

CERN IT View and Plans for Heterogeneous Computing

Arne Wiebalck, CERN IT

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Outline



- **Status of non-x86 resources in CERN IT**
(On-premises, Public Cloud, Industry Collaborations)

- **Thoughts and Common Plans**
(Resources, Integration)



On-premises IaaS on OpenStack



Resource	Spec	Available (Total)	Access	Used by																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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<p>GPU</p>  <p>NVIDIA</p>	<p>Total cards:</p> <table border="1"> <thead> <tr> <th>Model</th> <th>nodes</th> <th>cards</th> </tr> </thead> <tbody> <tr> <td>P100</td> <td>1</td> <td>1</td> </tr> <tr> <td>V100</td> <td>5</td> <td>17</td> </tr> <tr> <td>V100S</td> <td>6</td> <td>24</td> </tr> <tr> <td>T4</td> <td>73</td> <td>76</td> </tr> <tr> <td>A100</td> <td>18</td> <td>72</td> </tr> </tbody> </table>	Model	nodes	cards	P100	1	1	V100	5	17	V100S	6	24	T4	73	76	A100	18	72	<p>Current GPU usage:</p> <table border="1"> <thead> <tr> <th>Node</th> <th>Model</th> <th>Usage</th> <th>Free</th> <th>Used</th> <th>Available</th> </tr> </thead> <tbody> <tr><td>node01</td><td>V100</td><td>0%</td><td>17</td><td>0</td><td>17</td></tr> <tr><td>node02</td><td>V100</td><td>0%</td><td>17</td><td>0</td><td>17</td></tr> <tr><td>node03</td><td>V100</td><td>0%</td><td>17</td><td>0</td><td>17</td></tr> <tr><td>node04</td><td>V100</td><td>0%</td><td>17</td><td>0</td><td>17</td></tr> 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<tr><td>node149</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node150</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node151</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node152</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node153</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node154</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node155</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node156</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node157</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node158</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node159</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node160</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node161</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node162</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node163</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node164</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node165</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node166</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node167</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node168</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node169</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node170</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node171</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node172</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node173</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node174</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node175</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node176</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node177</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node178</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node179</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node180</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node181</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node182</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node183</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node184</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node185</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node186</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node187</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node188</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node189</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node190</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node191</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node192</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node193</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node194</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node195</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node196</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node197</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node198</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node199</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node200</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node201</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node202</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node203</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node204</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node205</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node206</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node207</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node208</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node209</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node210</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node211</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node212</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node213</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node214</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node215</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node216</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node217</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node218</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node219</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node220</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node221</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node222</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node223</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node224</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node225</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node226</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node227</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node228</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node229</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node230</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node231</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node232</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node233</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node234</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node235</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node236</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node237</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node238</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node239</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node240</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node241</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node242</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node243</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node244</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node245</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node246</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node247</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node248</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node249</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node250</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node251</td><td>T4</td><td>0%</td><td>76</td><td>0</td><td>76</td></tr> <tr><td>node252</td></tr></tbody></table>	Node	Model	Usage	Free	Used	Available	node01	V100	0%	17	0	17	node02	V100	0%	17	0	17	node03	V100	0%	17	0	17	node04	V100	0%	17	0	17	node05	V100	0%	17	0	17	node06	V100S	0%	24	0	24	node07	V100S	0%	24	0	24	node08	V100S	0%	24	0	24	node09	V100S	0%	24	0	24	node10	V100S	0%	24	0	24	node11	V100S	0%	24	0	24	node12	V100S	0%	24	0	24	node13	V100S	0%	24	0	24	node14	V100S	0%	24	0	24	node15	V100S	0%	24	0	24	node16	V100S	0%	24	0	24	node17	V100S	0%	24	0	24	node18	V100S	0%	24	0	24	node19	V100S	0%	24	0	24	node20	V100S	0%	24	0	24	node21	V100S	0%	24	0	24	node22	V100S	0%	24	0	24	node23	V100S	0%	24	0	24	node24	V100S	0%	24	0	24	node25	V100S	0%	24	0	24	node26	V100S	0%	24	0	24	node27	V100S	0%	24	0	24	node28	V100S	0%	24	0	24	node29	V100S	0%	24	0	24	node30	V100S	0%	24	0	24	node31	V100S	0%	24	0	24	node32	V100S	0%	24	0	24	node33	V100S	0%	24	0	24	node34	V100S	0%	24	0	24	node35	V100S	0%	24	0	24	node36	V100S	0%	24	0	24	node37	V100S	0%	24	0	24	node38	V100S	0%	24	0	24	node39	V100S	0%	24	0	24	node40	V100S	0%	24	0	24	node41	V100S	0%	24	0	24	node42	V100S	0%	24	0	24	node43	V100S	0%	24	0	24	node44	V100S	0%	24	0	24	node45	V100S	0%	24	0	24	node46	V100S	0%	24	0	24	node47	V100S	0%	24	0	24	node48	V100S	0%	24	0	24	node49	V100S	0%	24	0	24	node50	V100S	0%	24	0	24	node51	V100S	0%	24	0	24	node52	V100S	0%	24	0	24	node53	V100S	0%	24	0	24	node54	V100S	0%	24	0	24	node55	V100S	0%	24	0	24	node56	V100S	0%	24	0	24	node57	V100S	0%	24	0	24	node58	V100S	0%	24	0	24	node59	V100S	0%	24	0	24	node60	V100S	0%	24	0	24	node61	V100S	0%	24	0	24	node62	V100S	0%	24	0	24	node63	V100S	0%	24	0	24	node64	V100S	0%	24	0	24	node65	V100S	0%	24	0	24	node66	V100S	0%	24	0	24	node67	V100S	0%	24	0	24	node68	V100S	0%	24	0	24	node69	V100S	0%	24	0	24	node70	V100S	0%	24	0	24	node71	V100S	0%	24	0	24	node72	V100S	0%	24	0	24	node73	T4	0%	76	0	76	node74	T4	0%	76	0	76	node75	T4	0%	76	0	76	node76	T4	0%	76	0	76	node77	T4	0%	76	0	76	node78	T4	0%	76	0	76	node79	T4	0%	76	0	76	node80	T4	0%	76	0	76	node81	T4	0%	76	0	76	node82	T4	0%	76	0	76	node83	T4	0%	76	0	76	node84	T4	0%	76	0	76	node85	T4	0%	76	0	76	node86	T4	0%	76	0	76	node87	T4	0%	76	0	76	node88	T4	0%	76	0	76	node89	T4	0%	76	0	76	node90	T4	0%	76	0	76	node91	T4	0%	76	0	76	node92	T4	0%	76	0	76	node93	T4	0%	76	0	76	node94	T4	0%	76	0	76	node95	T4	0%	76	0	76	node96	T4	0%	76	0	76	node97	T4	0%	76	0	76	node98	T4	0%	76	0	76	node99	T4	0%	76	0	76	node100	T4	0%	76	0	76	node101	T4	0%	76	0	76	node102	T4	0%	76	0	76	node103	T4	0%	76	0	76	node104	T4	0%	76	0	76	node105	T4	0%	76	0	76	node106	T4	0%	76	0	76	node107	T4	0%	76	0	76	node108	T4	0%	76	0	76	node109	T4	0%	76	0	76	node110	T4	0%	76	0	76	node111	T4	0%	76	0	76	node112	T4	0%	76	0	76	node113	T4	0%	76	0	76	node114	T4	0%	76	0	76	node115	T4	0%	76	0	76	node116	T4	0%	76	0	76	node117	T4	0%	76	0	76	node118	T4	0%	76	0	76	node119	T4	0%	76	0	76	node120	T4	0%	76	0	76	node121	T4	0%	76	0	76	node122	T4	0%	76	0	76	node123	T4	0%	76	0	76	node124	T4	0%	76	0	76	node125	T4	0%	76	0	76	node126	T4	0%	76	0	76	node127	T4	0%	76	0	76	node128	T4	0%	76	0	76	node129	T4	0%	76	0	76	node130	T4	0%	76	0	76	node131	T4	0%	76	0	76	node132	T4	0%	76	0	76	node133	T4	0%	76	0	76	node134	T4	0%	76	0	76	node135	T4	0%	76	0	76	node136	T4	0%	76	0	76	node137	T4	0%	76	0	76	node138	T4	0%	76	0	76	node139	T4	0%	76	0	76	node140	T4	0%	76	0	76	node141	T4	0%	76	0	76	node142	T4	0%	76	0	76	node143	T4	0%	76	0	76	node144	T4	0%	76	0	76	node145	T4	0%	76	0	76	node146	T4	0%	76	0	76	node147	T4	0%	76	0	76	node148	T4	0%	76	0	76	node149	T4	0%	76	0	76	node150	T4	0%	76	0	76	node151	T4	0%	76	0	76	node152	T4	0%	76	0	76	node153	T4	0%	76	0	76	node154	T4	0%	76	0	76	node155	T4	0%	76	0	76	node156	T4	0%	76	0	76	node157	T4	0%	76	0	76	node158	T4	0%	76	0	76	node159	T4	0%	76	0	76	node160	T4	0%	76	0	76	node161	T4	0%	76	0	76	node162	T4	0%	76	0	76	node163	T4	0%	76	0	76	node164	T4	0%	76	0	76	node165	T4	0%	76	0	76	node166	T4	0%	76	0	76	node167	T4	0%	76	0	76	node168	T4	0%	76	0	76	node169	T4	0%	76	0	76	node170	T4	0%	76	0	76	node171	T4	0%	76	0	76	node172	T4	0%	76	0	76	node173	T4	0%	76	0	76	node174	T4	0%	76	0	76	node175	T4	0%	76	0	76	node176	T4	0%	76	0	76	node177	T4	0%	76	0	76	node178	T4	0%	76	0	76	node179	T4	0%	76	0	76	node180	T4	0%	76	0	76	node181	T4	0%	76	0	76	node182	T4	0%	76	0	76	node183	T4	0%	76	0	76	node184	T4	0%	76	0	76	node185	T4	0%	76	0	76	node186	T4	0%	76	0	76	node187	T4	0%	76	0	76	node188	T4	0%	76	0	76	node189	T4	0%	76	0	76	node190	T4	0%	76	0	76	node191	T4	0%	76	0	76	node192	T4	0%	76	0	76	node193	T4	0%	76	0	76	node194	T4	0%	76	0	76	node195	T4	0%	76	0	76	node196	T4	0%	76	0	76	node197	T4	0%	76	0	76	node198	T4	0%	76	0	76	node199	T4	0%	76	0	76	node200	T4	0%	76	0	76	node201	T4	0%	76	0	76	node202	T4	0%	76	0	76	node203	T4	0%	76	0	76	node204	T4	0%	76	0	76	node205	T4	0%	76	0	76	node206	T4	0%	76	0	76	node207	T4	0%	76	0	76	node208	T4	0%	76	0	76	node209	T4	0%	76	0	76	node210	T4	0%	76	0	76	node211	T4	0%	76	0	76	node212	T4	0%	76	0	76	node213	T4	0%	76	0	76	node214	T4	0%	76	0	76	node215	T4	0%	76	0	76	node216	T4	0%	76	0	76	node217	T4	0%	76	0	76	node218	T4	0%	76	0	76	node219	T4	0%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On-premises: GPU access



→ <https://clouddocs.web.cern.ch/gpu/index.html>

→ GPUs are available ...

- as virtual machines
- via the batch service
- on kubernetes clusters
- via Lxplus
- via Gitlab
- via Swan
- ml.cern.ch



→ Request for GPUs: [GPU Platform Consultancy FE](#)

→ Mattermost for GPUs: [~GPU](#)



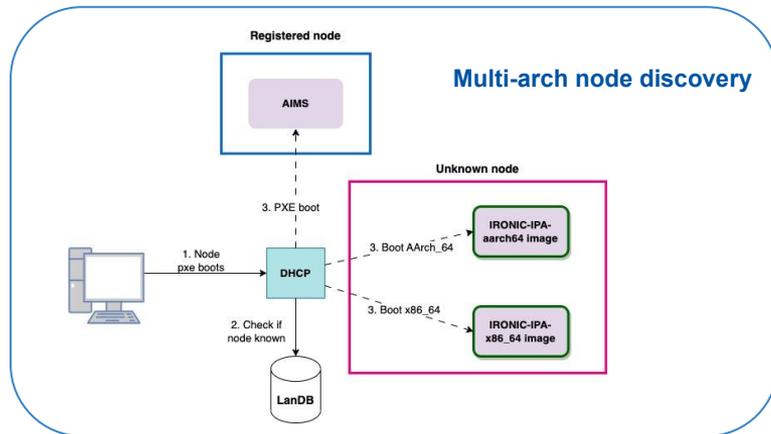
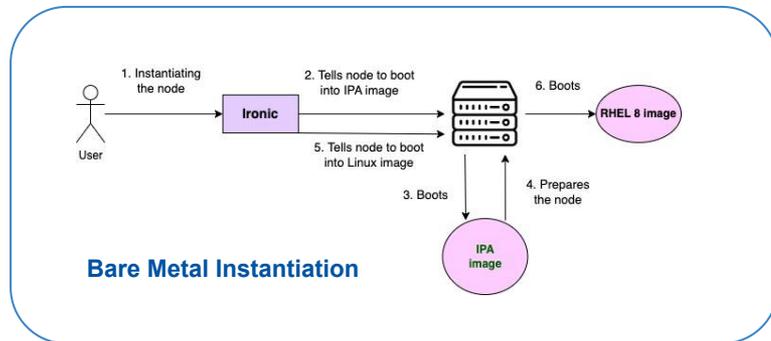
On-premises IaaS Integration: ARM

→ Virtual Machines ... “easy”

- Required EL8
- Image and capabilities filtering
- [Libvirt bug](#)

→ Physical servers ... “not so easy”

- Image boot-strapping with AArch64 QEMU
- Ironic as CERN IT’s fleet manager
- Multi-arch docker images & PXE
- Detailed talks at [HEPIX](#) & [CHEP](#)



On-premises IaaS Integration: GPUs

- ➔ Various hardware models
- ➔ Various access modes
- ➔ Used by higher level services

Provisioning	Access	Model
<i>Bare Metal</i>	Full access	A100
<i>PCI-passthrough</i>	Full access	T4, A100, V100s, V100
<i>vGPU</i>	Time sharing	T4, A100, V100s, V100
<i>Multi-instance GPU</i>	Partition sharing	A100

PCI-passthrough GPUs

- ⊕ Direct access to the graphics card from the guest
- ⊖ No monitoring of the GPU usage on the hypervisor
- ⊖ One device per GPU - no sharing
- EL7 with newer kernel on hypervisor
- Out of the box for EL7 guests
- Additional kernel boot options for EL8 and EL9 guests

Virtual GPUs

- ⊕ Hypervisor drivers give access to GPU usage information
- ⊕ Physical card shared between multiple virtual machines
- ⊖ Timesharing
- ⊖ Licenses for virtualisation drivers
- Puppet configuration:
 - CUDA
 - Drivers

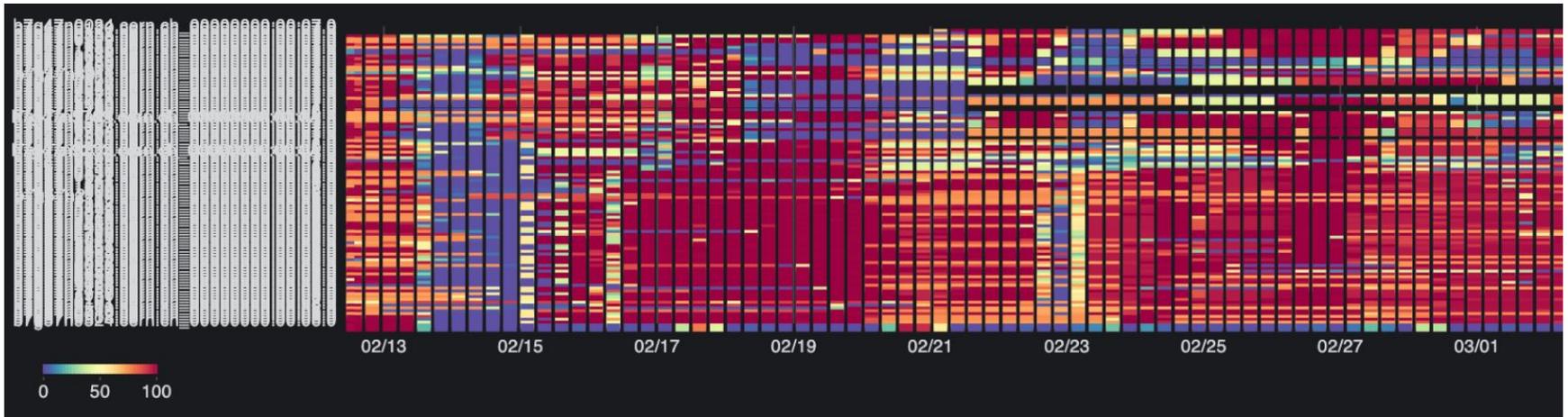
Multi-instance GPUs

- ⊕ Physical card shared between multiple virtual machines
- ⊕ Physical chunk, not timeshared
- ⊕ Thermal and power consumption per card only
- ⊖ All cards in a single HV have to be partitioned the same way
- ⊖ Only 1 device per VM
- ⊖ Licenses for virtualisation drivers
- Required a [backport](#) for UUID treatment for Nova

Example: Batch Integration

→ Accessed via HTCCondor

- PCI-passthrough, ~100 GPUs in total (V100, V100S, T4, A100)
- automatic publication of CUDA attributes (for GPU selection)



Public Cloud: Oracle Cloud



Resource	Spec	Amount	Access	Used by
<p>Ampere Altra</p>  <p>AMPERE</p>	<p>BM.Standard.A1.160 160 cores, 1TB RAM (3.0GHz)</p>	<p>~10 VMs 1 physical</p>	<p>Via keys on pre-created instances</p>	<p>{ALICE, ATLAS} builder WLCG benchmarking IT: lxplus & lxbatch, GitLab, Linux, Monit</p>
<p>- VM.GPU2.1 12 72. (Nvidia Tesla P100 16GB, 1 per node) - BM.GPU.A10.4 64 1024 (Nvidia A10 Tensor Core, 4 per node) - BM.GPU2.2 28 256 (Nvidia Tesla P100 16GB, 2 per node)</p>				<p>(not used at the moment)</p>



Collaborations: openlab (1)

Resource	Spec	Amount	Access	Used by
GPU 	V100 T4	20 8	Direct on (shared) bare metal nodes	openlab projects (ML, QTI, Medical)
GPU 	ATS-P	1		
DPU* 	Bluefield-2	2		

*DPU: Data Processing Unit combining CPUs, network links, and programmable accelerators.

Collaborations: openlab (2)

Resource	Spec	Amount	Access	Used by
ARM	ThunderX	2	Direct on (shared) bare metal nodes	Build nodes for SFT & experiments
	ThunderX2	3		Linux team
Power	Power8	4		CMS & LHCb build nodes
	Power9	2	-	

- **Power8 Minsky server acquired.**
- **Future of Power9 nodes still unclear.**

Outline



→ **Status of non-x86 resources in CERN IT**
(On-premises, Public Cloud, Industry Collaborations)

→ **Thoughts and Common Plans**
(Resources, Integration)



Integration Challenges

- **Tooling support may not available!**
 - E.g.: Puppet for Power?
- **Initial setup cost can be high!**
 - E.g.: OpenStack Ironic community usage of ARM is limited
- **Different use cases may have different license implications!**
 - E.g.: vGPUs vs MIG
- **Access Methods will vary!**
 - E.g.: Access automation, web portal vs ssh keys
- **Resources may be scarce!**
 - May require arbitration, prioritisation, lease management

Thoughts on Heterogeneous Architectures



→ Goal: Become more flexible for non-x86, at all stages!

- Provision for **testing** (grant access for evaluation)
- Facilitate **development**, optimisation & porting of applications (for non-CERN architectures)
- Address short term **production** needs (mitigate long procurement cycles)

→ How: Set up access on different levels

- Primarily via IT services (OpenStack, GitLab, LxPlus, Swan, ...)
- Industry collaborations: CERN openlab on-premises/remote
- HPC supercomputer testbeds
- IT Public cloud initiative

- NVIDIA CPUs and GPUs including GRACE and HOPPER
- ARM Marvell and Ampere CPUs
- RISC-V CPUs
- Intel CPUs and GPUs including Sapphire Rapids, Ice Lake
- Power
- FPGAs
- AI-specialised architectures
- Quantum simulators

→ Needed: Demand estimates and prioritised use cases



IT/RCS Initiative on Heterogeneous Arch's



→ Initiative to strengthen link between CERN IT and RC sector

- Technical Committee to identify areas of interest and to consolidate needs
- Steering Committee to review, prioritise, and resource projects

→ 'Heterogeneous Architectures / non-x86' is a focus areas

→ PSO document drafted by IT and EP

- Stresses need for stable multi-stage support
- Proposes "landing zone" for access
- Gives rough timelines and initial milestones

"... establish an IT provisioning mechanism for flexible access and infrastructure support for heterogeneous and non-x86 resources, with the aim to cover all stages in the usage life-cycle."



Resourcing Plans: On-premises



→ Purchase of ~20 additional ARM servers

- Existing resources fully used (... even before provisioning :-)
- Provisioning by preference via existing services

→ Exploitation of Multi-instance GPUs (MIG*)

- Provide GPU “flavors” → more flexible, better resource utilisation
- Licenses needed if done on the host

→ AMD processors for services hypervisors

- Price/performance ratio
- Different CPU flags ... but live-migration



Method of providing	Type of access	Model
<i>PCI-passthrough</i>	Full access	T4, A100, V100s, V100
<i>vGPU</i>	Time sharing	T4, A100, V100s, V100
<i>Multi-instance GPU</i>	Partition sharing	A100

*Multi-Instance GPUs: Static core partitioning rather than time-slicing



Resourcing Plans: Public Cloud



- **Evolve CERN IT service offering into a hybrid cloud**
 - Faster procurement cycle (access) / technology turn-around (exchange)
 - Cloud bursting for resource spikes
 - Optimise TCO (time limited access) for certain use cases
 - ...
 - **Access to resources not on-premises**

- **'Heterogeneous Architectures' one of the initial use cases**

- **Managed, Un-Managed, Hybrid**

- **Currently preparing pilot procurement process**

Integration Plans: Interactive (& Batch)



→ LxPlus aliases

- `lxplus{8,9}-arm`
- `lxplus{8,9}-gpu`
- `lxplus{8,9}-...`

→ Interactive batch jobs

- **At submission time**
`$> condor_submit -interactive gpu_job.sub`
- **While the job is running**
`$> condor_ssh_to_job -auto-retry jobid`

→ “Add resources as they become available.”

- **Private or public cloud (both have been used by LxPlus and Batch)**
- **Prerequisites:**
 - **EL & Config tool support**
 - **Network extensions**

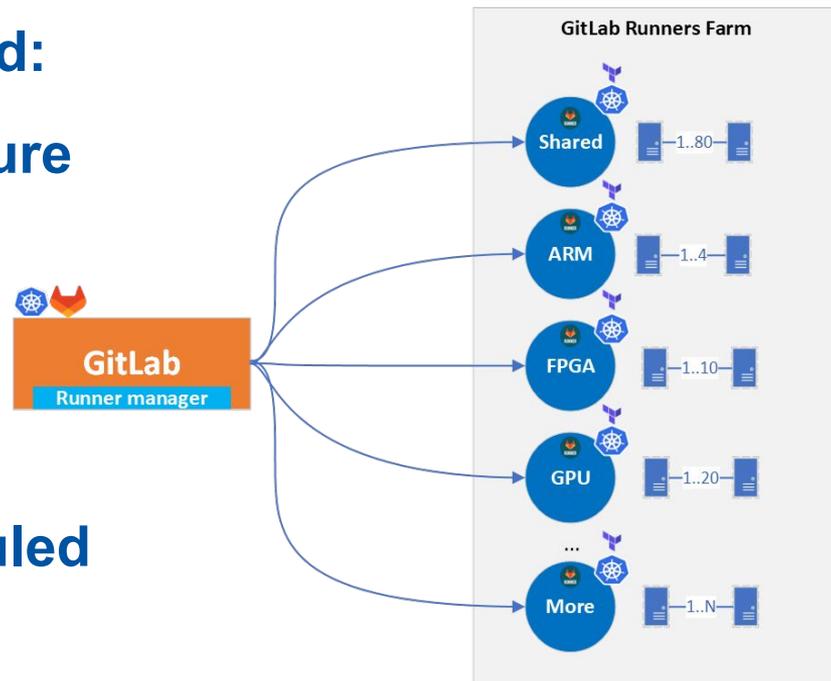
(OpenStack) VMs “not preferred” to optimise resource usage.

Integration Plans: GitLab

→ **New architecture being introduced:
K8s runner clusters per architecture**

- Shared, ARM*, FPGA*, GPU* ...
- Built with K8s and Terraform
- GitLab Application v15.10

→ **Cluster selection via tags, scheduled
By Runner Manager**



*planned

Integration Plans: SWAN

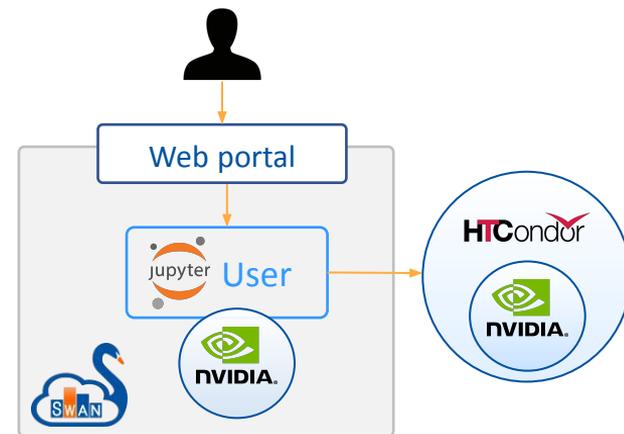


→ SWAN provides both interactive and batch access to GPUs

- Interactive (e.g. from a notebook): GPU attached to user session, GPU-enabled software readily available
- Batch: SWAN as entry point for job submission to HTCondor pools at CERN (for longer computations)

→ How to potentially handle spikes in GPU user load – example: schools, workshops

- Physical partitioning (MIG): sharing at the GPU level
- Shared pool of GPUs at CERN: used by all services that offer GPUs
- Offload to the cloud



Integration Plans: Operating System Support



→ Linux Strategy change to AlmaLinux & RHEL

➤ Arch support was one decisive factor:

x86, aarch64, ppc64le, s390x ... RISC-V

→ AlmaLinux team was visiting CERN
and the Linux team earlier this year!



Thanks!

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