# Advanced Refrigerant-based Cooling Technologies for Information and Communications Infrastructure (ARCTIC)

## Reducing operating costs by providing efficient cooling at the heat source.

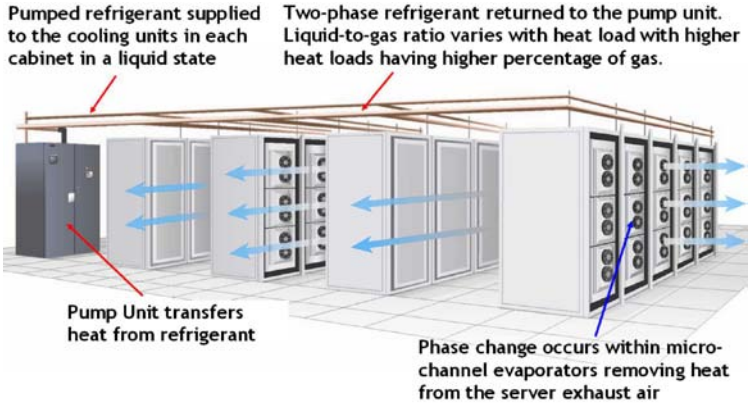
## Introduction

This project will develop and accelerate the commercialization of a refrigerant-based, liquid-cooling technology to enhance the management of server heat. The ARCTIC project is based on a modular cooling technology that supplies liquid refrigerant to micro-channel heat exchangers, which are extremely efficient at removing heat due to the close proximity of the refrigerant cooling medium to the actual heat sources. The research and development work will improve heat exchanger performance, develop component-level cooling technologies, optimize the refrigerant handling network, and evaluate system-level performance. By improving the manufacturing processes for key system components, this project is also expected to reduce the system cost—and thereby increase the commercialization potential—of the technology. This system is 90% more efficient than data center cooling systems that use conventional computer room air-conditioning (CRAC) units.

## Benefits for Our Industry and Our Nation

ARCTIC will deliver substantial benefits in three key areas important for promoting market acceptance across the data center and telecommunications sectors:

1. Reduced cooling costs—ARCTIC's projected energy and cooling cost savings are in excess of 90%, relative to conventional CRAC units used in data centers.
2. Reduced real estate footprint—As compared to air-cooled approaches, this project's pumped-refrigerant approach can handle significant increases in rack, shelf, circuit-pack, and component-level heat loads, allowing the much higher equipment densities required by burgeoning information and communication technology (ICT) facility needs.
3. Enhanced reliability—ARCTIC's ability to retrofit equipment without service interruption is particularly important to our nation's large installed ICT customer base, while the use of a non-toxic, non-conducting, and non-corrosive refrigerant will not, unlike water, damage electronics in case of a leak.




Advanced refrigerant-based cooling for rack mounted equipment.

*Image courtesy of Alcatel-Lucent Bell Laboratories.*

The ARCTIC approach has a significant potential for energy savings. For example,the replacement of conventional widely used data center CRAC units with this refrigerant-based liquid cooling system is expected to reduce cooling energy use by 93%.

## Applications in Our Nation's Industry

The ability to reduce cooling costs and increase real estate utilization will be an attractive feature for ICT facilities. This project will be of most interest to the following manufacturers and end-users:

- Data center and telecommunication facility owners and operators
- Rack and equipment manufacturers
- Construction and development companies
- Manufacturers and resellers of facility cooling and refrigeration equipment

## Project Description

The system created in this project provides an efficient way to provide shelf-level cooling of equipment racks in a telecommunications central office or data center. In this new system, a heat exchanger is mounted between shelves of the equipment rack. The air that is driven through the shelf to carry off the waste heat exits the shelf through the heat exchanger, which cools the air back down to ambient temperature. A fluid-handling system pumps refrigerant through the heat exchangers to provide the cooling. Heat is removed from the refrigerant in the pumping unit by heat exchange with, in one scenario, building-chilled water. A great advantage of this technology is that hot and cold air mixing is eliminated. Mixing is a major contributor to wasteful overcooling and inefficiencies that are typical in hot and cold aisle configurations using traditional air-based cooling methods. The technology is so efficient that the maximum heat dissipation per cabinet that can be cooled is approximately 10 times larger

than what is possible with existing technology. This advantage allows for higher equipment density and correspondingly lower real estate costs. It also allows data center designers to lay out the equipment as best dictated by function, without having to worry about local overheating due to high heat density equipment.

At present, ICT facilities are typically cooled by CRAC units, which provide cold air that is drawn into racks of heat-dissipating equipment by rack, and component-level fans. The heated exhaust air is recirculated back to the CRAC units via room-level blowers and air movers. This approach has many disadvantages, including: inefficient transporting and cooling of large quantities of air; poor air distribution, which necessitates additional air sub-cooling to overcompensate for this inefficiency; and the limited heat-carrying capacity of air, which creates acoustic noise restrictions and fan reliability concerns. Because of these inefficiencies, cabinets often cannot be filled with equipment to their maximum capacity, which results in wasted space. The technology in this new system overcomes these challenges and represents an advance in the thermal management of ICT equipment.

## Barriers

Principal barriers to deploying new cooling technologies in existing data center installations are downtime associated with retrofit, and customer acceptance. One significant advantage of this modular cooling technology is that it requires no operational downtime for retrofits. The project will also address customer acceptance issues by reducing cost and thoroughly understanding system performance.

## Pathways

The objectives of the ARCTIC project are threefold:

1. Advanced research innovations that bring liquid cooling much closer to heat sources
2. Manufacturing optimization of key components
3. Reduction in cost to promote rapid market acceptance while thoroughly understanding system performance and developing viable commercialization strategies

## Milestones

- Development and testing of advanced components
- System installation and evaluation of new technologies
- Creation of a viable commercialization strategy

## Commercialization

The commercialization strategy is comprised of two paths:

1. An initial focus on retrofitting data centers with the modular liquid-cooling technology
2. New installations such as new ICT facilities as well as next-generation equipment that can be expected to be particularly challenging to cool.

## Project Partners

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