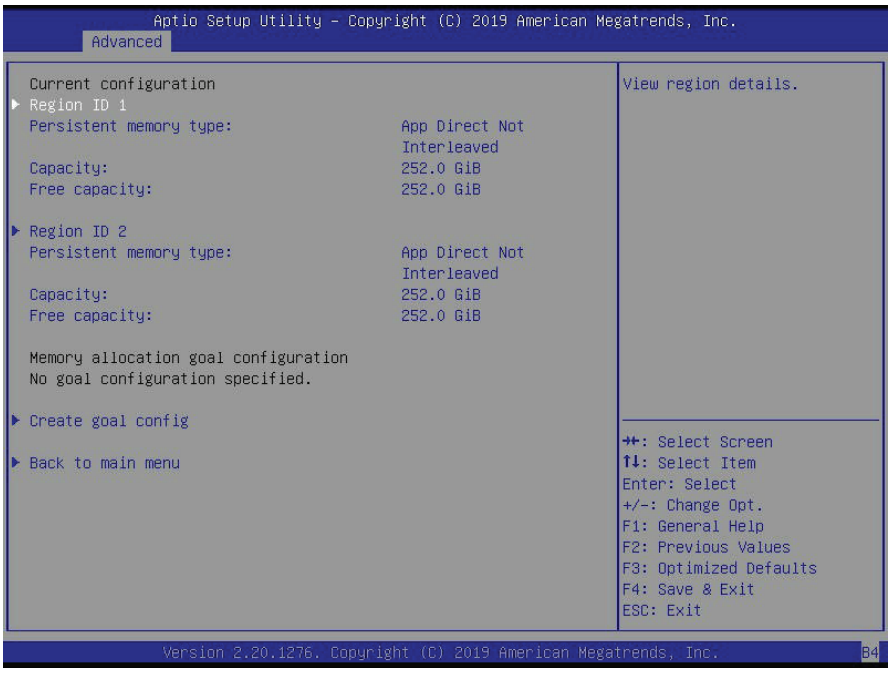
B.1. Create Goal Config Main Menu

Setting All DCPMM Memory Modules to App Direct Mode

Please complete the procedures below to properly configure DCPMM memory as App Direct Mode.

- Select **Platform** as the default setting for the the item: **Create goal config for**. This will set all DCPMM memory modules to App Direct Mode.
- Set the values of "Reserved [%]" and "Memory Mode [%]" to **0**.
- Change Persistent memory type to **App Direct** as needed.
- Scroll down to the screen and select "**Create goal config**" and press <**Enter**>.
- Select **Save** from the **Save & Exit** menu, and press <**Enter**> to save the changes.
- Reboot the system, and enter the BIOS utility again to continue with DCPMM configuration.

Note: Be sure to reboot your system for the changes you've made to to take effect.



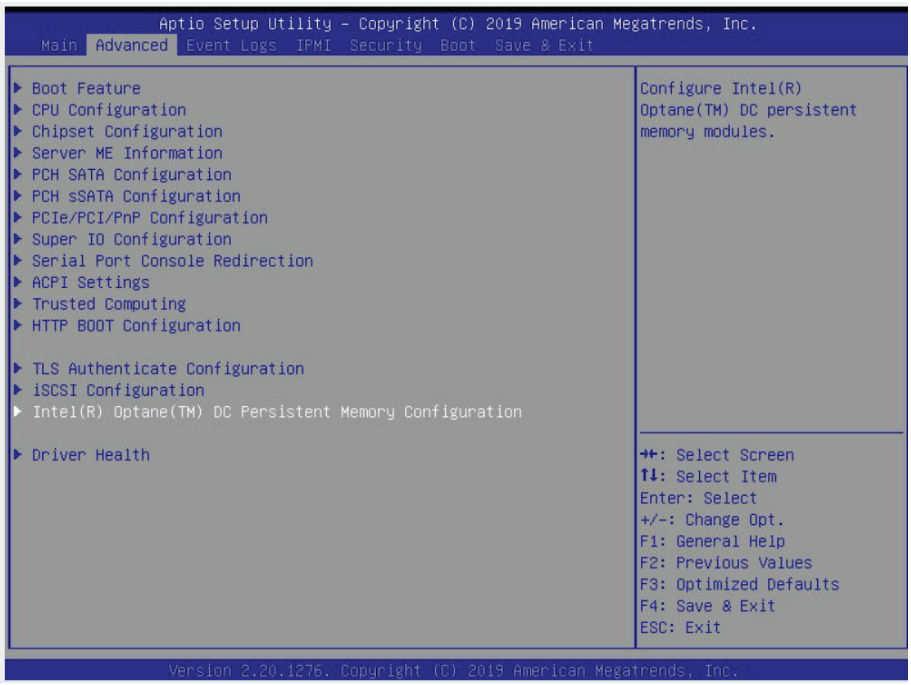
B.2. Create Goal Config-Region ID

Note: If you have properly configured the DCPMM settings, your BIOS screen will display as shown on the next page.

To Create a Namespace for a Region

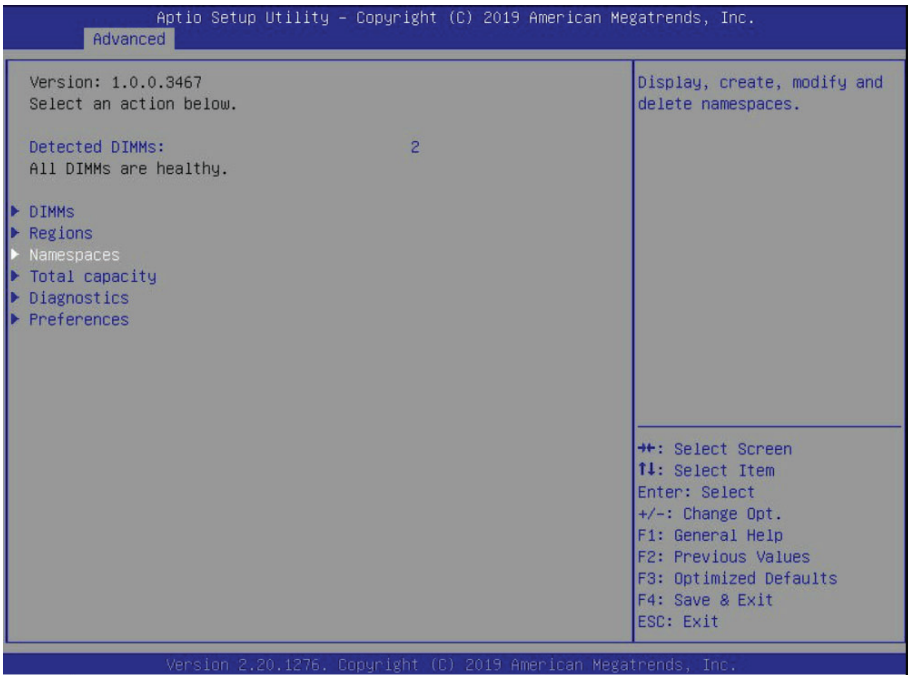
This section provides the instructions on how to create a namespace for a DCPMM memory region. To create a namespace, please follow the steps below.

- Follow the instructions given in Section 1 to enter the BIOS utility. Select **Advanced** on the top of the menu bar and press <Enter>. The following screen will display:



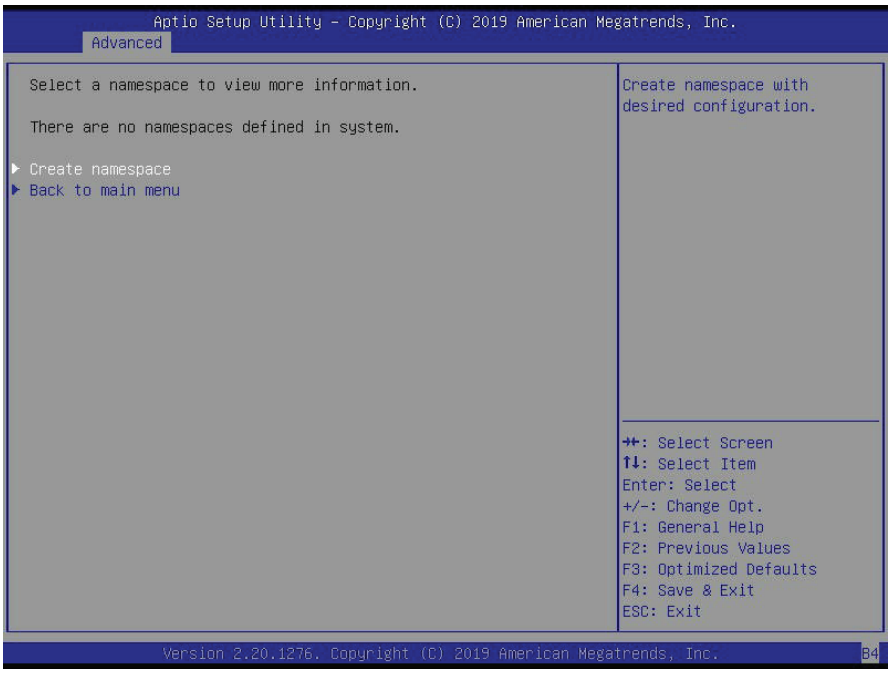
B.3. Intel DCPMM Configuration Settings

- Use the down-arrow key to select **Intel(R) Optane(TM) DC Persistent Memory Configuration** and press <**Enter**>. The following screen will display:



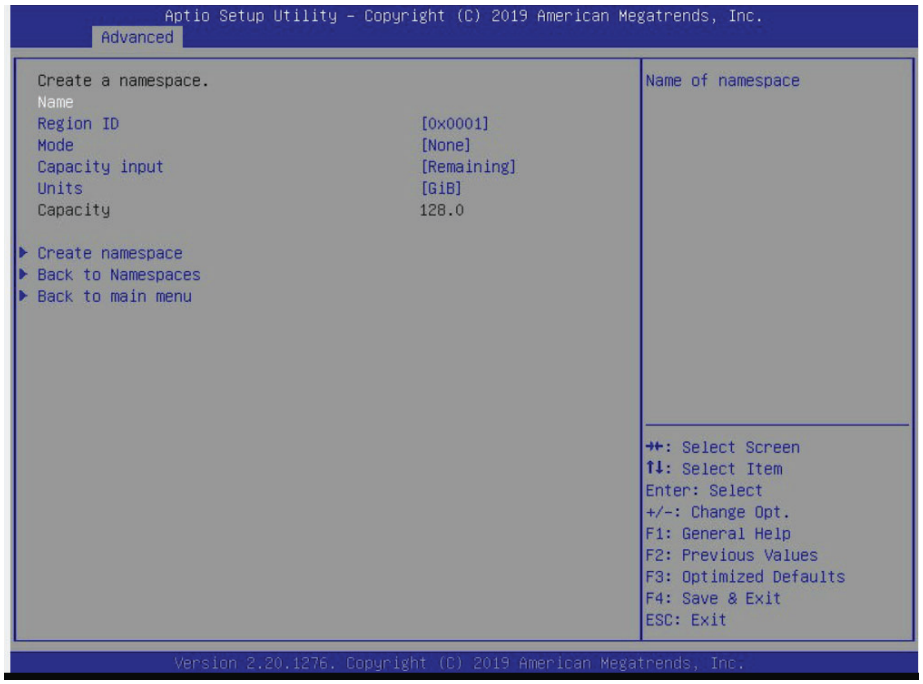
B.4. Namespace Configuration Settings

- When the screen above displays, scroll down to" "**Namespaces**" to select it and press <**Enter**>, the following screen will display for you to create a namespace:



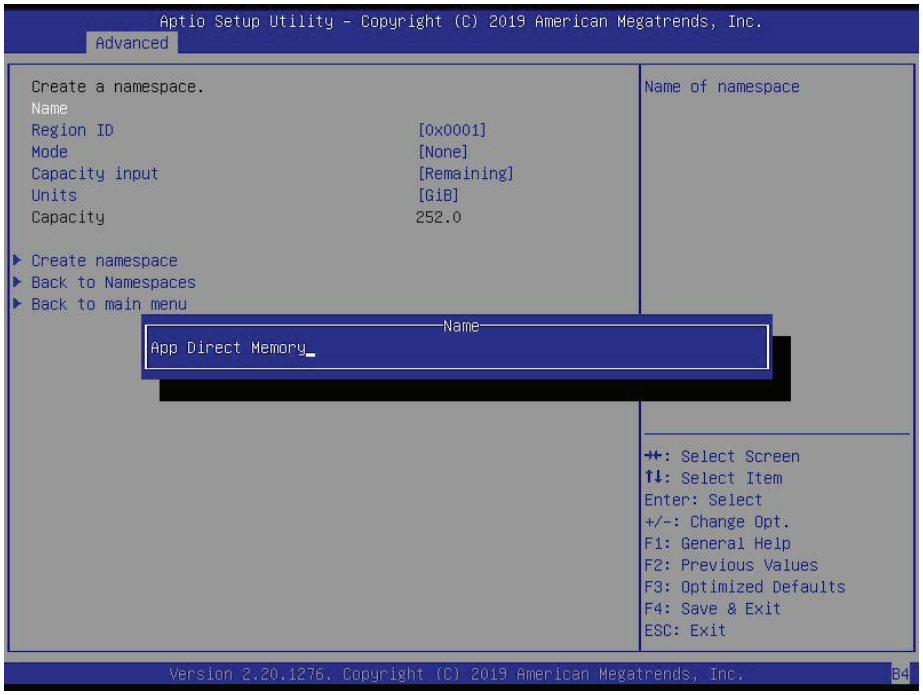
B.5. Create Namespaces Entry

- Select **Create Namespaces** and press <**Enter**> to create a namespace for the region. The screen shown on the next page will display:



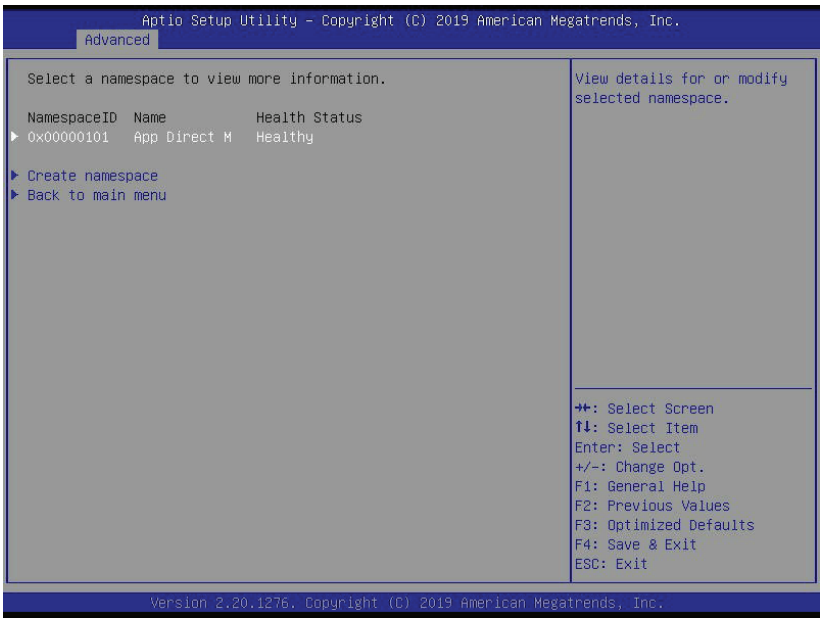
B.6. Create a Namespace

- Select **Name** and press <**Enter**>.
- Enter a **name in the popup window**.
- Select **Create Namespace** and press <**Enter**> to create a namespace for a region as shown below.



B.7. Enter a Name Field

- Be sure to confirm that the namespace was successfully created.
- If the namespace was properly created, the health status of the memory region will be displayed as shown below.

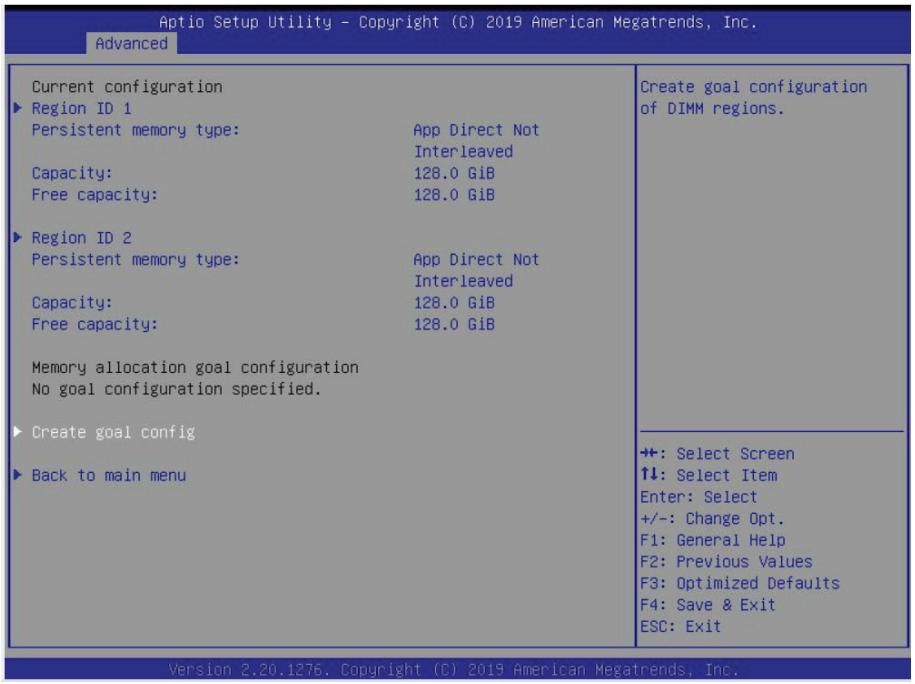


B.8. App Direct Health Status

4.3 To Configure DCPMM Memory as Memory Mode

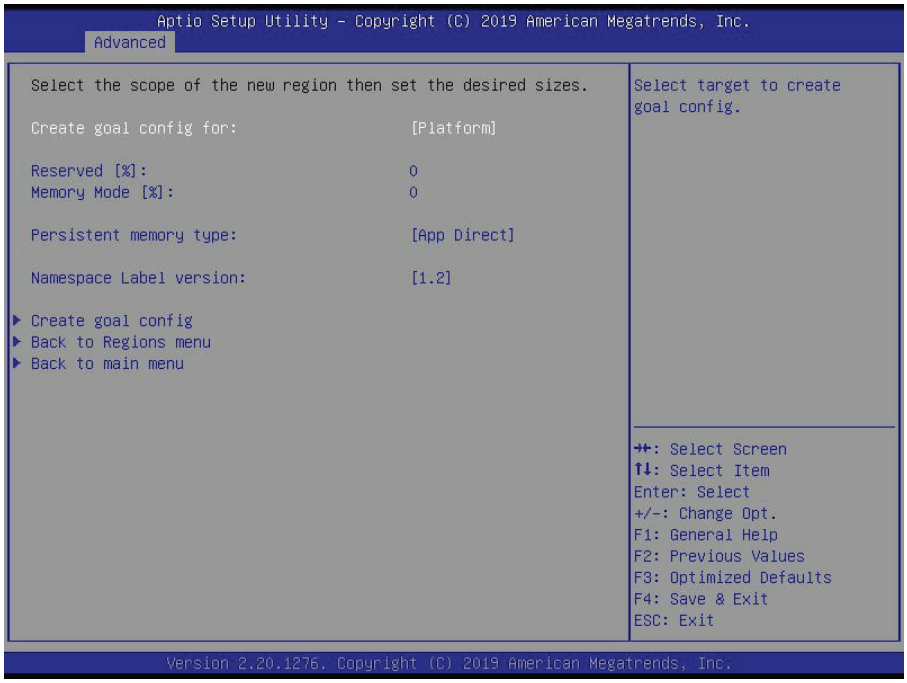
To configure DCPMM memory as Memory Mode, please follow the steps listed below.

- Follow the instructions given in Section 1 to enter the BIOS utility. Select **Advanced** to enter the Advanced menu.
- Select **Intel(R) Optane DC Persistent Memory** and press <**Enter**>.
- Select **Region** to configure Region settings and create Region IDs
- Select a **Region ID** and press <**Enter**>. The following screen will display:



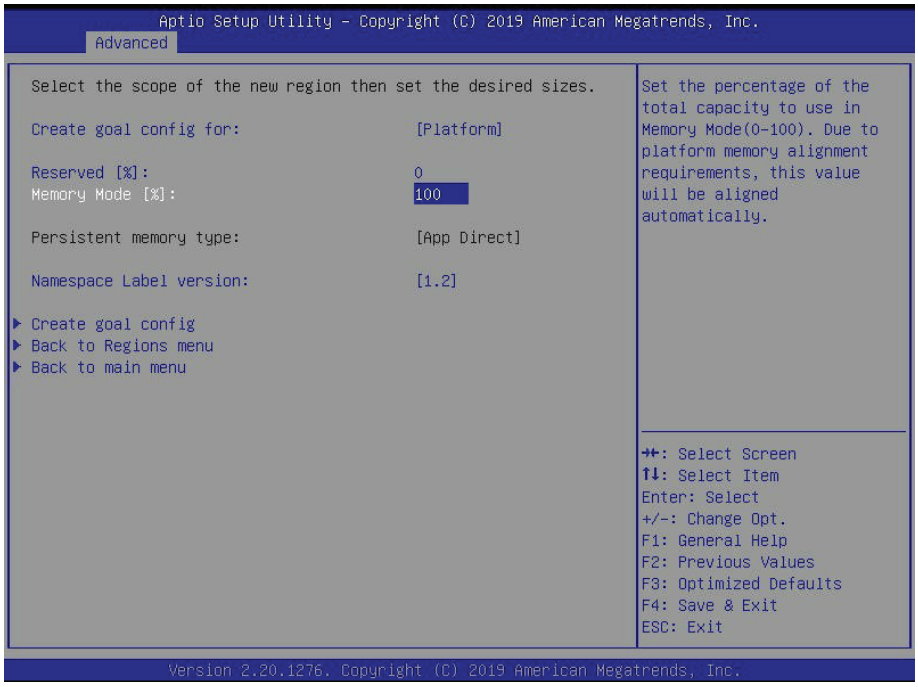
C.1. Create Goal Config Entry

- When the screen as shown above displays, select **Create goal config** and press <**Enter**>, the following screen will display.



C.2. Create Goal Config Main Menu

- When the screen shown as above displays, select **Create goal config** and press <**Enter**>, the following screen will display.



C.3. Create Memory Mode

- To configure DCPMM as Memory Mode, select **Memory Mode [%]** and enter **100** as the default. Save the setting and reboot the system for the changes you've made to take effect.

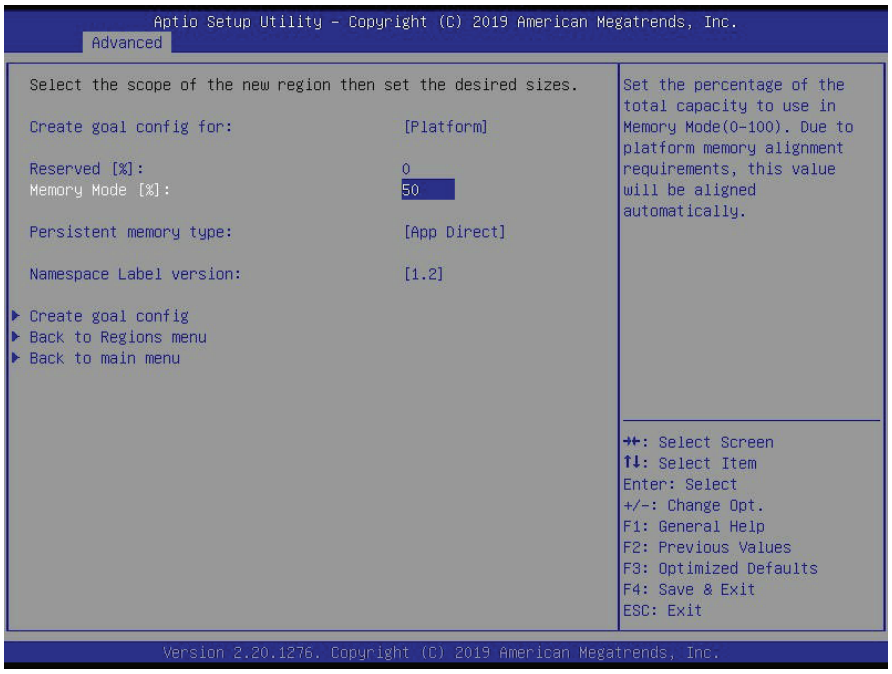
Note: To configure DCPMM as Memory Mode, Memory Mode [%] needs to be set to 100.

4.4 To Configure DCPMM Memory as Mixed Memory Mode

To configure DCPMM memory as Mixed Memory Mode, please follow the instructions to configure DCPMM as Memory Mode as listed in Section 4.3 (pages 36-37).

- After you've set DCPMM memory to Memory Mode as shown on the previous page, change the Memory Mode [%] to a value between 1 to 99. as shown the screen below.

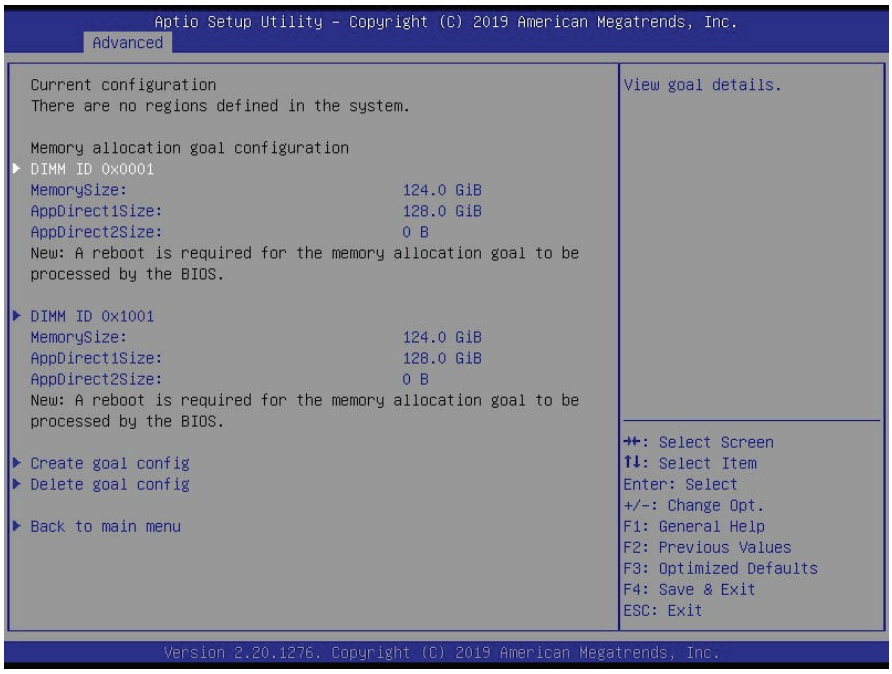
Note: To configure DCPMM as Mixed Memory Mode, **Memory Mode [%]** needs to be set to **a value between 1-99**.



D.1. Create Mixed Memory Mode

- The rest of the memory allocation will be configured as App Direct memory. Save the changes you've made and reboot the system for the changes to take effect.

- After the system reboots, enter the BIOS utility to confirm that a Mixed Memory region was successfully created as shown in the screen below.

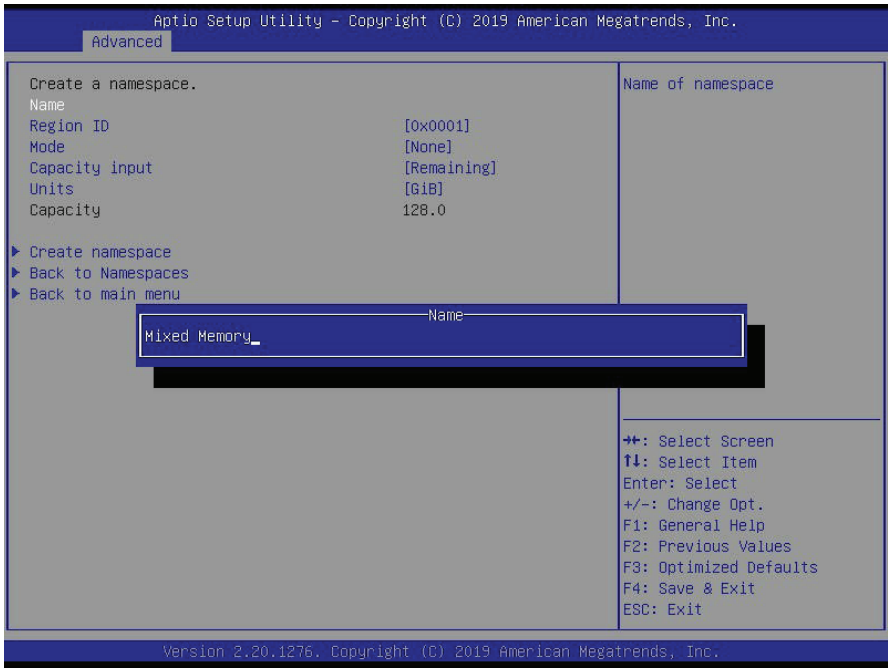


D.2. Current Configuration

To Create a Namespace for a Mixed Memory Region

This section provides the instructions on how to create a namespace for a Mixed Memory region.

- Refer to the instructions given in the section-"**To Create a Namespace for a Region** (pages 32-35) to create a name space for a Mixed Memory.



D.3. Create a Mixed Memory Region NameSpace

- After you've created a namespace for a Mixed Memory region, confirm that the namespace was successfully created.

- Save the changes you've made before existing from the BIOS utility. (Please note that you will need reboot the system for the changes to take effect.)